GZ Science Resources

2018 Version

Force and Motion

Junior Science

Force can cause an object to change its velocity or shape.

Forces push, pull, tug, heave, squeeze, stretch, twist or press.
Forces can change:

- The shape of an object
- The movement of an object
- The speed of an object
- The direction of an object

Not all forces can be seen but the effects can be measured.

Forces can either be **contact forces**, where the force needs to be in contact with the object experiencing the force OR **non-contact forces** that will act on an object from a distance without touching it.

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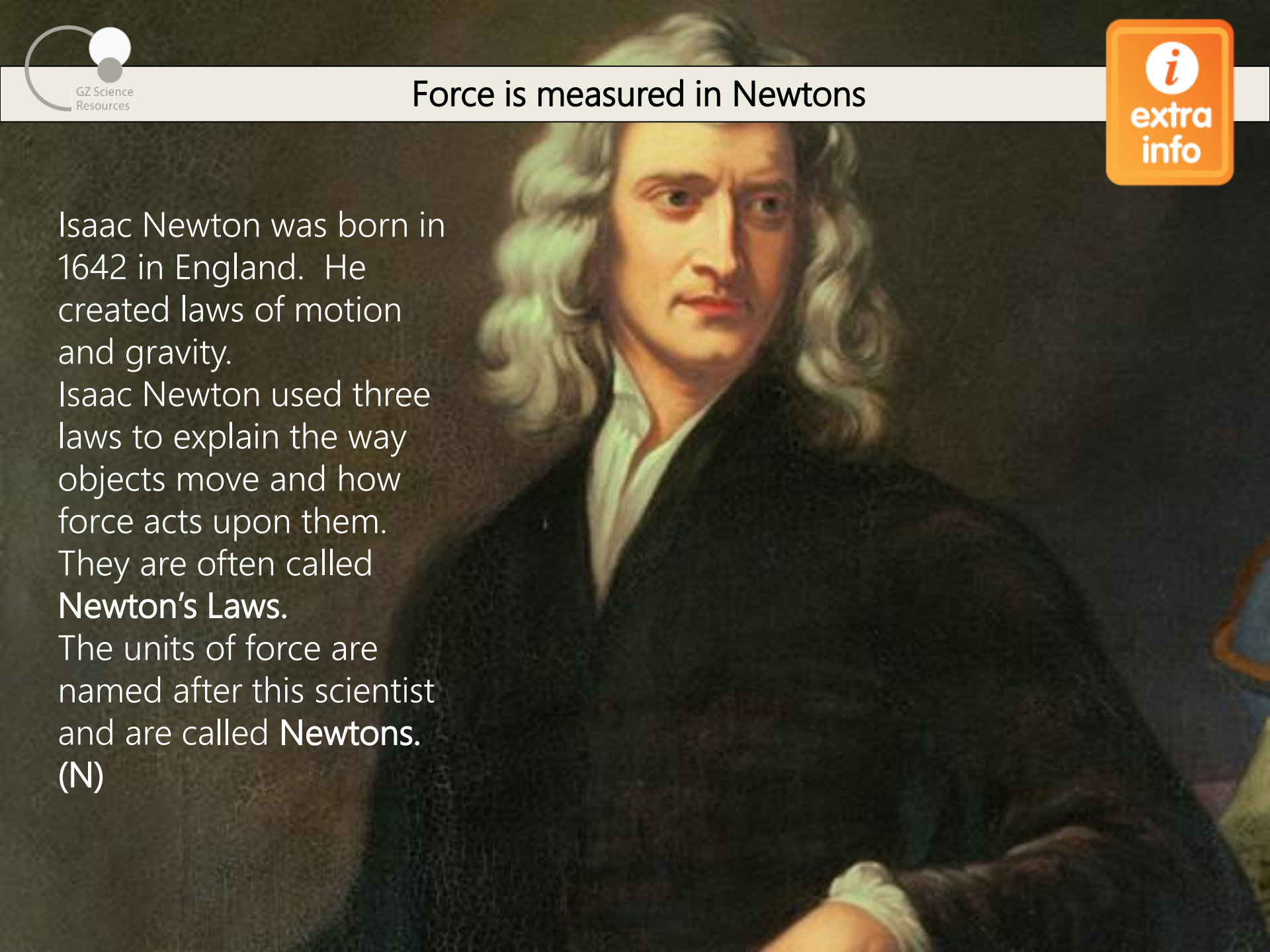
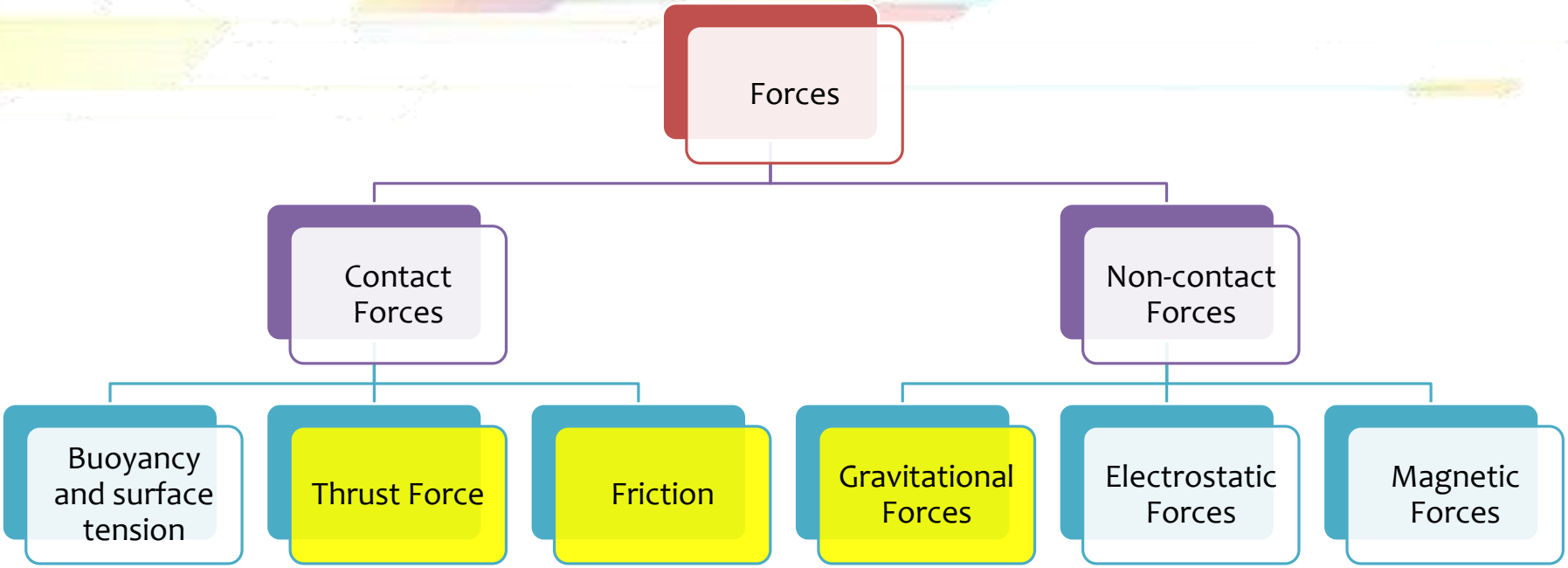
Force is measured in Newtons

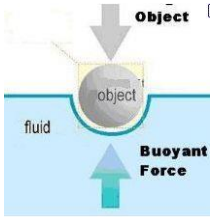
extra info

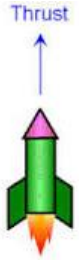
Isaac Newton was born in 1642 in England. He created laws of motion and gravity.
Isaac Newton used three laws to explain the way objects move and how force acts upon them. They are often called **Newton's Laws.**
The units of force are named after this scientist and are called **Newtons. (N)**

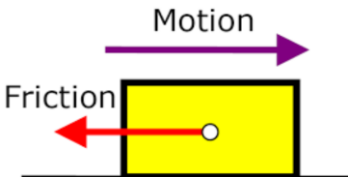


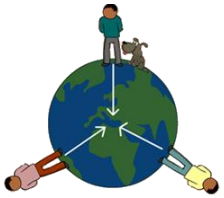
Contact and non-contact forces

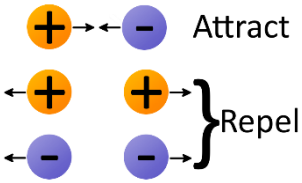


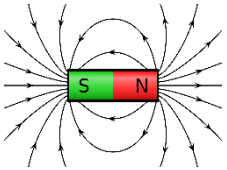












Pushes, pulls, friction and tension are **contact forces**. Whatever causes the force actually touches the object it acts upon.

Non-contact forces such as electrostatic forces, magnetic forces and gravitational forces act without contact between the object.

Comparing contact and non-contact forces

extra info

Similarities:

1. Both contact and non contact forces can be represented by direction and size (vectors)
2. Both involve attraction between the objects

Differences:

Contact Forces	Non contact Forces
•Force arises due to the contact between two different objects	•Force arises due to the attraction between two objects there is no contact between the objects
•This force takes immediate effect after the applied force	•There is a time lag between the applied force and the effect of this force
•There is no field associated with a contact force.	•There is always a field associated with a non-contact force

Units of Force, Motion and Energy in Science

Quantity	What is it measured in?	Symbol	Equipment used
Force (including weight)	Newton's	N	Spring balance
Mass	kilograms	kg	scales
Velocity / speed	metres per second	ms^{-1}	Ticker timer
Acceleration (including gravitational acceleration)	metres per second per second	ms^{-2}	Ticker timer
Energy (including Work)	Joules	J	

Background Knowledge

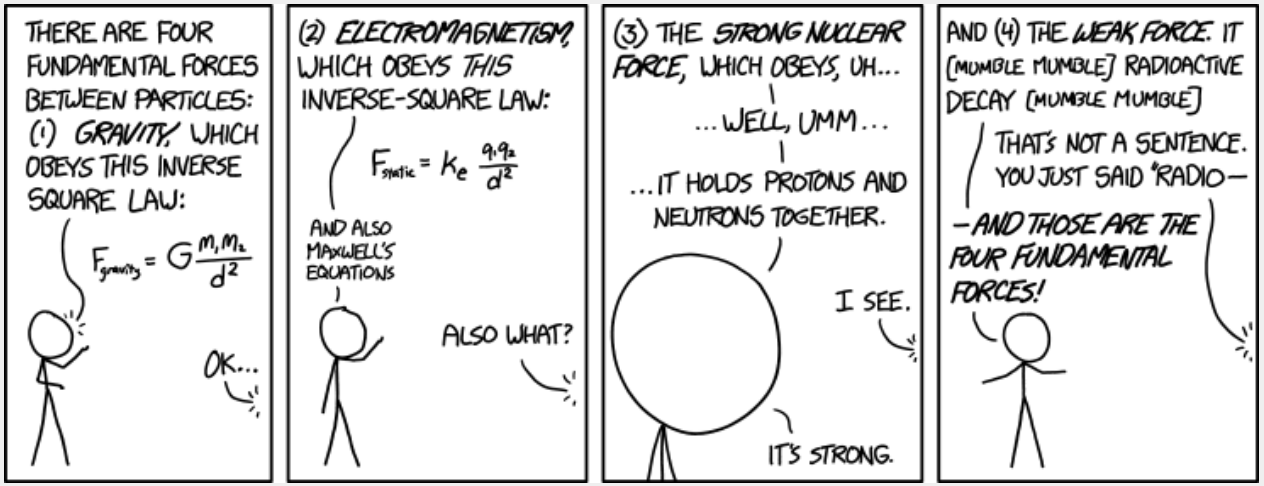
Four Fundamental Forces

extra info

Non-Contact Forces can often be classified into **four Fundamental forces.** These act over a distance between particles of matter.

- The particles need not be in contact.
- Force is affected by the distance between

1. **Electromagnetic forces** – only forces that both attract and repel.
2. **Strong nuclear forces** - holds neutrons and protons together
3. **Weak nuclear forces** – attractive force between particles in nucleus
4. **Gravitational forces** – attractive force between any two objects



Gravity is a force which acts between bodies even though they are not in contact

GRAVITATIONAL FORCE

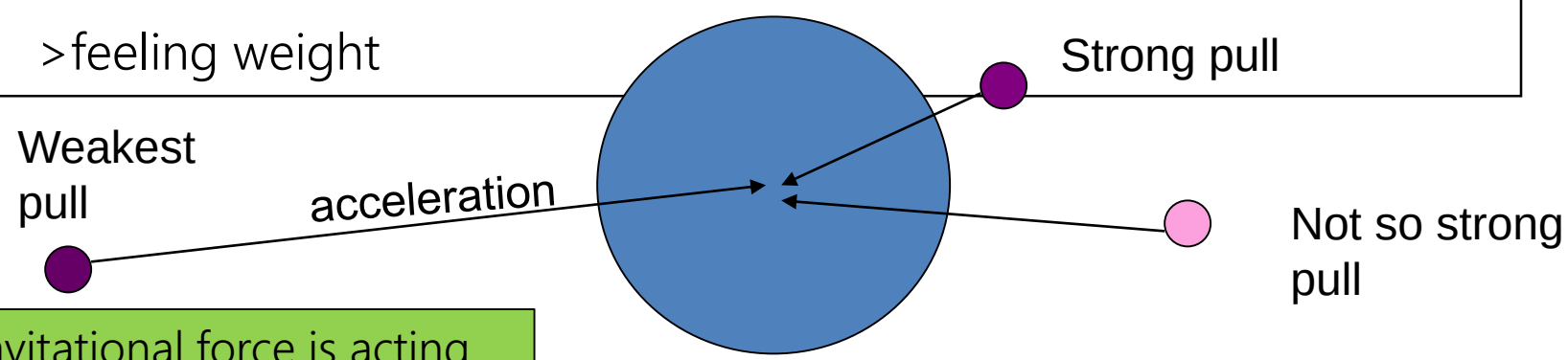
Objects create a gravitational field around them. Gravity gives objects of mass in the field a weight force.

- the bigger the object; the stronger the field
- the further away from the object, the less gravitational pull

Any other object within the field is pulled to the center of the mass:

> accelerating

> feeling weight



When gravitational force is acting on an object then we can say the object has weight force

Background Knowledge

The Earth is the source of a gravitational field

Isaac Newton was also famous for his work on gravity. His law of **universal gravitation** states that objects with mass attract each other with a force that varies directly as the product of their masses and decreases as the distance between them increases.
This gravitation force causes objects to accelerate towards the centre of the Earth (remember F = m x a). Once they reach solid ground the **support force** prevents them falling any further. Because we also have mass the Earth feels a gravitational attraction and accelerates towards us but our mass is so tiny compared to the Earth and the effect is not noticed.

GRAVITATIONAL FORCE

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Thrust force

THRUST FORCE

Thrust (or applied force) requires some parts of an object (whether gas, liquid or solid) being pushed forcefully from itself (rocket fuel from a rocket, for example). Once the rocket has left, the "thrust" is no longer present. It also requires reaction (actual touching) of the thrust medium against the object.

Acceleration is the state of an object, due to a force applied. It is dependent on the force, and on the mass of an object, but is not a force itself.

Friction force opposes an object that is experiencing thrust force.

Thrust and friction are “paired forces” that act in opposite directions on an object.

