Engineering

Contact Forces

Contact Forces

Contact forces act between objects that are physically touching each other.

friction – The force between two surfaces that are sliding, or trying to slide, past each other.

air resistance – The force that acts in the opposite direction to an object's movement as it moves through the air.

reaction – The force that supports an object on a solid surface.

tension – The force transmitted through a rope, string or wire when pulled by forces acting on each end.

upthrust – The upward force exerted by a fluid on an object floating in it.

Forces always act in pairs.

The person's weight pushes down on the chair.

The reaction force from the chair pushes the person up.

Forces are measured in newtons (N).

Forces can be measured using a newton meter.

Non-contact forces

Non-contact forces act in fields. The field is the area around the object where the force is exerted.

As an object gets farther away from the object exerting a force, the field gets weaker. For example, if a magnetic object is farther from a magnet, it will experience a smaller force of attraction towards the magnet.

Non-Contact Forces

Non-contact forces act between objects without them physically touching each other.

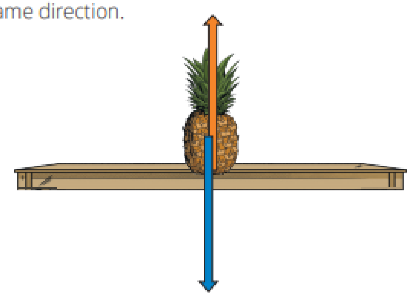
gravitational force – The force acting on an object due to gravity.

magnetic force – The force exerted by a magnetic field on a magnetic material.

electrostatic force – The force that acts between two charged objects.

Balanced

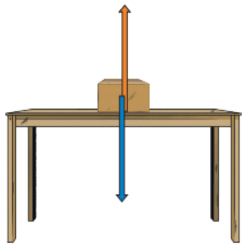
When the forces acting on an object are the same size but in opposite directions, we say that the forces are **balanced**. When this happens, the object is in a state of **equilibrium**. There will be no change to the motion of the object: a stationary object will remain stationary and a moving object will continue to move at a constant speed in the same direction.



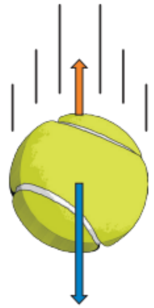
Forces are another example of a **vector quantity** and so they can also be represented by an **arrow**.

The arrows show the direction and the size of the force (the longer the arrow, the bigger the force).

The force arrows should touch the object in the diagram.



Un-balanced

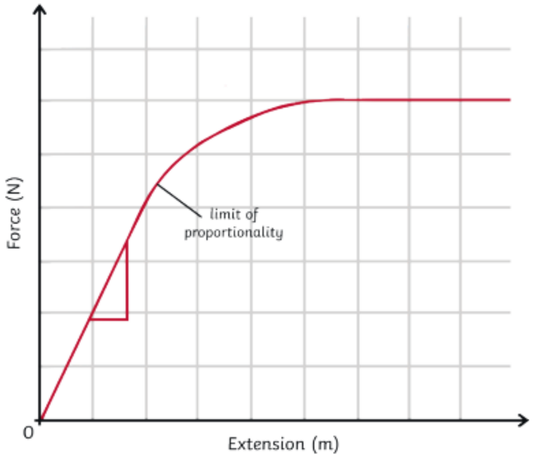


Unbalanced forces act in opposite directions but are not the same size. One force is greater than the other.

If forces are unbalanced there will be a change in the motion of the object. It may speed up, slow down or change direction.

Hooke's Law

force applied (N) = spring constant (N/m) × extension (m)



Hooke's Law describes that the extension of an elastic object is **proportional** to the force applied to the object. However, there is a maximum applied force for which the extension will still increase proportionally. If the **limit of proportionality** is exceeded, then the object becomes **permanently deformed** and can no longer return to its original shape. This can be identified on a graph of extension against force when the gradient stops being linear (a straight line) and begins to **plateau**. The limit is shown on the graph above and this is the specific object's **elastic limit**.

Elastic objects can be compressed or stretched by forces. When an object is changed in these ways, we say it is **deformed**.

The amount that an object is stretched is called the **extension**.

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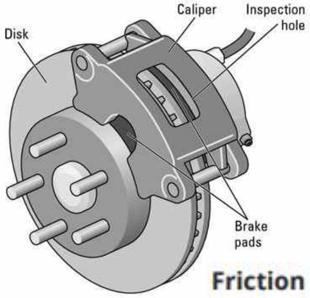
Friction



Friction between the pads and disc slows the wheel

Friction can be reduced by using **lubrication**. Lubrication is grease or oil that helps two surfaces move past each other more easily.

