Yr 9 Science P2.2 Newton's Laws

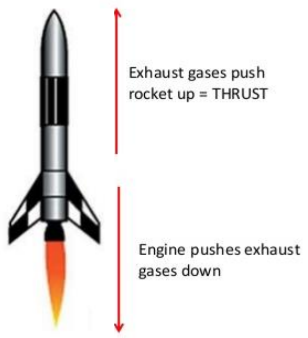
Section P2.2.1- Forces and interactions

Pairs of forces arise when objects interact, and they always follow these principles:

- Each force acts on a *different* object.
- The forces are the *same* size, and type (e.g., gravitational).
- The forces act in *opposite* directions.

This is **Newton's Third Law**.

Contact forces need to be touching an object to act.
Non-contact forces do not need to directly touch an object to act.



Contact forces examples	Non-contact force examples
Friction	Magnetism
Air resistance	Gravity
Tension	Electrostatics

Forces are vectors, so we represent them by an arrow. The length of the arrow shows the magnitude, and the direction of the arrow shows the direction of the force.

Section P2.2.3 – Newton's first law

"An object will continue to stay at rest or move with uniform velocity unless a force acts on it."

It takes a resultant force to change the motion (the speed or direction) of an object.

This is **Newton's First Law**.
It is based on the principle of inertia – how an object resists motion. The larger the inertia, the more difficult it is to change an object's motion and therefore, it will continue to move with the same velocity.

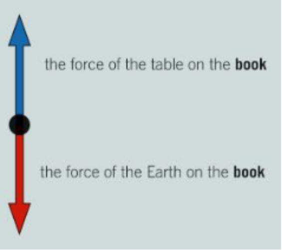
Section P2.2.2 – Free body diagrams

A free-body force diagram shows all the forces acting on a single object.
Only one of each pair of forces will act on the object.

How do you draw a free body diagram?

You know that the force or forces acting on an object can be from several different interaction pairs.

- Step 1: Identify all the non-contact pairs.
- Step 2: Identify all the contact pairs.
- Step 3: Focus on a *single* object. Draw that object with arrows showing all the forces acting on the object.



Study tip

The force arrow that you draw should be in contact with the object because forces act *on* objects.

When you have drawn your free body diagram, you can work out the **resultant force**, or **net force**. Forces are vectors so you need to take account of their direction when you add them (Figure 3).

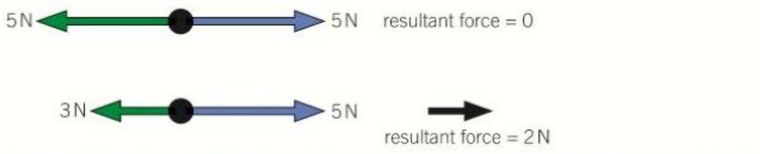


Figure 3 *Calculating resultant forces for forces acting in the same direction.*

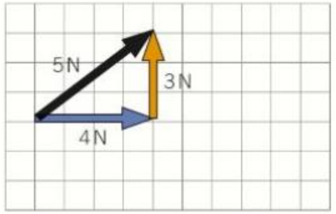


Figure 4 *Calculating resultant forces for forces acting at right angles. Grid scale: the length of the side of one square is 1 N.*

If the forces are at a right-angle to each other, you can also use Pythagoras to calculate the resultant force.

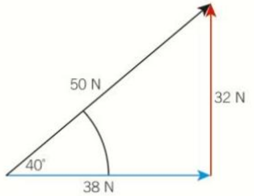
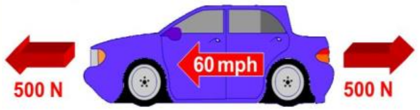


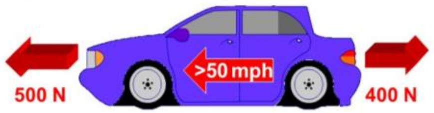
Figure 6 *You can resolve a force of 50 N acting at an angle of 40 degrees into two components.*

Sometimes you are asked to "**resolve**" a force into 2 "**components,**" a horizontal and vertical. This means make the force the hypotenuse of a right-angled diagram, with the specified angle (see diagram)



The resultant force = 0

The car is moving with a **constant velocity**



The resultant force = 100N to the left

The car is **accelerating**

When there is no resultant force (object in equilibrium):

- a stationary object stays stationary
- a moving object continues to move at the same **velocity**

If there is a resultant force on an object (i.e. It is not equal to zero) the object is **not** in equilibrium. It must be:

- Accelerating
- Decelerating
- Changing direction

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Section P2.2.4 - Newton's second law

When a resultant force acts on an object, it accelerates. Acceleration is a **vector**, so it has both a **magnitude** (size) and **direction**.

If an object is moving in a straight line, a resultant force in the same direction as its motion, will cause it to speed up.