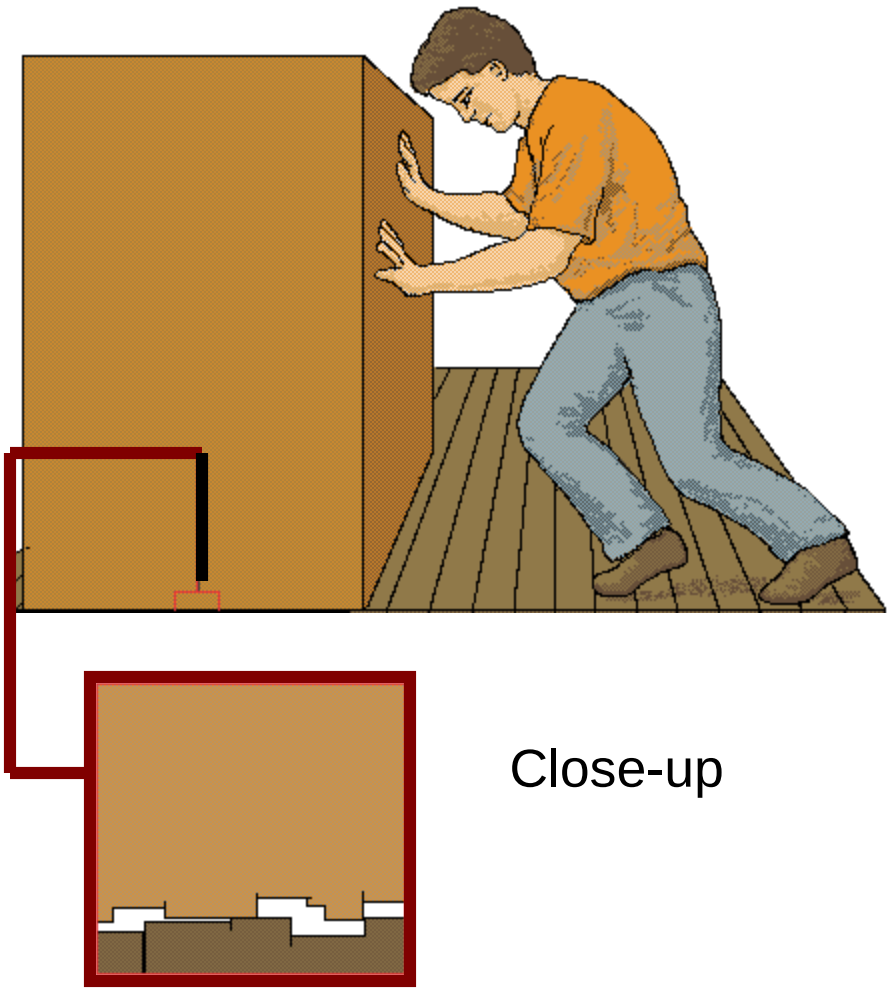
Friction often provides opposing force acting on moving bodies

FRICTION

Friction is a force that opposes motion. If an object has no motion then there is no friction.

When friction occurs, and one surface moves against another, the movement causes Kinetic energy to be changed into heat energy. Smooth surfaces create less friction than rough surfaces. Friction that occurs between air or water and a solid body is called resistance.

If friction and thrust forces are **equal and opposite** then they are said to be **balanced.**

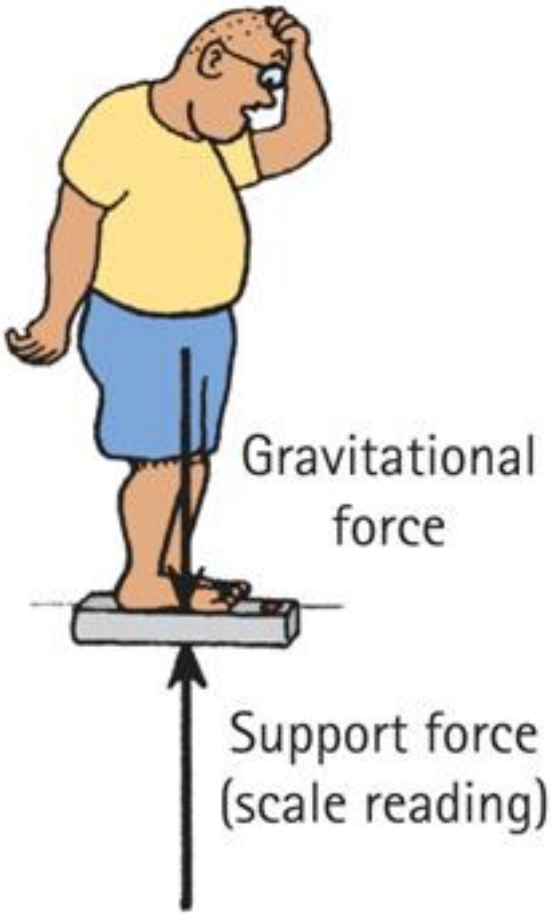


Support forces

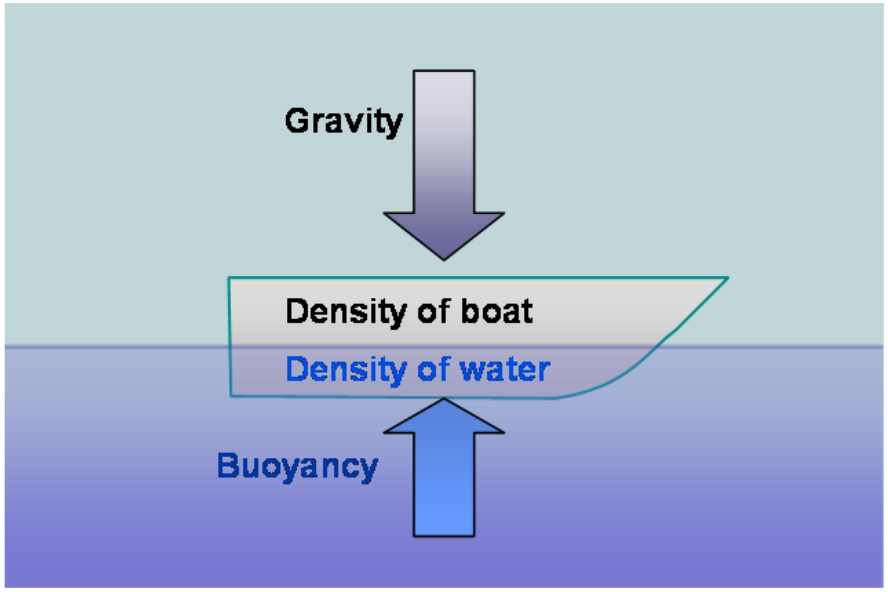
SUPPORT FORCE

Support forces are equal and opposite to an object experiencing weight if the forces are balanced.

Support force in air is called lift and in water is called buoyancy.



Buoyancy is an upward support force caused by a fluid that opposes the weight (gravitational force) of an object in the fluid, usually water. Once the object remains at a set depth then the support force and weight force are balanced.



Sometimes friction is useful, at other times it is unhelpful.

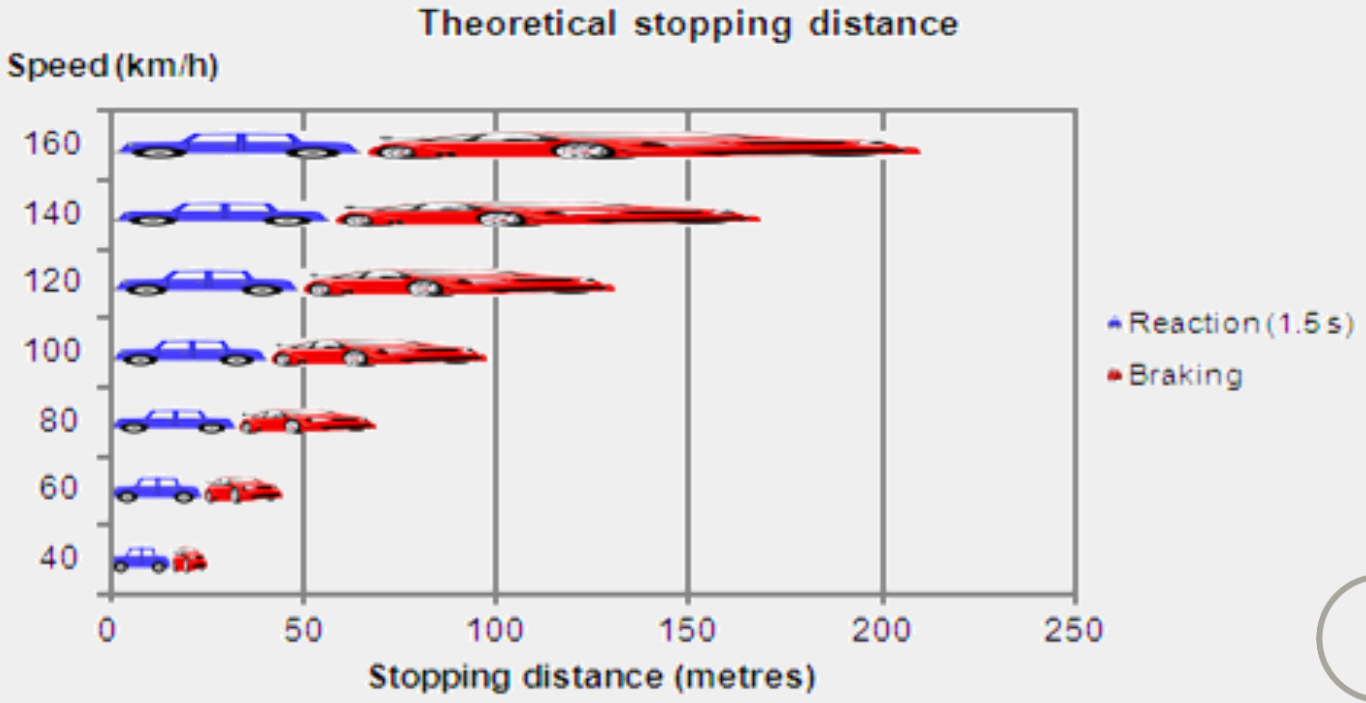
Situations where Friction is useful	
situation	Increased by
walking	Having grip on the soles of your shoes
cycling	Wider tyres with tread
driving	Good tread on tyres. Brake pads

Situations where Friction is unhelpful	
situation	decreased by
Friction in bearings	Oil around bearings
Drag on car	Aerodynamic design to reduce drag
Drag on snowboard	Smooth lacquered surface

Background Knowledge

Case Study: Stopping distance

The **Stopping distance** of a vehicle is the total distance travelled from the time the driver registers they have to stop to the actual stopping point. The reaction time (1.5seconds) is the average time a driver takes to apply the brakes. The main factor affecting the stopping distance is the speed the vehicle is travelling at before the brakes are applied.



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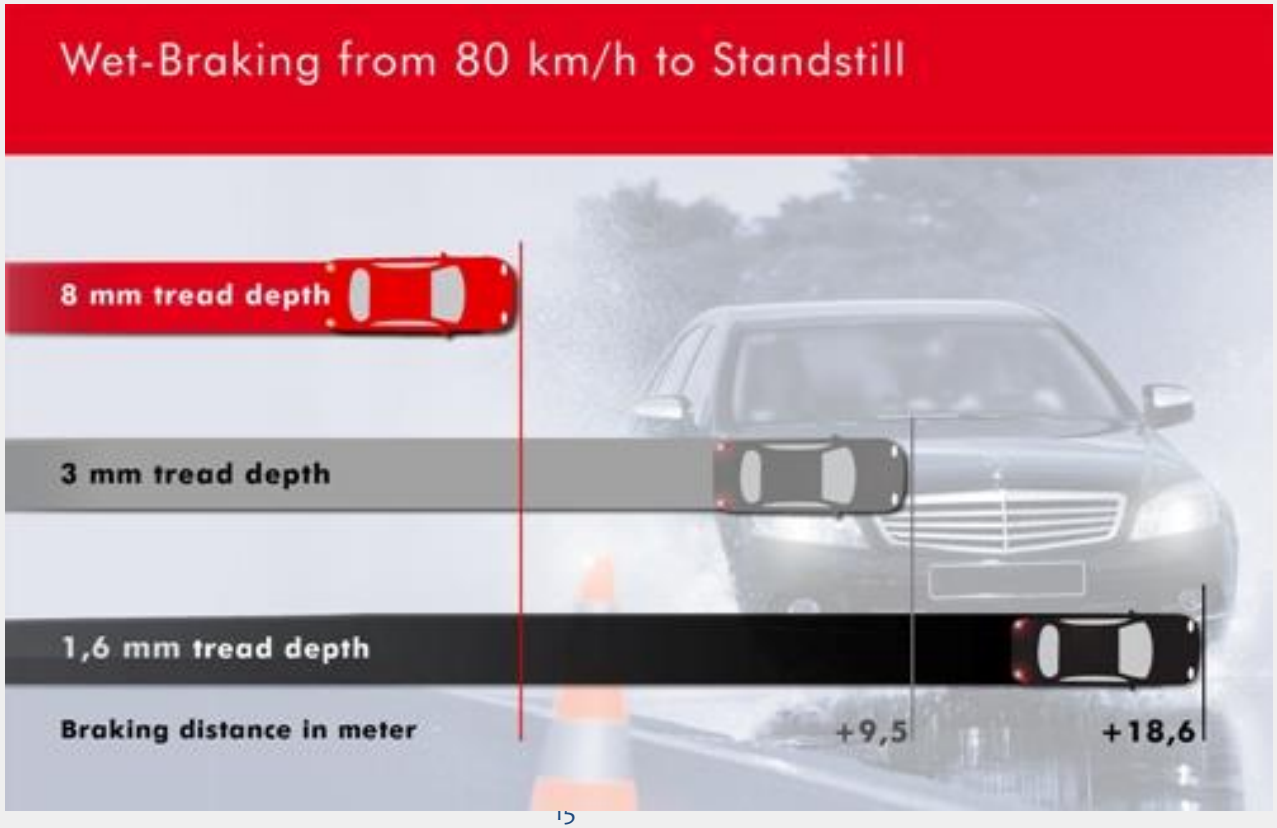
Background Knowledge

Factors effecting stopping distance

Other factors that increase stopping distance include a wet road, low tread on a tyre and worn brakes. These factors **decrease friction** and therefore the kinetic energy of the car (making it move) is transformed into heat energy at a **slower rate.**



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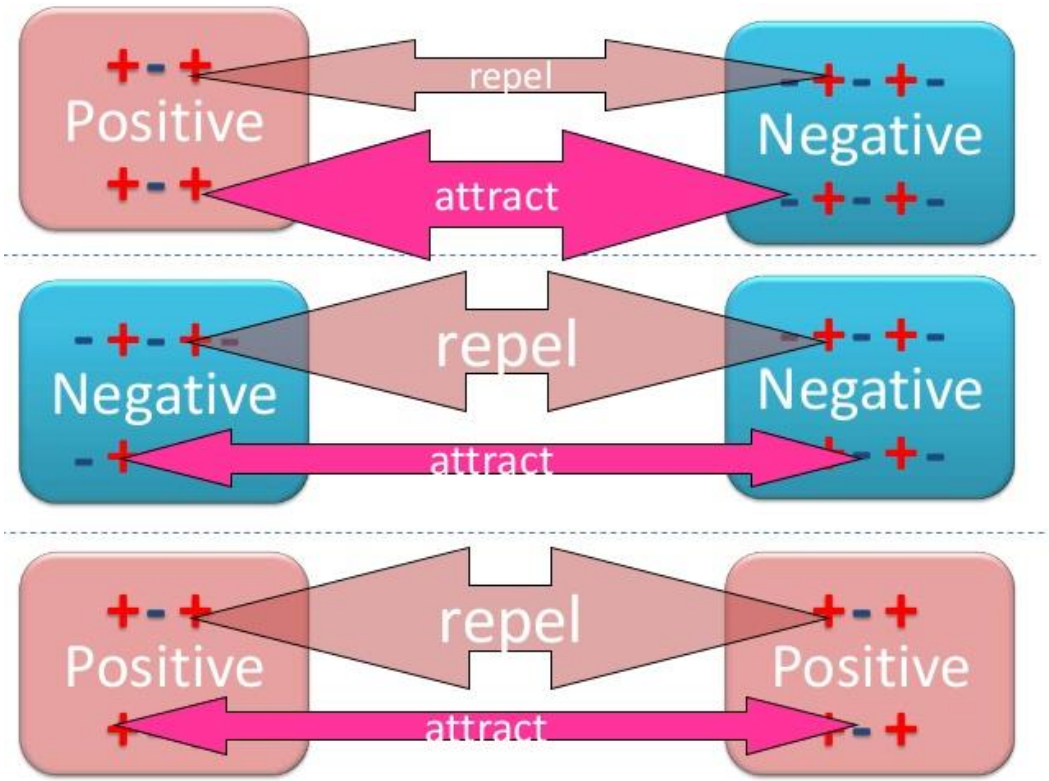
Electrostatic forces can act on non-moving charged particles

ELECTROSTATIC FORCE

Although moving charges create electromagnetic force, non-moving charges create electrostatic force (static means non-moving). Commonly we see this as static electricity in situations such as lightning. It is also the force that bonds ions together to form molecules and some molecules together to form substances.

Electrostatic forces cause like charges (+ and + or – and -) to repel and unlike charges (+ and -) to attract.