Having a smaller **surface area** in contact with a surface will also reduce the amount of friction.

Drag forces, like water resistance and air resistance, can be reduced by making objects more **streamlined**.

Newton's 1st Law

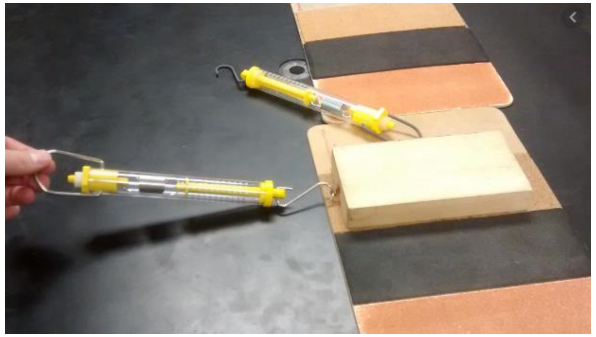
If the resultant force acting on an object is zero...

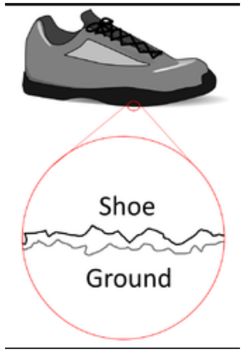
- a stationary object will remain stationary.
- a moving object will continue at a steady speed and in the same direction.

100N resistance (friction and air)

100N thrust

Friction Investigation





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Speed

When an object moves in a straight line at a steady speed, you can calculate its average speed if you know how far it travels and how long it takes. The following equation shows the relationship between average speed, distance moved and time taken:

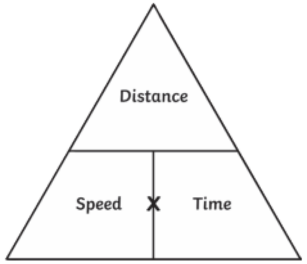
$$\text{average speed} = \frac{\text{distance moved}}{\text{time taken}}$$

average speed is measured in metres per second, m/s

distance moved is measured in metres, m

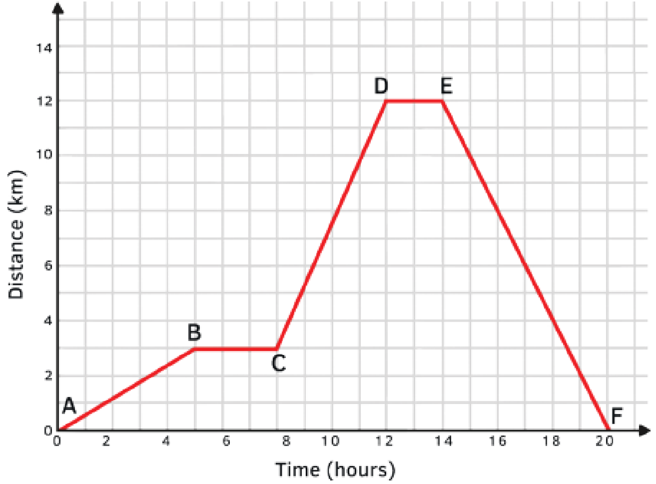
time taken is measured in seconds, s

ed = distance ÷ time



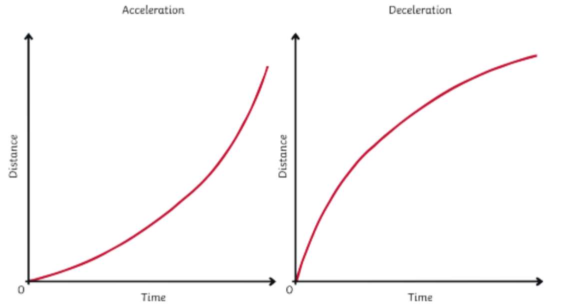
You should be able to use this equation and rearrange it to find the distance or time.

Distance-time graphs



A distance-time graph shows how far something travels over a period of time. The vertical axis of a distance-time graph is the distance travelled from the start. The horizontal axis is the time from the start.

Graph Feature	Distance-Time Graph
x-axis	time
y-axis	distance
gradient	speed
plateau	stationary (stopped)
uphill straight line	steady speed moving away from start point
downhill straight line	steady speed returning to the start point
uphill curve	acceleration
downhill curve	deceleration
area below graph	



When the graph is a **straight line**, it is representing a **constant speed**. A **curve** represents a changing speed, either **acceleration** or **deceleration**.