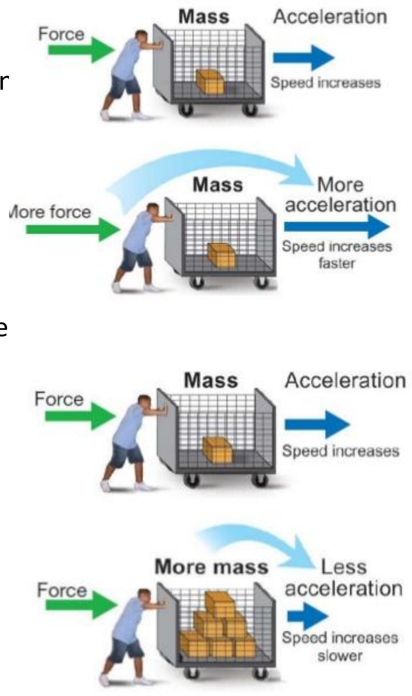
If an object is moving in a straight line, a resultant force in the opposite direction as its motion, will cause it to slow down (negative acceleration or deceleration).

If the resultant force is applied at a right angle to the motion, the object will change direction (e.g. move in a circle)

The force, mass and acceleration of an object are related by the equation:

force = mass × acceleration

force is measured in **N**
mass is measured in **kg**
acceleration is measured in **m/s²**



Section P2.2.5 - Everyday forces and their effects

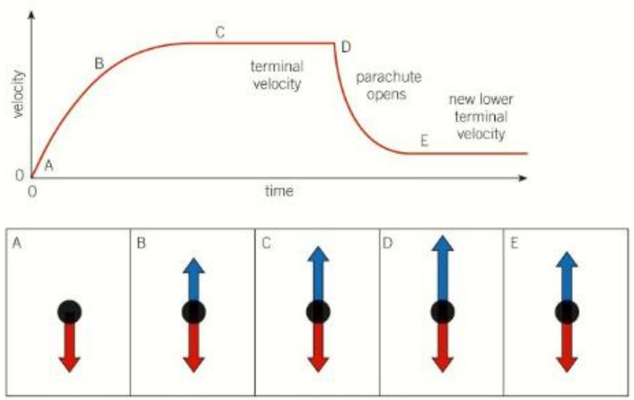


Figure 2 *You can reach a lower terminal velocity using a parachute. The free body diagrams show the forces on the parachutist at the points labelled on the graph. Red arrow: weight; blue arrow: air resistance.*

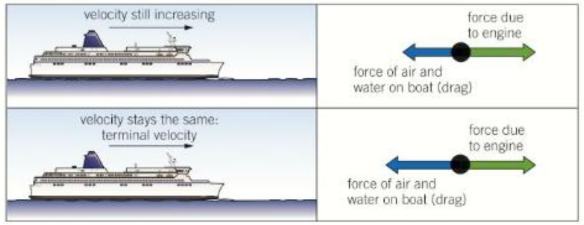


Figure 3 *Objects such as boats and cars also reach terminal velocity.*

The maximum speed an object can reach on Earth, depends on air resistance.

Air resistance increases with speed.

When the air resistance balances the weight / thrust, the object has reached this maximum speed called the **terminal velocity.**

The larger the air resistance, the smaller the terminal velocity. Parachutes have a large surface area so create a lot of air resistance, so you fall slower and more safely.

Section P2.2.6 - Momentum

An object's momentum depends on 2 things:
1) Mass
2) Velocity

Momentum (kgm/s) = mass (kg) x velocity (m/s)

In any collision momentum is conserved, so the momentum before is equal to the momentum afterwards. This is the **Law of Conservation of Momentum**.

In Figure 1 the momentum before the skaters push apart is zero. If they move away from each other with a momentum that is equal in size but opposite in direction, the momentum afterwards is also zero.

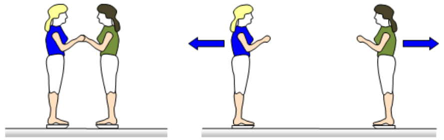


Figure 1(a) Figure 1(b)

In **elastic** collisions, no energy is lost to the surroundings so:
total kinetic energy before the collision = total kinetic energy after

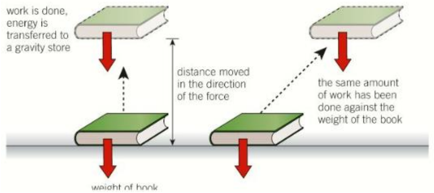
Most collisions transfer some kinetic energy to thermal energy as the objects collide so kinetic energy after is less than the total kinetic energy before.

Section P2.2.7 - Work and power

In Physics, **work** is only being done when **energy is transferred**

Power is the **rate of doing work.** This means power is how quickly work is done or energy is transferred

You must measure the distance *along the line of the force* (Figure 3).



Study tip
Make sure you use the distance in line with the force, which is not necessarily the total distance moved by the force.

work done (J) = force (N) × distance (m)

$$\text{power (W)} = \frac{\text{work done (J)}}{\text{time (s)}}$$

So a more powerful crane will lift the same weight (same amount of work) quicker than a less powerful crane