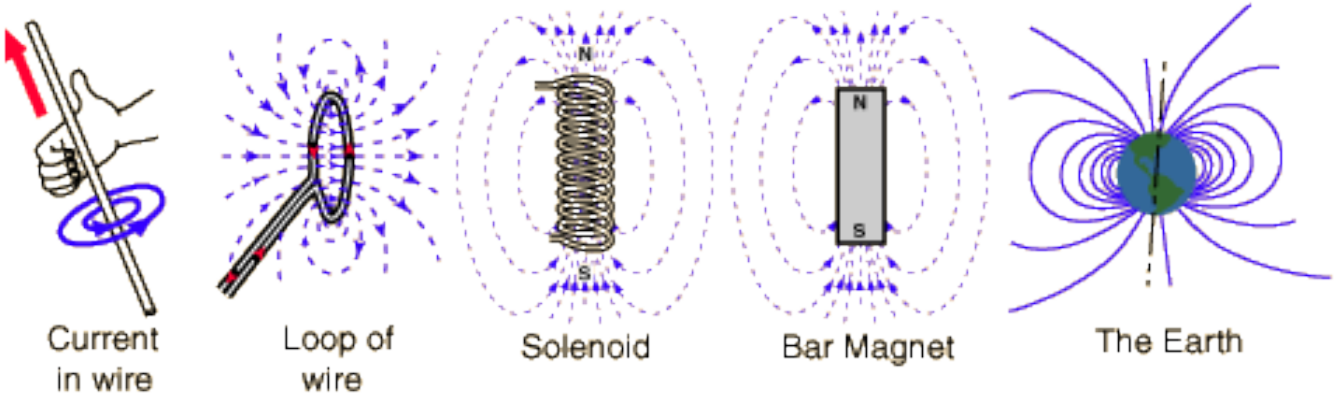
extra info

Magnetic forces can act on magnetic objects

MAGNETIC FORCE

Magnetic force is the force that exists between two magnets, caused by the interaction of their magnetic fields. This force causes the magnets to attract or repel one another. Magnets can be made out of materials such as iron, cobalt, or nickel.
Magnetic fields affect neighbouring objects along things called magnetic field lines. Magnetic poles are the points where the magnetic field lines begin and end. Field lines come together at the poles. We call those poles north and south because that's where they're located on Earth. All magnetic objects have field lines and poles.

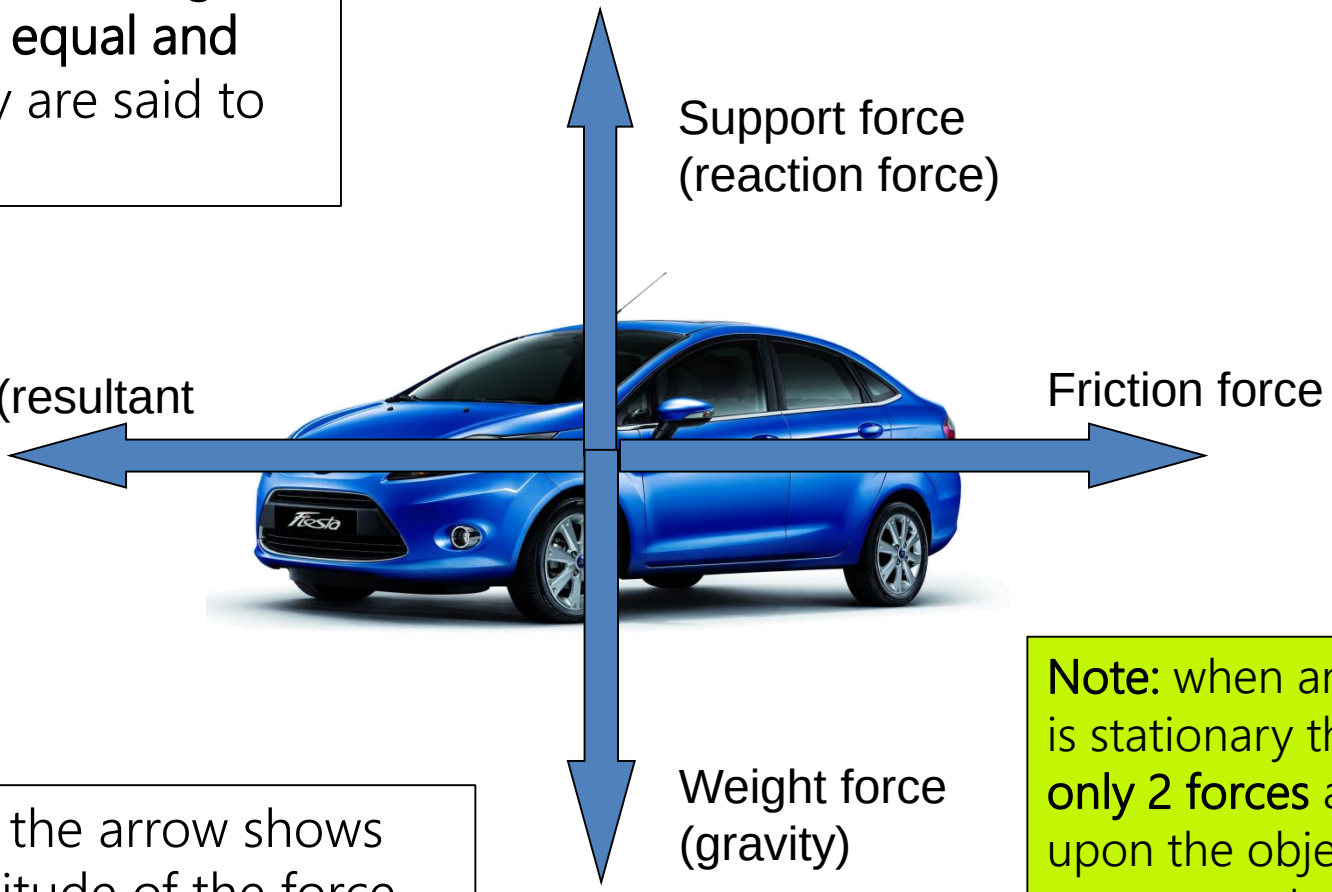
Magnetic fields are can also be produced by **moving charges** (current). And moving charges are affected by magnets. This is called an **electromagnetic** force.



Magnetic Field Sources

Balanced forces

If pairs of forces acting on an object are **equal and opposite** they are said to be **balanced**.



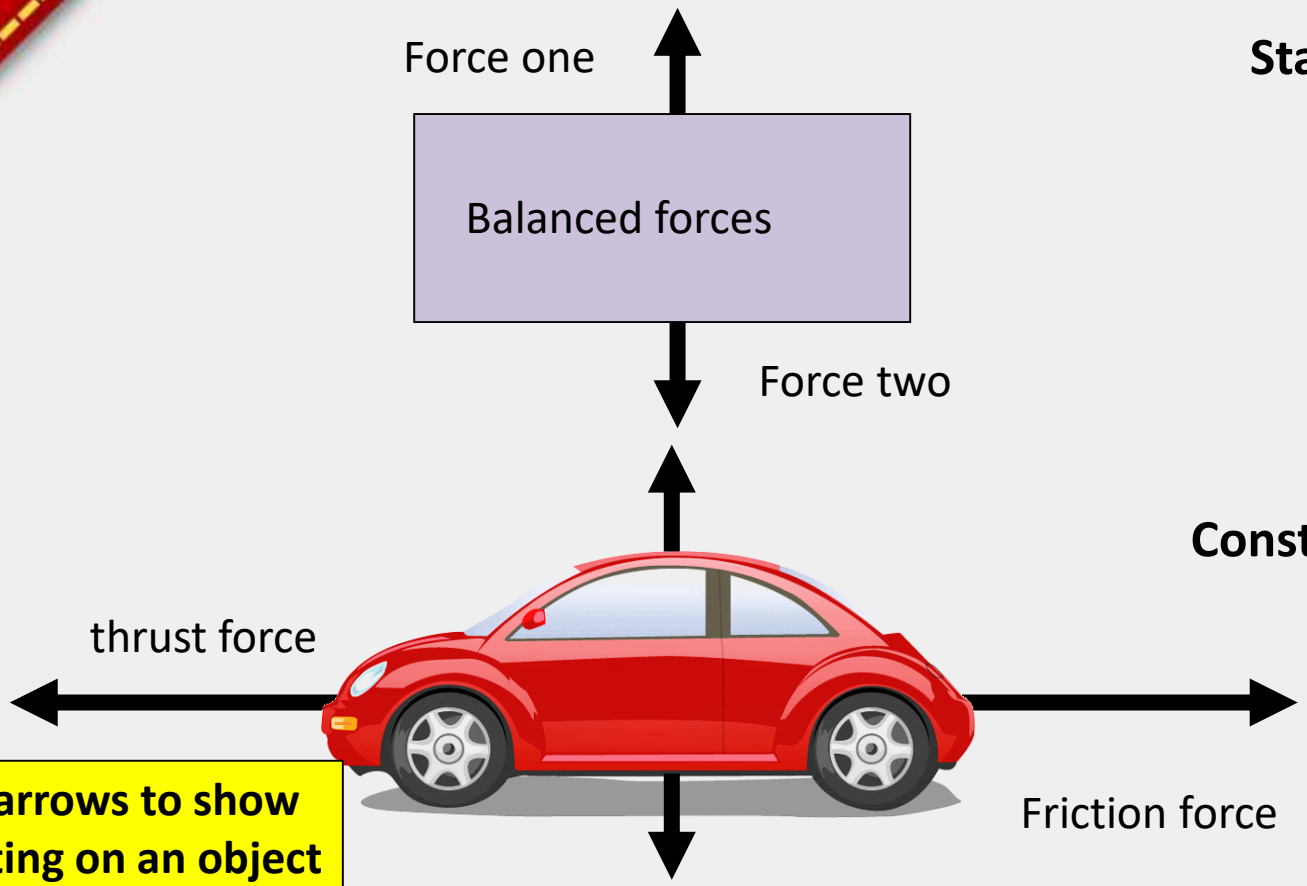
The length of the arrow shows relative magnitude of the force. The arrows must start from the middle of the object.

Note: when an object is stationary there are **only 2 forces** acting upon the object; support and weight force. There is no thrust or friction force

Background Knowledge

Newton's Laws – 1st law

If the forces acting on an object are balanced, then the object will remain stationary or carry on at the same speed in the same direction.



Stationary

Constant speed

We use arrows to show forces acting on an object

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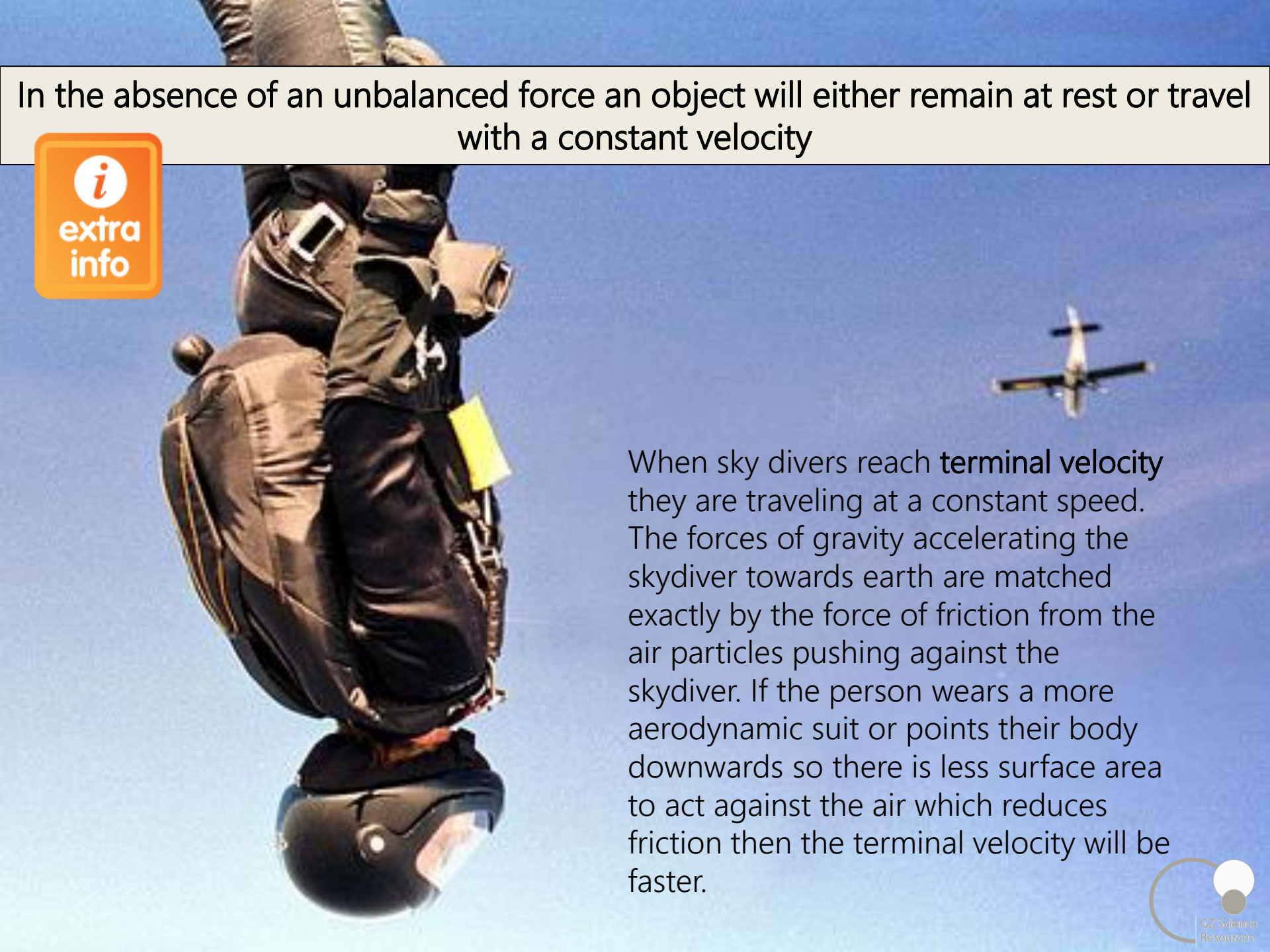
In the absence of an unbalanced force an object will either remain at rest or travel with a constant velocity

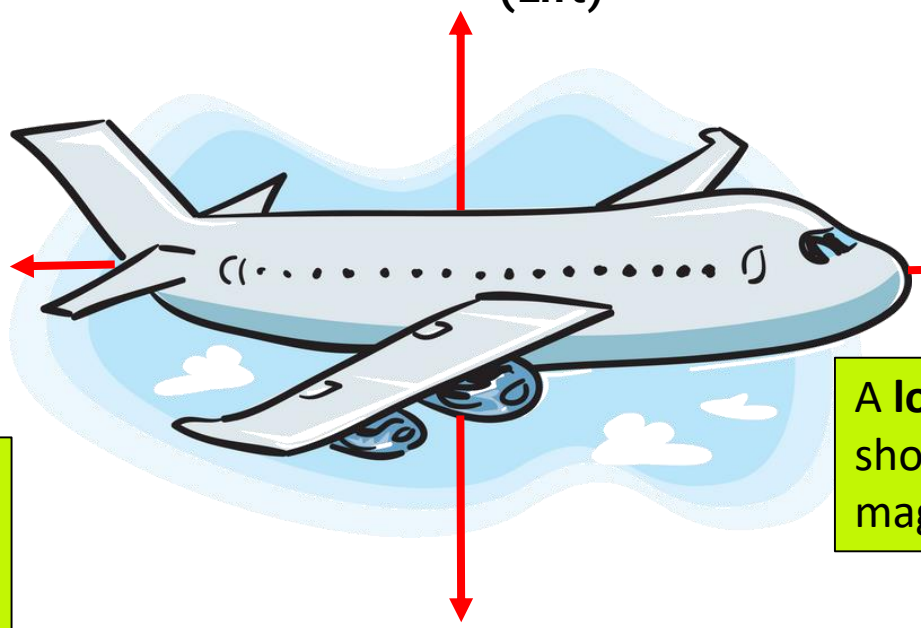
extra info



When sky divers reach **terminal velocity** they are traveling at a constant speed. The forces of gravity accelerating the skydiver towards earth are matched exactly by the force of friction from the air particles pushing against the skydiver. If the person wears a more aerodynamic suit or points their body downwards so there is less surface area to act against the air which reduces friction then the terminal velocity will be faster.

Unbalanced forces change motion

Balanced forces cause no change in speed or direction, since they exert equal, but opposite, push/pull effects on an object. However, **Unbalanced forces** can change the speed and/or direction of an object. Unbalanced forces occur when **opposite forces** are of a **different magnitude** (size)



A **longer force arrow** shows a greater magnitude of force

Note: in air the type of support force is called **lift** and in water the support force is called **buoyancy**

Background Knowledge

Newton's Laws – 2nd Law

<u>Second Law</u>

If unbalanced forces act on an object, then the object will accelerate in the direction that the net force acts.
More than one force can act on the object in the same direction, so these forces are added.