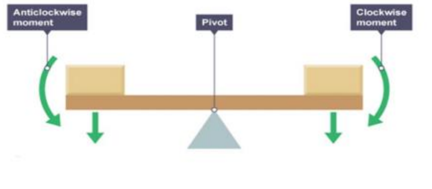
Moments

The turning effect of a force is called a moment.

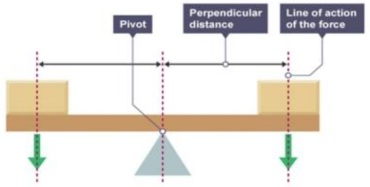
Moment (Nm) = force (N) x perpendicular distance from pivot (m)

Law of Moments:

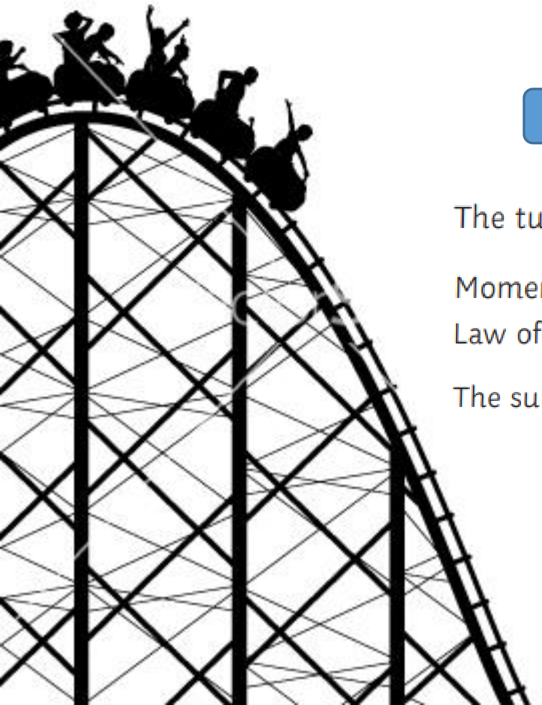
The sum of the clockwise moment = the sum of the anticlockwise moment



The anticlockwise moment acts downward on the left, and the clockwise moment acts downwards on the right



The perpendicular distance is the shortest distance between the pivot and the line of action of the force.



Pressure

Pressure is the force per unit area.

This means that the pressure a solid object exerts on another solid surface is its weight in newtons divided by its area in square metres.

Pressure can be calculated by the equation: Pressure (N/m^2) = force (N) / area (m^2)

To increase pressure - increase the force or reduce the area the force acts on.

To reduce pressure - decrease the force or increase the area the force acts on.

Gas pressure is caused by the force exerted by particles when they collide with a surface.

Factors affecting gas pressure:

- Volume – a smaller volume leads to greater pressure
- Temperature – the higher the temperature, the more energy the particles have, leading to more collisions and greater pressure.

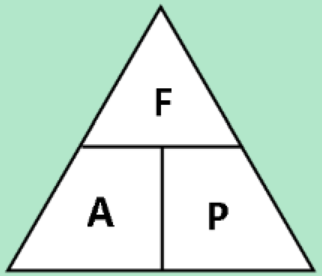
Pressure in liquids

Liquids exert pressure on objects. The pressure in liquids changes with depth.

The deeper you go:

- the greater the weight of liquid above
- the greater the liquid pressure

Force Area Pressure



$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$\text{Area} = \frac{\text{Force}}{\text{Pressure}}$$

$$\text{Force} = \text{Area} \times \text{Pressure}$$

Using pressure

Who needs to know about water pressure?

Divers need to be aware of pressure in water. If you dive to the bottom of a swimming pool, your ears may start to hurt. This is due to the extra pressure around you.

Deep sea divers train themselves to go many times deeper and need to know how to cope with this extra pressure.

Submarines can go very deep. They must be designed carefully to handle the enormous water pressure at those depths.

At the bottom of the ocean the pressure is equivalent to an elephant standing on your finger, so submarines have to be very strong indeed!

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If you walk through snow, you usually sink into it.

This is because your shoes have a small surface area. Your weight is only spread out over a small area, so the pressure on the snow is high.

However, you will not sink so far into the snow if you are on skis. This is because your weight is spread out over a greater surface area, so the pressure on the snow is low.

Drawing pins have a large round end for your thumb to push. The round end has a large area, so it exerts a low pressure to your thumb.

The sharp end has a very small area. The same pushing force produces a high pressure there, so it pushes into the notice board.

If you swing round on one leg of a chair, you put four times as much pressure on one point of the floor as you do if you sit properly.

This is because four chair legs spread the pressure over four times more area than one chair leg can.