Un-Balanced forces

Unbalanced forces will show arrows of different length

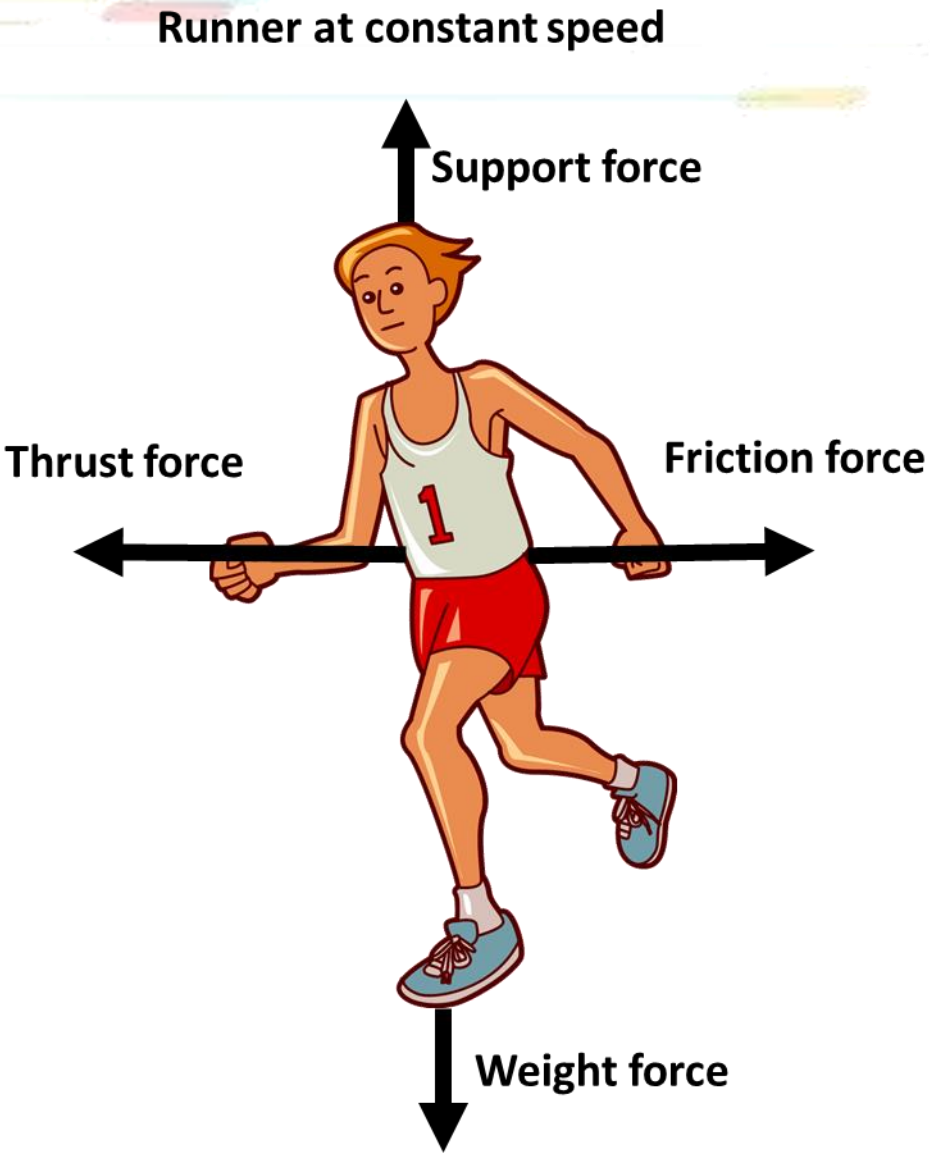
Direction of acceleration

Rules of Force Diagrams

We use force diagrams to show the direction and magnitude (size) of a force.

Force diagrams have rules:

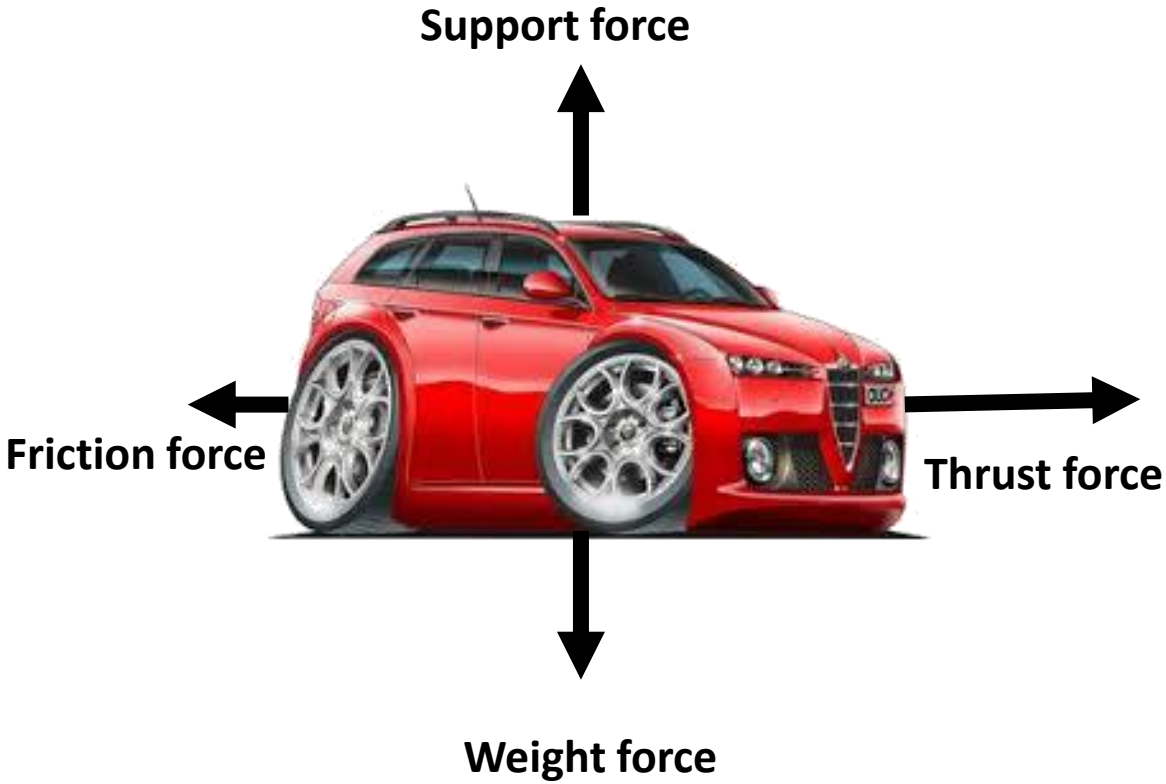
- The arrows showing a force must start (preferably) from the centre of an object, but at least touching it.
- Pairs of forces, such as support and weight, must be directly opposite each other
- Arrows must be pointing out.
- The length of an arrow indicates magnitude of a force. More force=longer arrow
- Pairs of balanced forces have equal length arrows.
- Pairs of unbalanced forces have different length arrows



Unbalanced Force Diagrams

Falling cat

Accelerating car



Net Force

A net force is the resultant force when multiple forces interact. When forces are balanced on an object, the net force is **zero.** If there is zero net force, the object maintains **constant speed or is stationary.**

An object experiencing **unbalanced force** will have a net force greater or less than zero and will **accelerate** in the direction of the largest force.

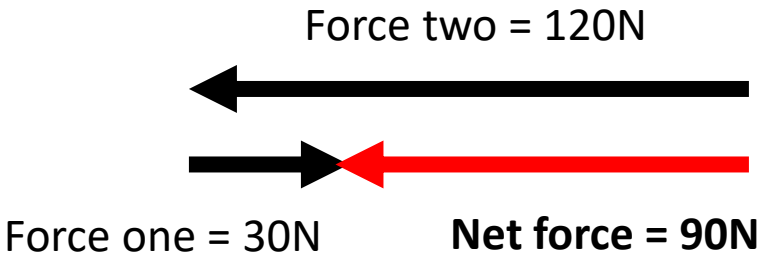
If the net force is pointing in the same direction as the direction of motion, the object accelerates. If the net force is pointing in the opposite direction to the direction of motion, the object decelerates.

Calculating Net Force

The net force can be **calculated** by subtracting the smaller force from the larger force. If the forces are pointing in the **same direction**, the **forces add**, giving a larger net force. If the forces are in **opposite direction**, the **forces subtract**, giving a smaller net force (including a zero net force).

Net force = 120N – 30N = 90N accelerating the object from right to left (forward)

Note: if there are two or more forces acting in the same direction then they are added



Force, mass and acceleration

The Force experienced by an object can be calculated by multiplying the mass of the object by its acceleration.

Force = Mass x Acceleration

If more force is applied to an object then it will accelerate faster

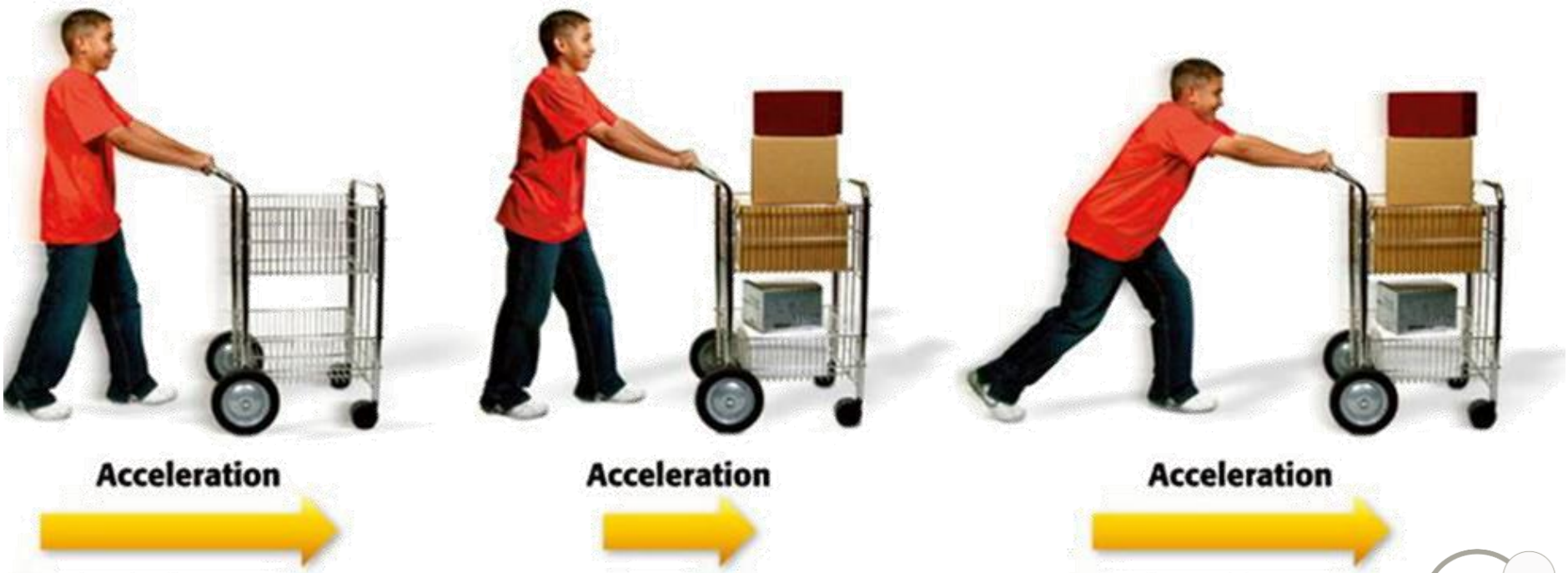
$$F=ma$$

a = acceleration (ms^{-2})
F= force (N)
m = mass (kg)

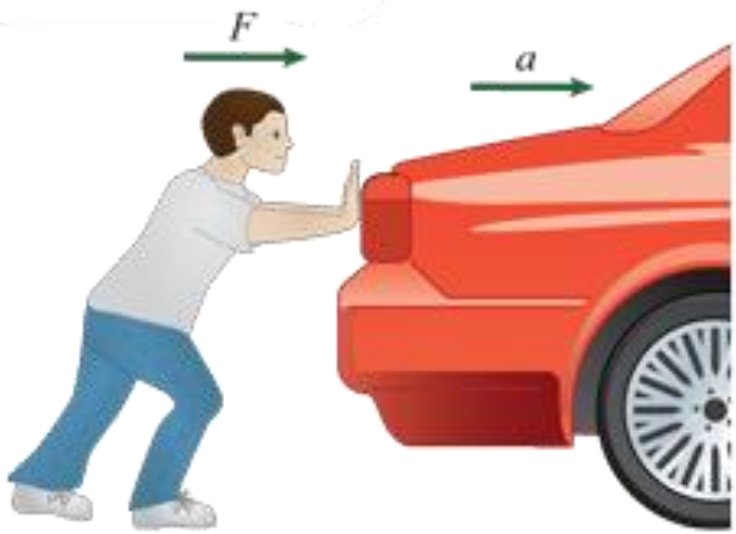
Acceleration of a body depends both on its mass and on the size of the unbalanced force acting on it

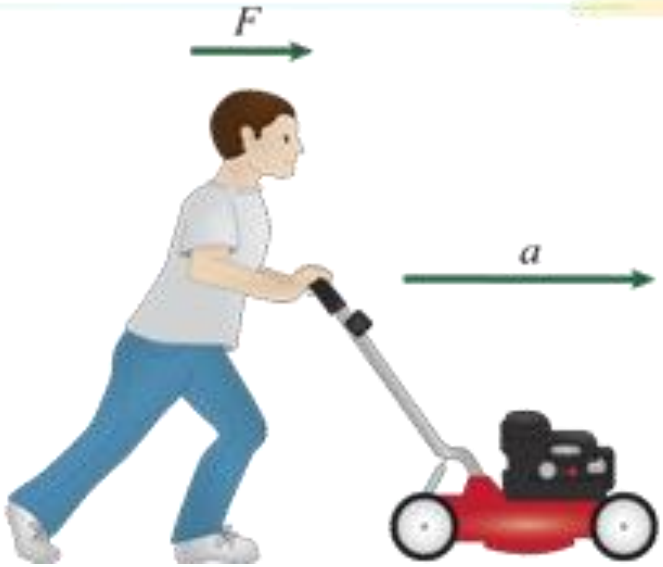
Force = Mass x Acceleration

If the same amount of force is applied to two similar objects that have different mass, then then smaller object will accelerate faster.



F = ma calculations





$$F=ma$$

a = acceleration (ms^{-2})
F = force (N)
m = mass (kg)

Ben is able to push both the car and the lawn mower so they accelerate at $0.5ms^{-2}$. The mass of the car is 950kg and the mass of the lawn mower is 10kg. What is the force required to accelerate the car compared to the lawn mower?

Car

F=ma
F=950kg x $0.5ms^{-2}$
F= 475N

lawn mower

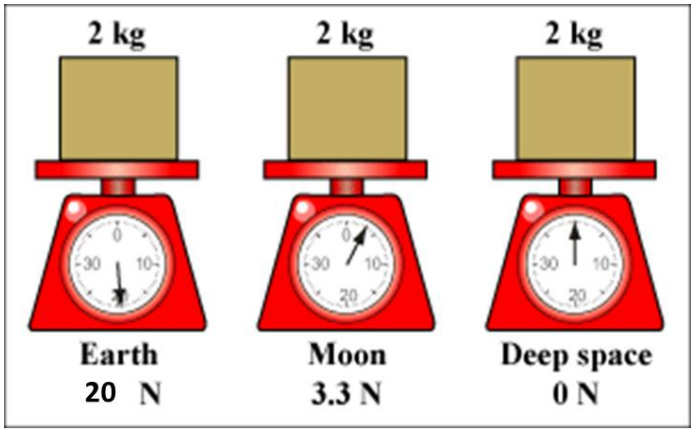
F=ma
F=10kg x $0.5ms^{-2}$
F= 5N

Mass and Weight

All objects have **Mass**. Mass refers to the amount of atoms, or substance, in an object. The formula symbol for mass is **m**.

Mass is measured in kilograms (kg). 1kg = 1000g

The mass of the object remains the **same** regardless of its **location**.



Weight is the downward force due to gravity that an object experiences due to its mass. The weight of an object depends on its location and the **gravity** pulling down on it. The weight of an object can change depending on where it is located. Astronauts weigh less on the moon because the force of gravity is less, but their mass is the same in both locations. The formula symbol for weight is F_w (weight force). Weight is measured in **Newtons** (N)

Converting mass to weight

$$F_w = mg$$

This is still the **F = ma** formula

g = acceleration due to gravity = ($10ms^{-2}$)

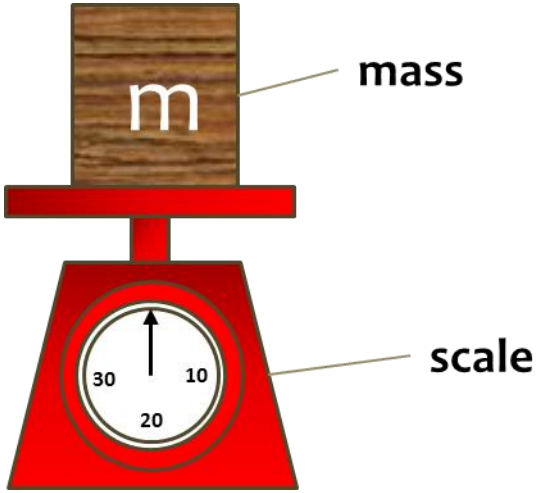
Fw= Weight force (N)

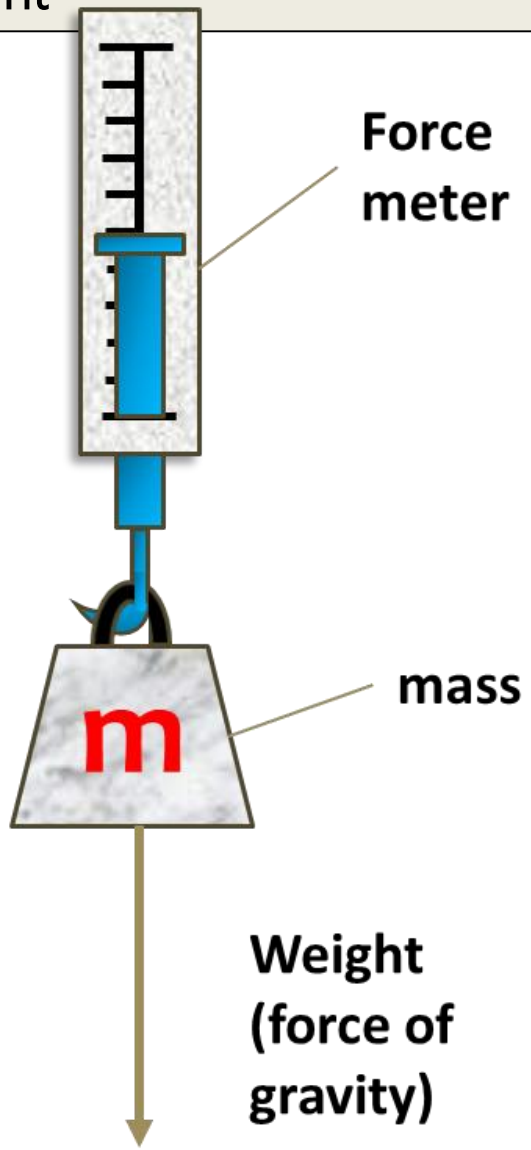
m = mass (kg)

Measuring Mass and weight

Weight can be measured with a spring balance, where the mass can vertically hang and the weight can be read off the force meter. The scale will be in Newtons (N).
A 2kg mass would read as ($2 \times 10ms^{-2}$) **20N**

Mass can be measured with scales, where the mass can sit on top and the mass can be read off the meter. The scale will be in kilograms kg (or grams)



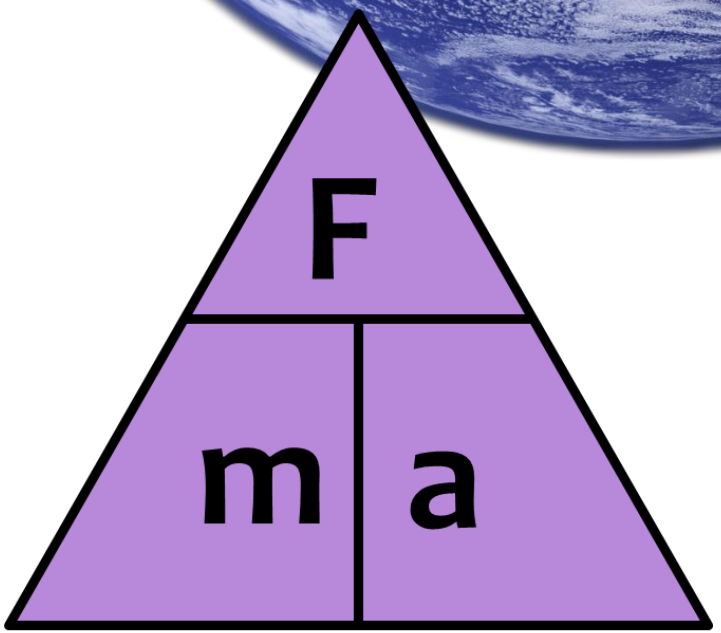


The Earth is the source of a gravitational field

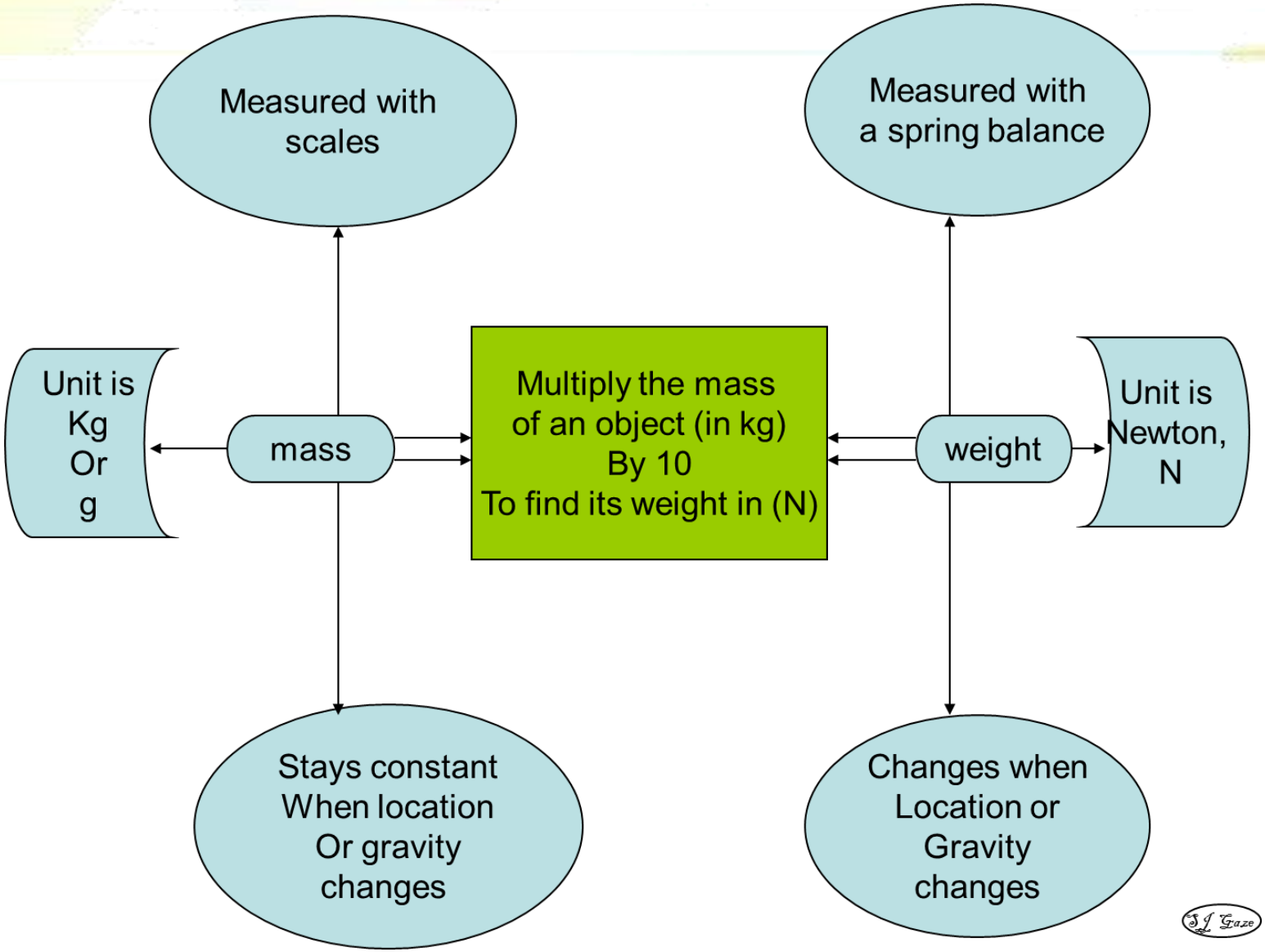
The mass of the Earth creates an acceleration of 10 ms^{-2} for objects falling towards it. Regardless of the size of the object, they all fall with the same acceleration - only the shape, which causes changes in air resistance, causes some objects to experience more opposing force and accelerate slower.

To calculate our weight, which is a force on an object in a gravitational field, we multiply our mass by the gravitational acceleration of Earth On Earth, due to the size and mass of the planet, we experience a gravitational pull of **10ms^{-2}**

This means if we were to freefall to Earth, every second we would accelerate 10m more per second – 1 second fall 10m, the next second fall 20m, the next second fall 30m etc.



Mass and weight



Mass and Weight

Question 2a(i) : The kererū (also known as New Zealand wood pigeon or kūkupa) is one of the largest pigeons in the world.
Explain the difference between mass and weight. Calculate the weight of a kererū that has a mass of 630 g.

Converting mass to weight

$F_w = mg$

This is still the **F = ma** formula

g = acceleration due to gravity = ($10 ms^{-2}$)
Fw= Weight force (N)
m = mass (kg)

How do we answer this question?
Weight is the downward force due to gravity that an object experiences due to its mass, while mass is a measure of the amount of matter that an object has.

Define and Compare Mass with Weight

Mass does not change when location changes while weight does; (explaining) this can be given as an example of a person on the earth or on the moon.

Explain Mass does not change but weight can

Mass is measured in kg while weight is a force measured in N

$$F_w = m \times g$$
$$= 0.630 \times 10$$
$$= 6.30 \text{ N}$$

Show working and remember units

Mass and Weight - Calculations

Q1: A box in a warehouse has a mass of 2 500 kg. assuming $g=10ms^{-2}$
(a) Explain the difference between weight and mass.
(b) Calculate the weight of the box.

Weight is the downward force due to gravity that an object experiences, while mass is a measure of the amount of matter that an object has.

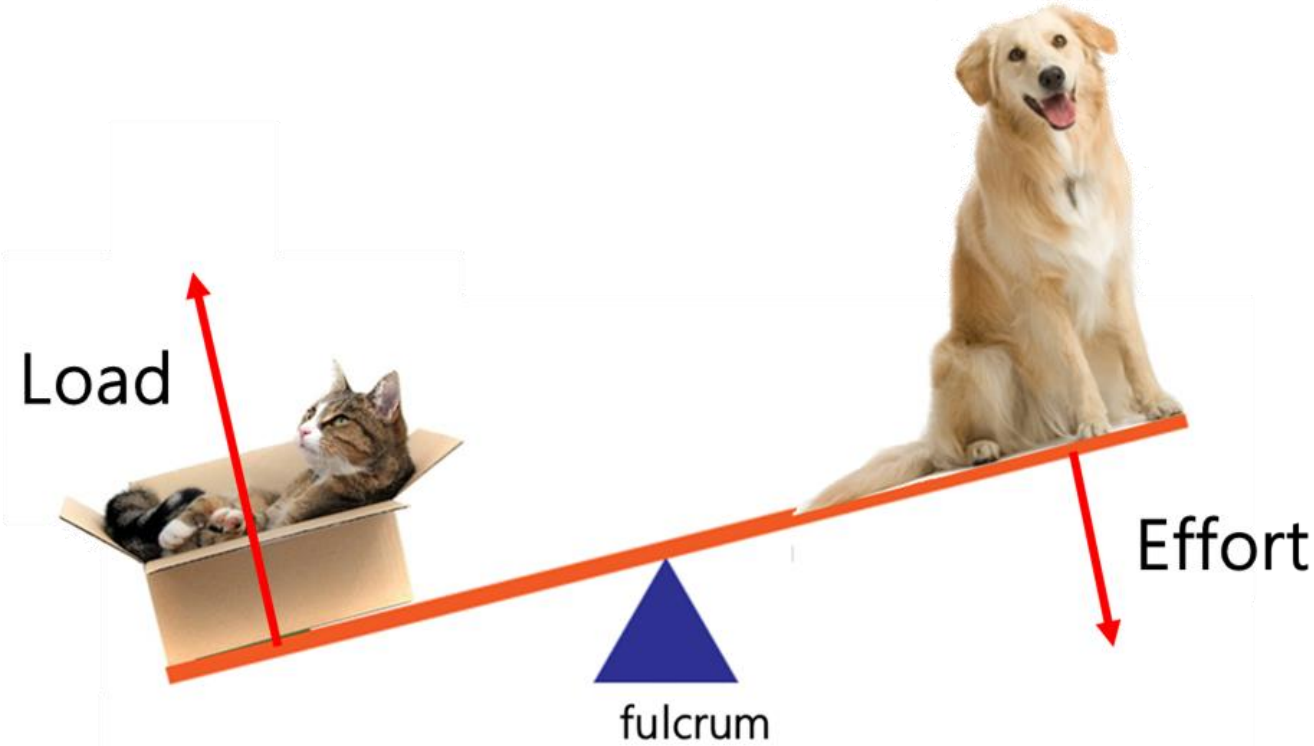
$$F_{\text{weight/gravity}} = mg$$

$$= 2\,500 \times 10 = 25\,000 \text{ N}$$

Simple machines (Levers)

Simple machines can change the direction or size of a force by using 'mechanical advantage' to multiply force.
A lever is balanced on a fulcrum, which allows it to pivot. A load is lifted by placing effort on another part of the lever.

A lever involves moving a **load** around a pivot using effort (or a **force)**.
Examples of tools that are classified as levers include **scissors**, pliers, hammer claws and tongs.

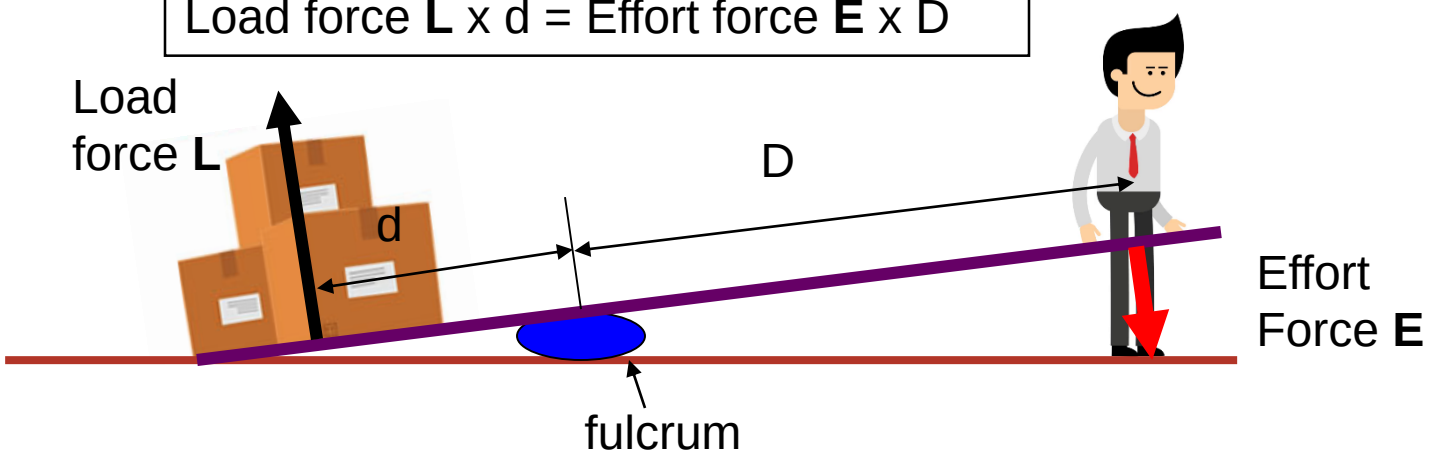


Levers are a simple machine that increase force

For a tool to be classed as a lever there must be:

- a rigid handle
- a fulcrum (or pivot) around which the handle rotates
- a force increase – caused by the distance from the effort force to the fulcrum being larger than the load force to the fulcrum

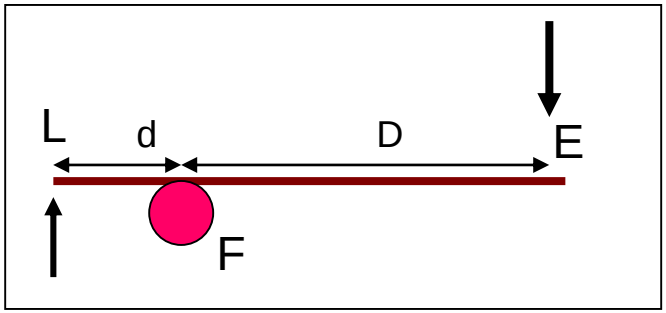
Load force **L** x d = Effort force **E** x D



Levers are a simple machine that increase force

Levers are classified in classes depending on the position of the effort and load in relation to the fulcrum.

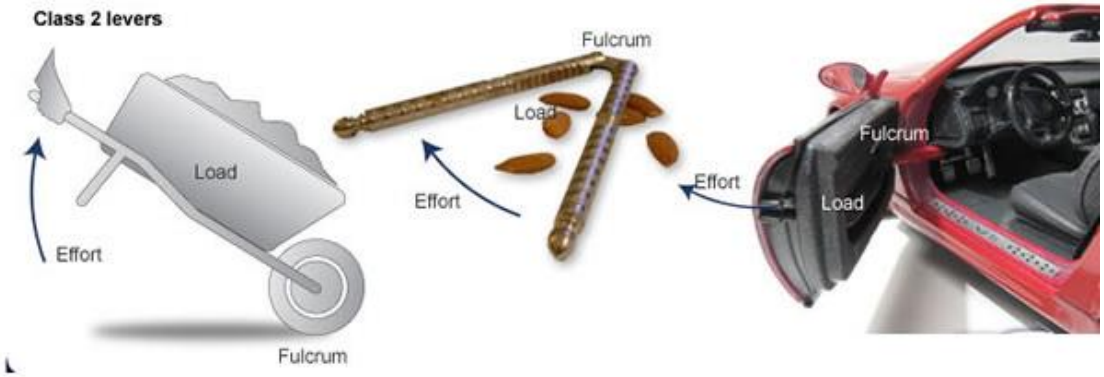
Seesaw type Lever (Class 1)	
Definition	A lever where the load force acts on the **opposite** side of the fulcrum to the effort force
Examples	❑ Crowbar ❑ Hammer ❑ Tyre iron

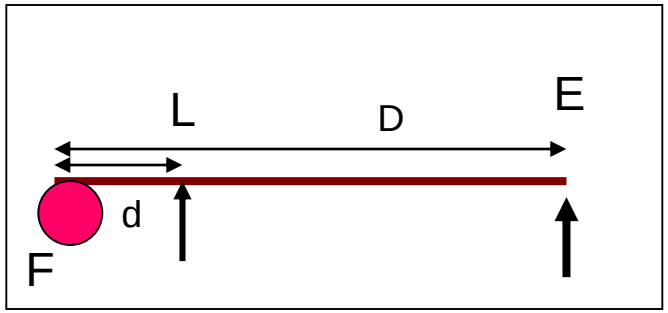


Levers are a simple machine that increase force

Levers are classified in classes depending on the position of the effort and load in relation to the fulcrum.

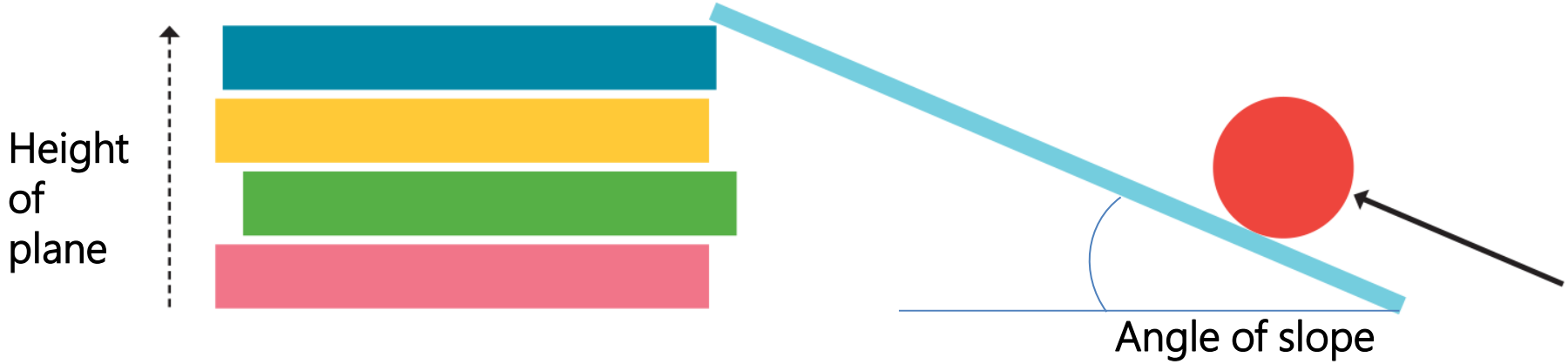
Wheelbarrow type lever (class 2)	
Definition	A lever where the load force acts on the **same** side of the fulcrum as the effort force
Examples	❑ Wheelbarrow ❑ Spanner ❑ Ratchet/tiedown





Inclined Planes

An inclined plane is a simple machine and it can be used to reduce the effort required to move a load. If the slope has a small angle, then a person has to push or pull the object over a longer distance to reach a height, but with very little effort. If the slope is steep, with a greater angle, a person has to push or pull the object over a very short distance to reach the same height, but with more effort. Mechanical advantage is calculated by length of slope divided by height of the slope. There is a greater mechanical advantage if the slope is gentle because then less force will be needed to move an object up (or down) the slope.



The different types of motion

Objects that move from one point of space to another over time are said to have **motion**. Examples include a tortoise slowly moving across the ground or a bullet moving fast after it has been fired from a gun. Objects that remain at the same point of space over a period of time are called **stationary**. Examples include a person sitting still on a chair or a parked car.

Measuring Motion in Science

Quantity	Unit	Symbol	Equipment used
Distance	Kilometre	km	odometer
	Metre	m	Metre ruler
	millimetre	mm	Hand ruler
Time	Hour	hr	clock
	minute	min	watch
	second	s	Stop watch

Converting measurements

Quantities are often measured in different **scales** depending upon what is most appropriate for the original size. In Science (and Mathematics) we use common **prefixes** to indicate the scale used.
We sometimes want to convert scales from one to another to compare data or to place the measurements into equations.

Prefix		Scale
Kilo	=	1000
Centi	=	$1/100^{th}$
Milli	=	$1/1000^{th}$

So 1 kilometre = 1000 metres
1 metre contains 100 centimetres
1 metre contains 1000 millimetres

To convert from metres to kilometres **divide** by 1000

To convert from kilometres to metres **multiply** by 1000

Time is measured in "imperial units" 1 hour has 60 minutes and 1 minute has 60 seconds **therefore** 1 hour has 3600 seconds

NOTE:
m/s to km/h multipy by 3.6
km/h to m/s divide by 3.6

Background Knowledge

GZ Science Resources

Errors may occur in measurements may be reduced by taking the average of a number of readings

When collecting and measuring data in investigations, such as that for calculating speed, errors can occur. This may be due to the measuring instrument and the way it is used. Data can also be recorded incorrectly.

Repeating the investigation a number of times and averaging out the measurements can help reduce random errors. This value is called the **mean**.

The mean is the most common measure of average.

To calculate the mean add the numbers together and divide the total by the amount of numbers:

Mean = sum of numbers ÷ amount of numbers

Distance walked in 1 minute

	Trial 1	Trial 2	Trial 3
Distance (m)	113	121	119

Mean = (113 + 121 + 119) ÷ 3

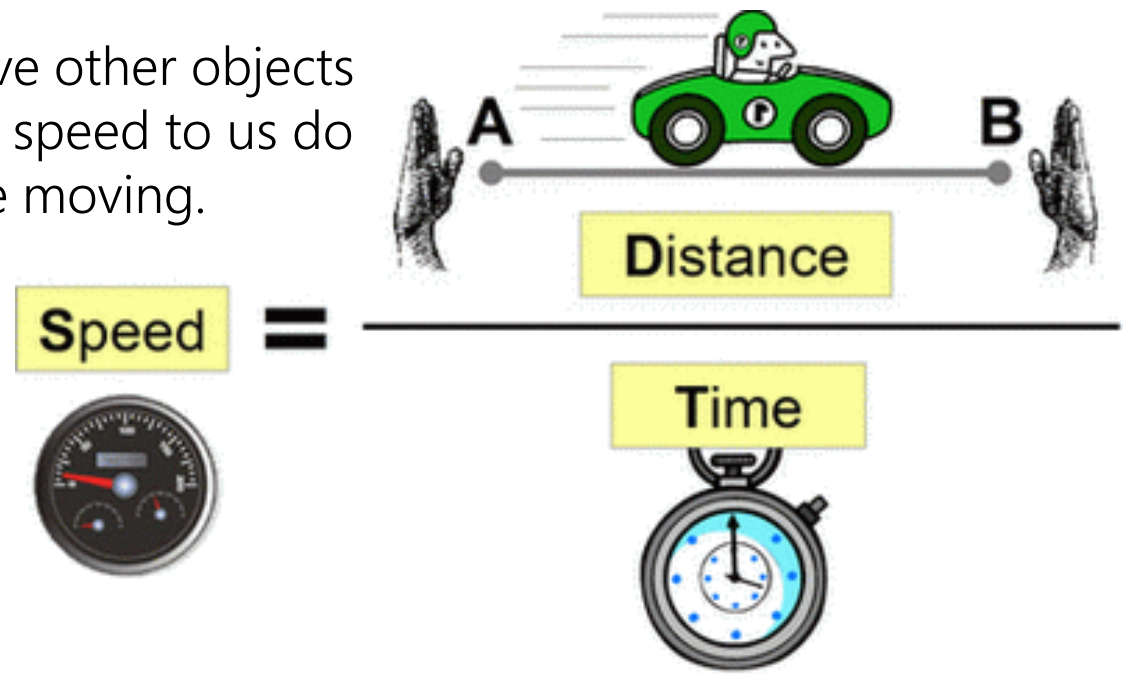
= 117.7 m

Speed

Speed is a measure of the distance travelled over the time taken. The more distance covered by an object during a given time, the faster the speed it is moving. In this unit we use the term **velocity** to mean the same thing.

Constant speed occurs when the object travels the same amount of distance at each even time period. When we travel on an object moving at a constant speed, we do not feel movement for example travelling in an airplane.

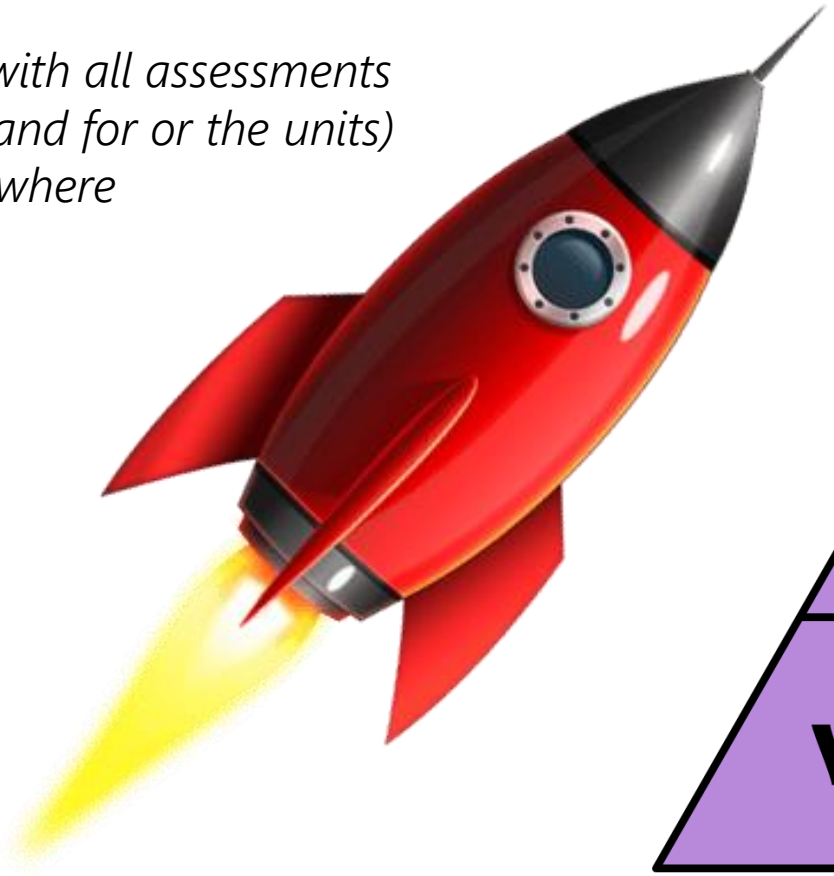
Only when we observe other objects moving at a different speed to us do we notice that we are moving.



Calculating speed

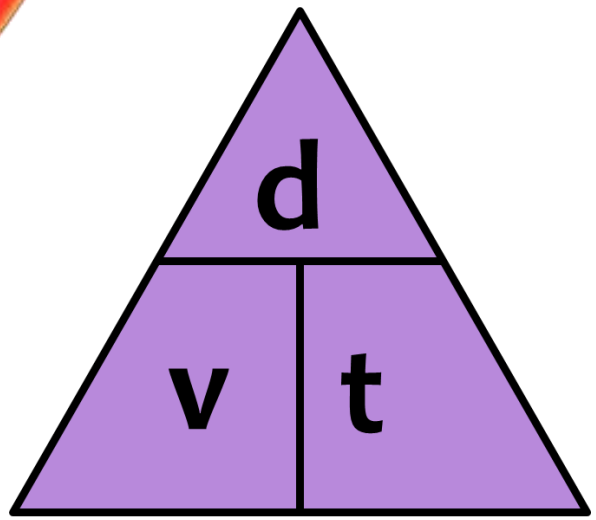
We use this **formula** to calculate speed by placing in the information we have about distance /time into it.
We can also rearrange the formula to calculate distance or time, as long as we know the other two values.
It is important to also use the units after any value in Science.

This formula will be given with all assessments (but not what the letters stand for or the units) and you will need to learn where to apply it.



$$v = d/t$$

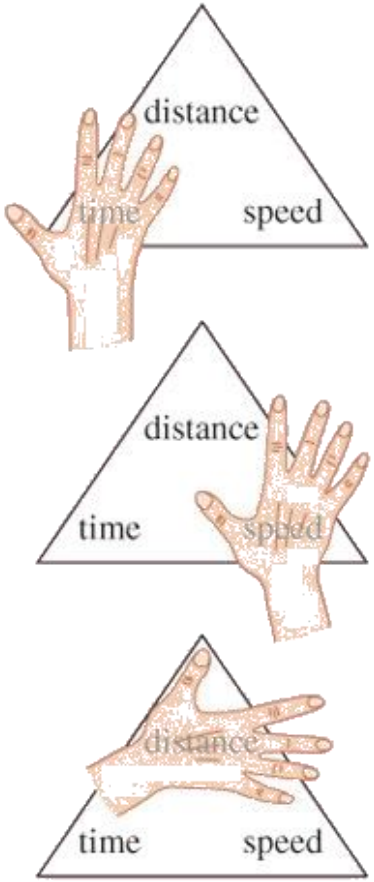
v = velocity (ms^{-1})
d = distance (m)
t = time (s)



The relationships between distance, time and speed

Triangles can be used to calculate speed, distance or time.
Cover the part of the triangle you wish to calculate and multiply or divide the remaining two values.

The unit for speed depends upon the units for time and distance but the most common unit in the lab is metres per second (ms^{-1})



$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{distance} = \text{time} \times \text{speed}$$

Speed calculations

A football is kicked and during the first **2s** it travels **36m**. What speed is it going during this time?

$v=d/t$

$v=36m/2s$

$v=18ms^{-1}$

$$v=d/t$$

v = velocity (ms^{-1})
d = distance (m)
t = time (s)

Average speed and instantaneous speed

We calculate **average speed** (velocity). That is the speed that has been travelled on average over the entire distance. In a car the odometer measures **instantaneous speed**. This is the speed that the car is travelling at in that particular moment.

The average speed a car may have been travelling at for a journey from Cambridge to Hamilton may have been 70km per hour but at some times they may have been travelling at 100km per hour and at other times they may have been travelling at 45km per hour.

$$v_{ave} = \Delta d / \Delta t$$

v = velocity (ms^{-1})
d = distance (m)
t = time (s)

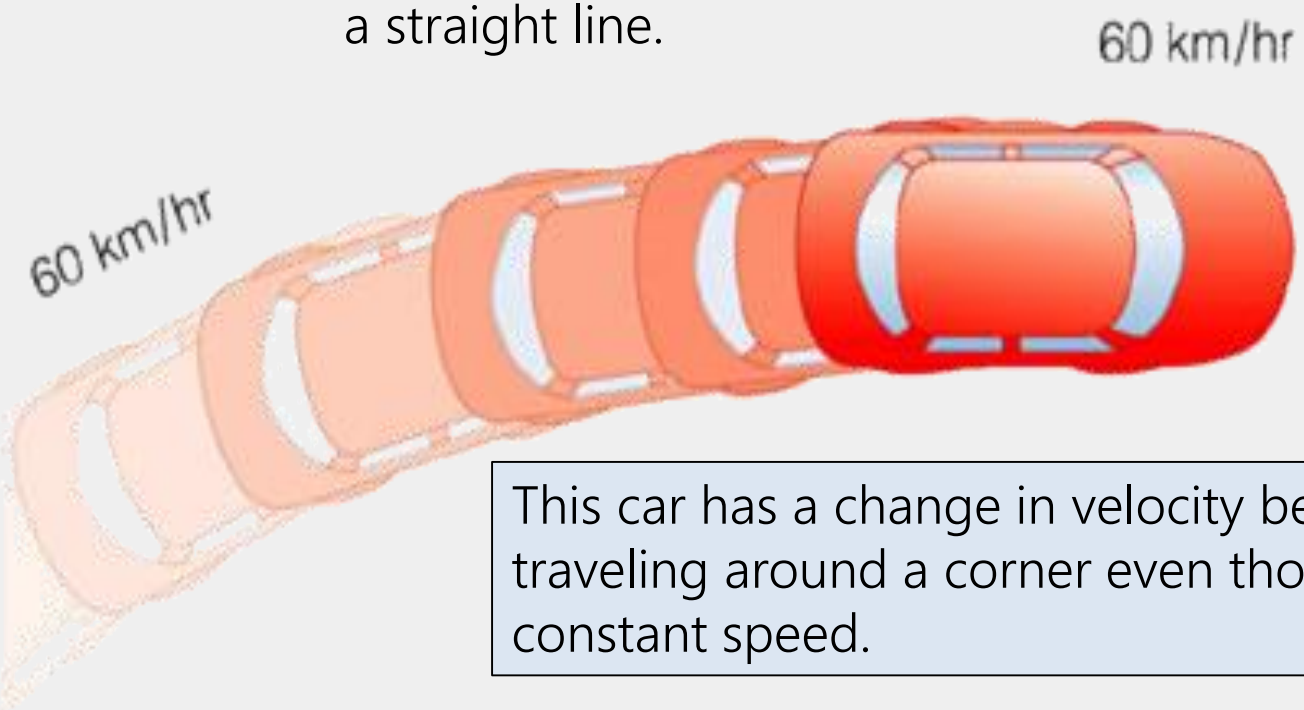
We use the symbol Δ to mean "change in". So using the formula we calculate the average velocity by dividing the change in distance by the change in time taken.

Background Knowledge

Speed and Velocity

extra info

Velocity measures the speed of an object **and** the direction it travels. Two objects can have the same speed but different velocities if they are not travelling the same direction. An object can have a constant speed but its velocity can change if it does not travel in a straight line.

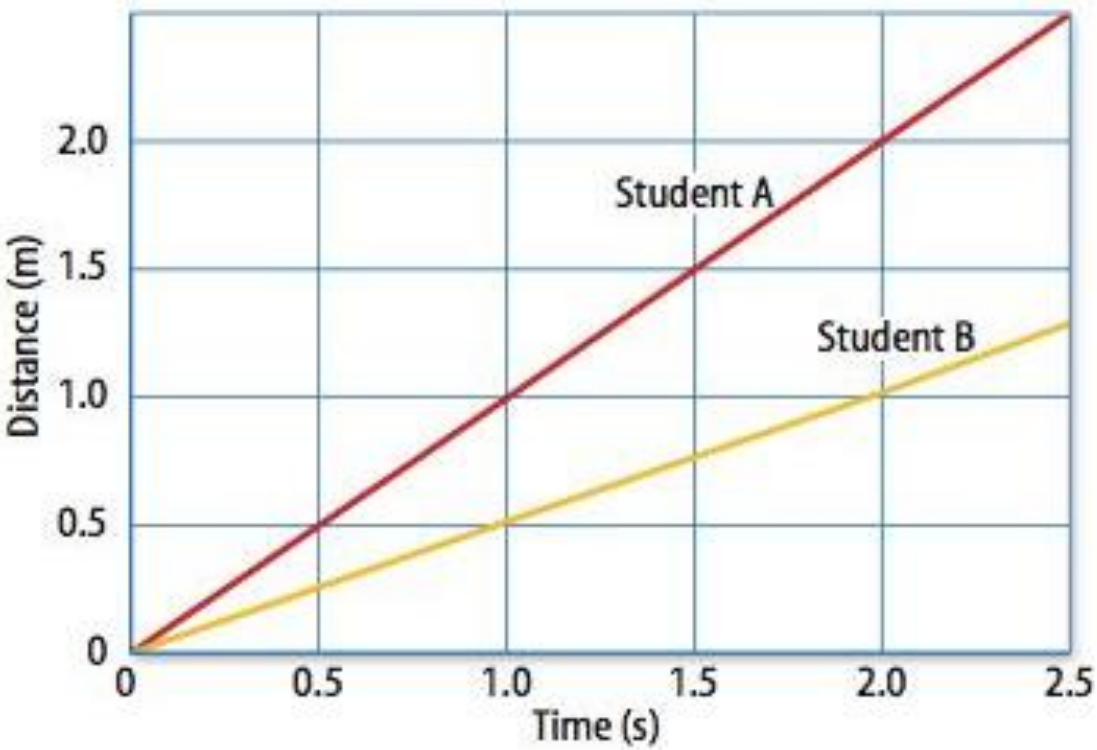


This car has a change in velocity because it is traveling around a corner even though it has constant speed.

GZ Science Resources

Motion can be represented graphically - Distance vs Time

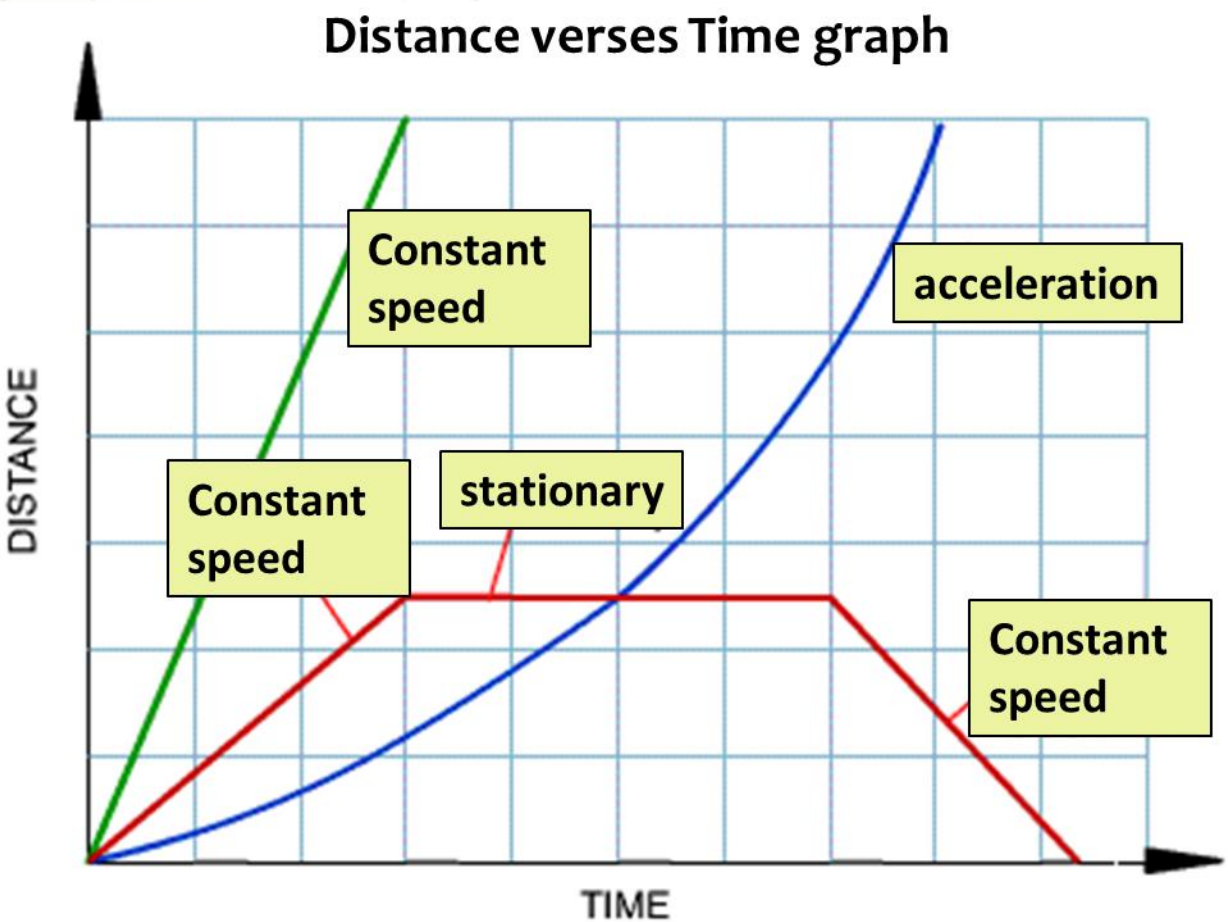
Distance verses Time graph



Distance (y axis) and time (x axis) data can be plotted on a graph to show patterns and compare speeds.
The steeper line on the left shows student A has a faster speed than student B.

A straight diagonal line indicates **constant speed**.
A straight horizontal line indicates the object is **stationary** .

Interpreting Distance/time graphs

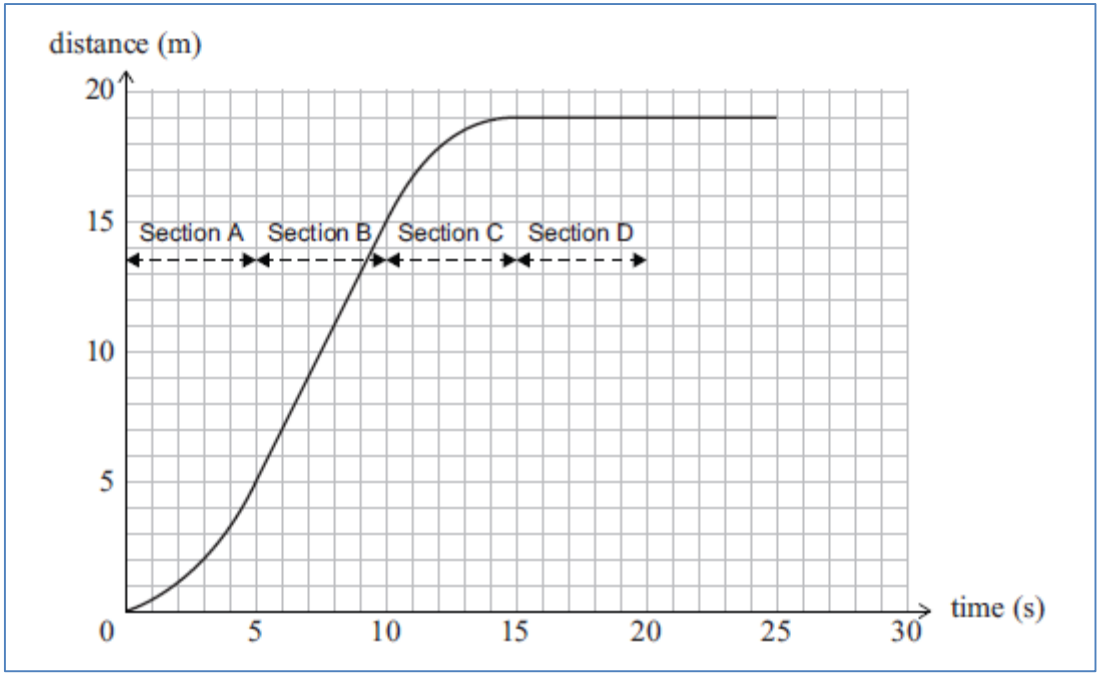


A distance time graph can also show **acceleration** with a curved line (blue) because at each time interval the distance travelled becomes larger and larger. Changes in speed are also shown with a combination of diagonal and horizontal lines (red).

We only find curved lines on a Distance-time graph

Distance / time graph – Describing motion

Q1: The cyclists journey was plotted on the distance / time graph below. Describe the motion of the cyclist in each of sections A,B,C and D



Section A: Increasing speed / accelerating

Section B: Constant speed

Section C: Decreasing speed, decelerating

Section D: Stopped / stationary

Q2: Calculate the cyclists speed during section B.

v = d / t

= 10 / 5

= 2 ms^{-1}

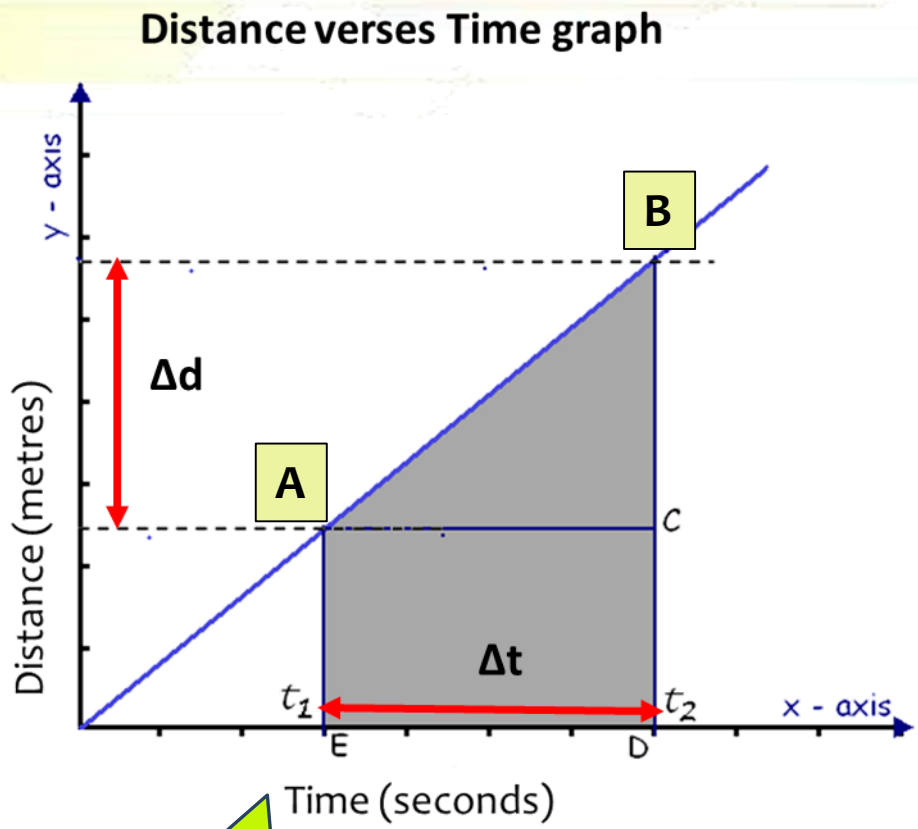
Don't forget units

Q3: what is the total distance covered from 5 to 15seconds?

19m – 5m

= 14m in distance covered

Gradients can be calculated from a Distance-time graph



Make sure the part of the line you are using is straight

The **gradient** of a distance - time graph can be used to calculate speed (velocity). The co-ordinates of a straight line in the graph are taken (for example from **A to B**) by projecting back to the x and y axis.

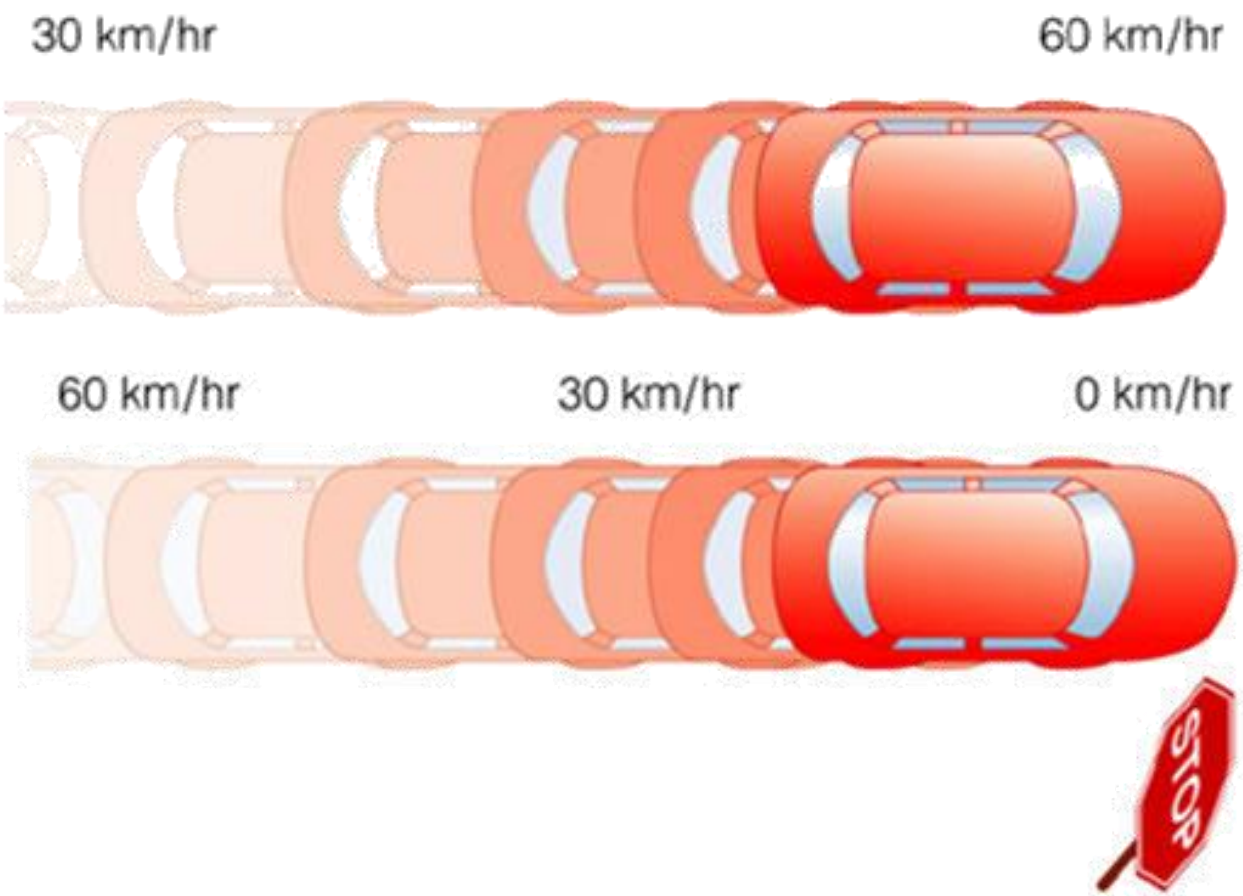
To calculate the value for time find the difference between **t1 and t2** by subtracting the smallest value from the largest value. This will be your Δ time.
Repeat to find distance on the y axis. This will be your Δ distance.

Place both values into your formula to calculate speed (velocity)
v = Δd/ Δt

extra info

Acceleration is a change in velocity

Objects that have a **change in velocity** are said to have **acceleration**.



An increase in velocity or a decrease in velocity (deceleration) are both types of acceleration. A change in direction while travelling a constant speed is also acceleration. We notice when we are travelling on an object that is accelerating by experiencing a change in gravity or G-force.

Acceleration

$$a_{ave} = \Delta v / \Delta t$$

a = acceleration (ms^{-2})
v = velocity (ms^{-1})
t = time (s)

$$\text{acceleration} = \frac{\text{change of velocity}}{\text{change in time taken}}$$

The units for Acceleration depend on what velocity and time are measured in.

If time is measured in seconds (s) and velocity is measured in metres per second (ms^{-1}) then the units for acceleration will be metres per second per second (ms^{-2})

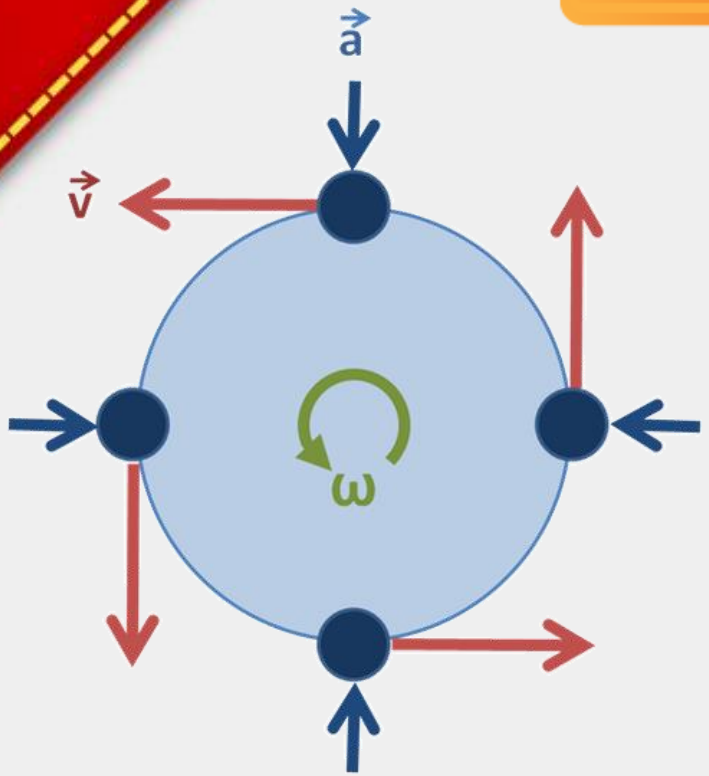
Acceleration or Deceleration

If an object is changing in speed and that change is positive, then the object is speeding up. When calculating a value we can place a + sign in front of it if we wish.

If an object is changing in speed and that change is negative, then the object is slowing up. When calculating acceleration we need to show this with a – (negative sign) in front of the value. Alternatively if we clearly state the value is deceleration then we can leave the – sign off.

Background Knowledge

The Earth accelerates around the Sun



The Earth travels at a constant average speed around the Sun (the speed varies slightly due to the elliptical path) and yet it is accelerating. This is because the direction that the Earth is travelling is constantly changing as it moves around the sun. The gravity force from the sun acts on the Earth and causes a change in velocity or acceleration. The Earth's speed is fast enough so that it does not spiral into the Sun but not so fast that it continues in a curved line away from the Sun.

Satellites including the Moon also accelerate around the Earth. If the Speed of a satellites falls beyond a set limit then it will fall to the Earth.

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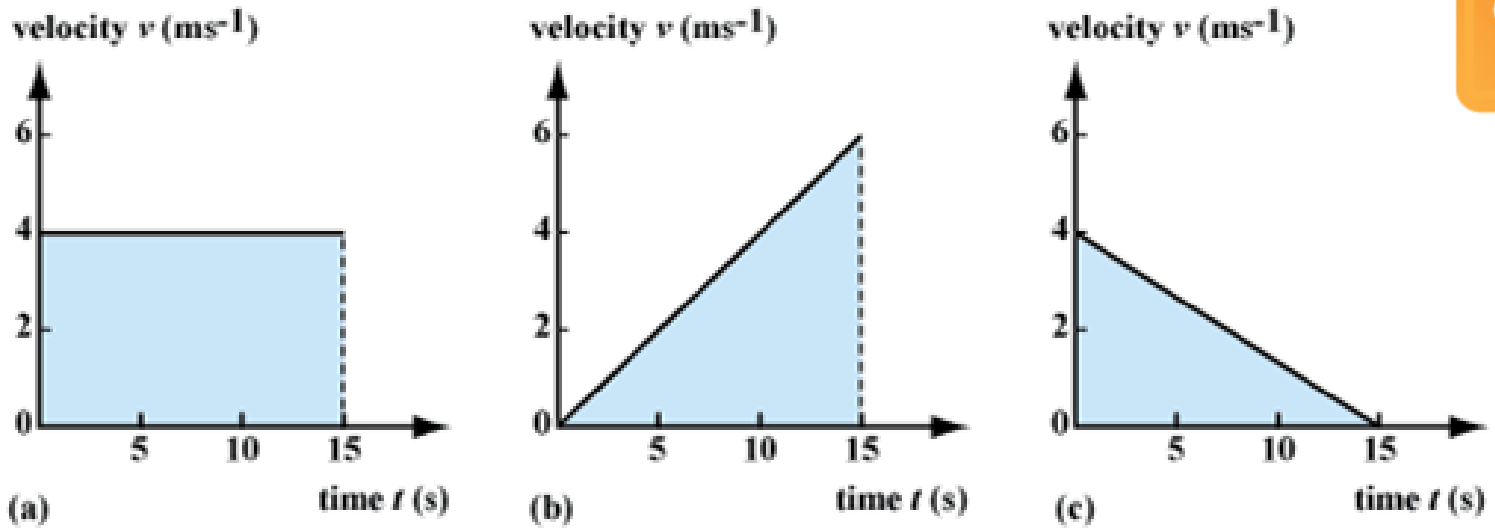
Acceleration can be calculated from a speed-time graph



$$a_{ave} = \Delta v / \Delta t$$

a = acceleration (ms^{-2})
v = velocity (ms^{-1})
t = time (s)

Use the start and finish points of the time and the velocity to work out the total change.
If the time starts from 0 use that as your start point.

Remember: that Δ means change in.
The line must be straight in order to calculate acceleration

Acceleration Calculations

The BMW 135i is a formidable sports car, accelerating from $0 kmhr^{-1}$ to $97 kmhr^{-1}$ in 4.6 seconds. What is the acceleration of this car in ms^{-2}?

$97 kmhr^{-1} / 3.6 = 26.9 ms^{-1}$

$a_{ave} = \Delta v / \Delta t$

$a_{ave} = 26.9 ms^{-1} / 4.6 s$

$a_{ave} = \Delta v / \Delta t$

$a_{ave} = 5.9 ms^{-2}$

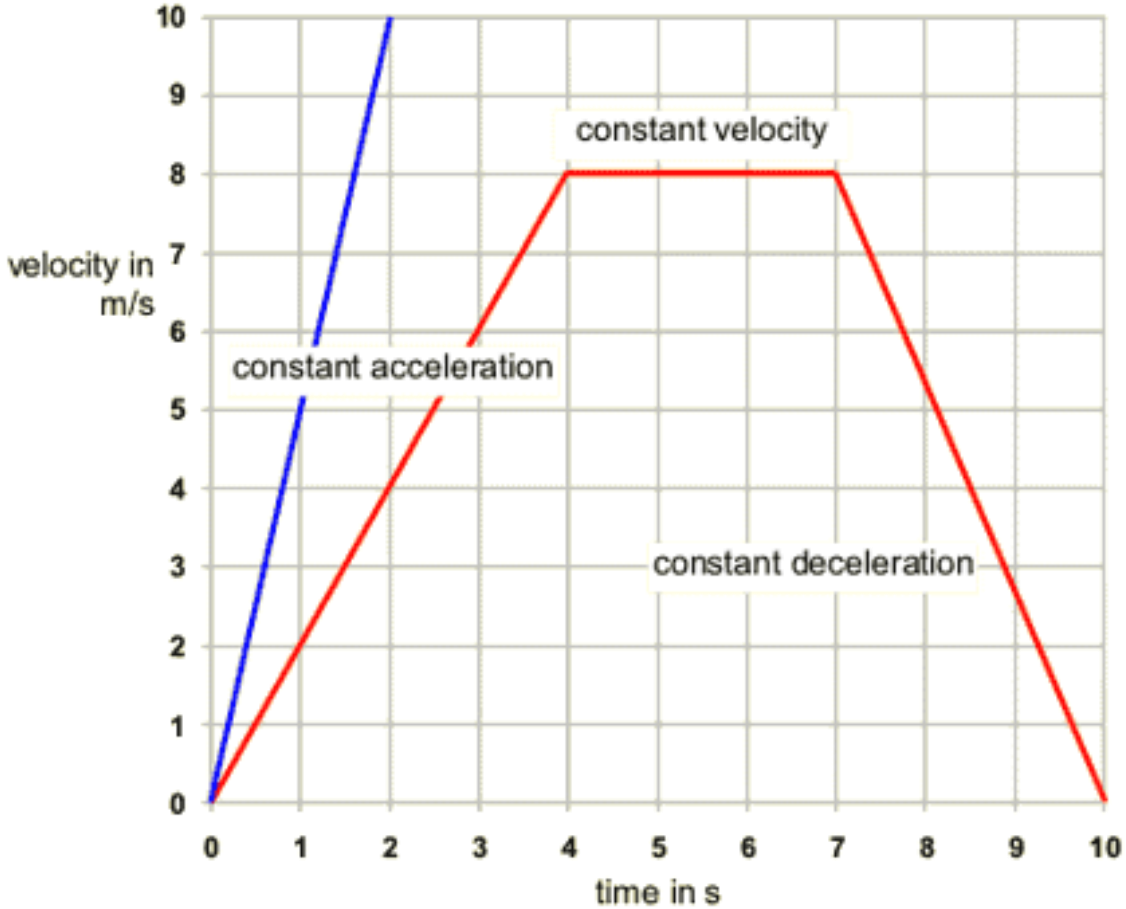
REMEMBER:
m/s to km/h multipy by 3.6
km/h to m/s divide by 3.6

$$a_{ave} = \Delta v / \Delta t$$

a = acceleration (ms^{-2})
v = velocity (ms^{-1})
t = time (s)

Motion can be represented graphically – Velocity vs Time

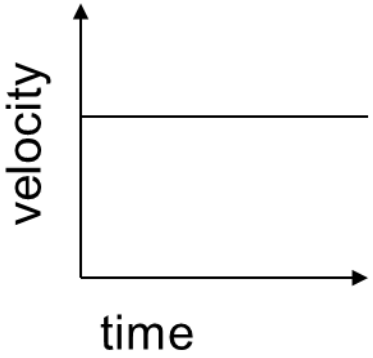
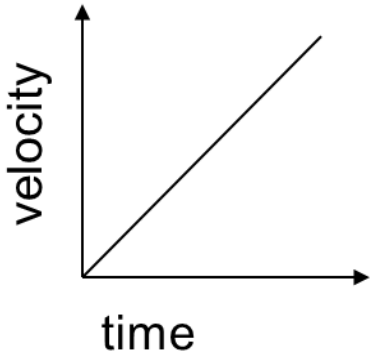
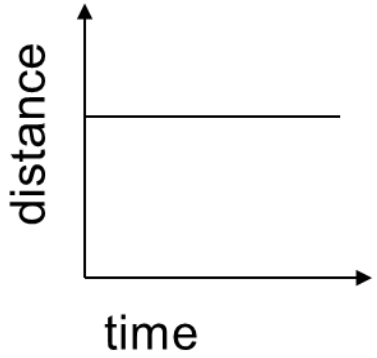
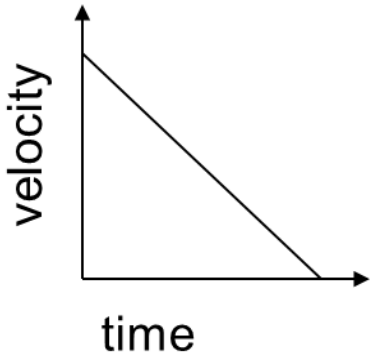
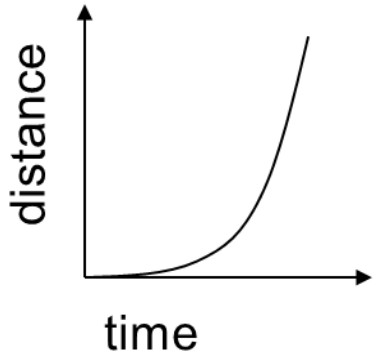
Velocity verses Time graph



A velocity time graph can show acceleration with a diagonal line.
Constant velocity is shown with a straight horizontal line.
Values can be taken from the graphs and used to calculate acceleration.
The blue line shows a velocity of $10ms^{-1}$ travelled in 2 seconds.
The acceleration would therefore be:

$a = \Delta v / t$
$= 10/2$
$a = 5ms^{-2}$

Graphs may be used to display motion/time relationships

Distance-time graph showing object changing speed overtime 	**Speed–time graph** Showing object traveling at constant speed 	**Speed-time graph** Showing object experiencing constant acceleration 	**Distance-time graph** Showing stationary (non-moving) object 
Formula for calculating **speed** $\frac{\text{Distance traveled}}{\text{time taken}}$	**Formula** for calculating acceleration $\frac{\text{change of speed}}{\text{time taken}}$	Graph showing object undergoing constant deceleration until it stops 	Graph showing object moving at faster and faster speeds 

extra info