Combined Physics			
Paper 1		Paper 2	
2	Motion and Forces	8	Forces Doing Work
3	Conservation of Energy	9	Forces and Effects
4	Waves	10	Electricity
5	Light and E.M.	12	Magnetism and Motors
6	Radioactivity	13	Electromagnetic Induction
P	Equations	14	Particle Model
C	Core Practical	15	Forces and Matter

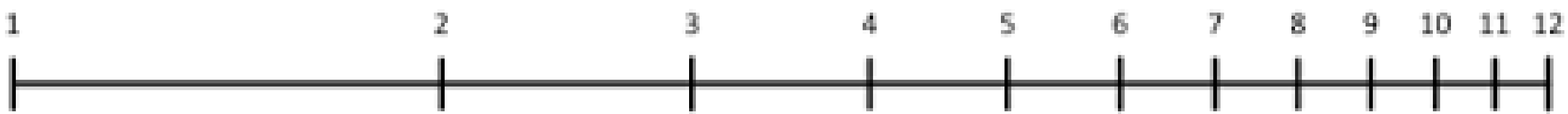
2.1 Explain that a **scalar** quantity has magnitude (size) but no specific direction

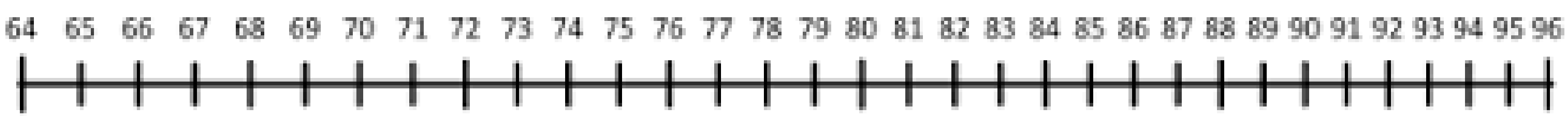
Magnitude:

Magnus : greatness and *tudo*: size

Fancy word for "amount of a thing"

Anything you can put a number on.





2.2 Explain that a **vector** quantity has both magnitude (size) and a specific direction

Vector:

Vehere : to carry or move

Fancy word for "something with a direction"

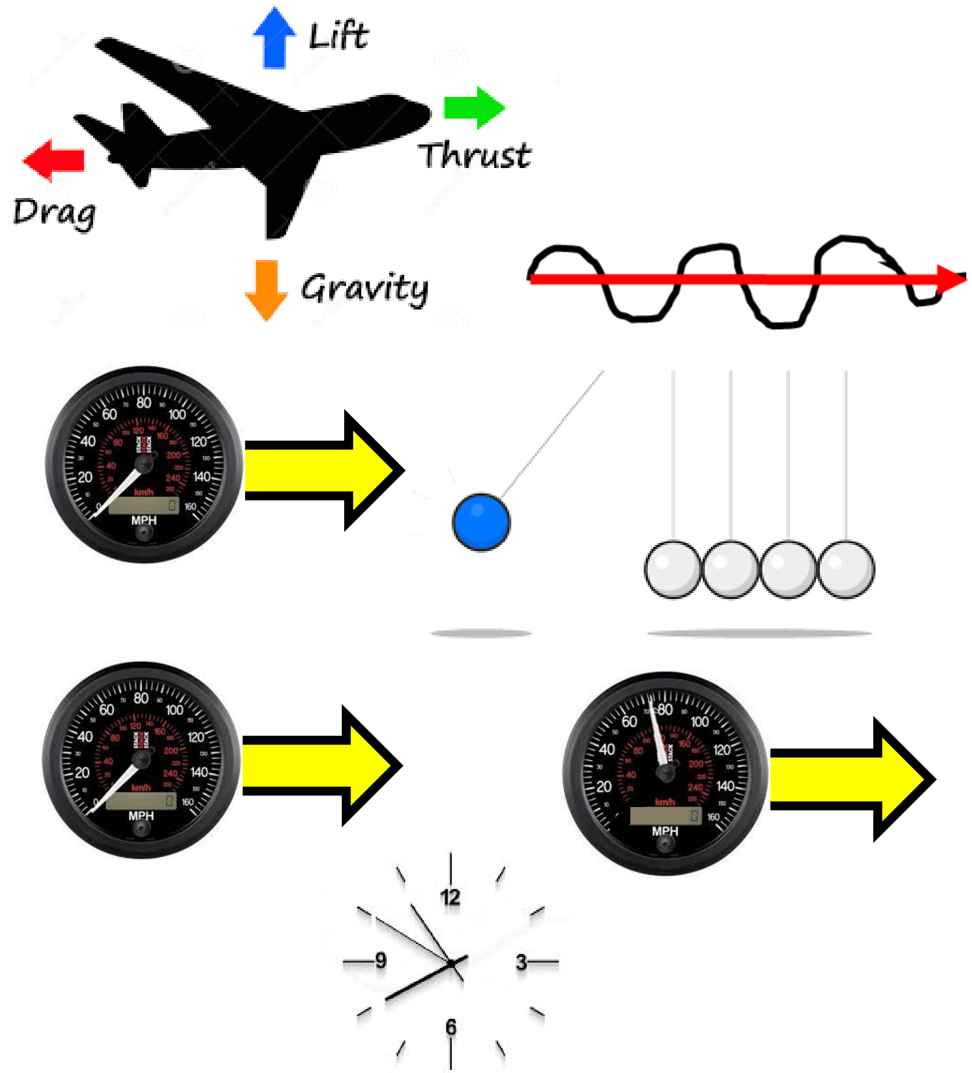
Anything you can put a number AND a direction on.

23 Newtons Right

2.4 Recall vector and scalar quantities, including: a displacement/distance b velocity/speed c acceleration d force e weight/mass f momentum g energy

Scalars

Vectors



2.5 Recall that velocity is speed in a stated direction

The base units for velocity are m/s.

An object at rest has a velocity of 0m/s

2.6 Recall and use the equations: a (average) speed (metre per second, m/s) = distance (metre, m) ÷ time (s) b distance travelled (metre, m) = average speed (metre per second, m/s) × time (s)

Distance Travelled

$$distance\ travelled(m) = average\ speed\left(\frac{m}{s}\right) x\ time(s)$$

$$m = \frac{m}{s}\ x\ s$$

Average Speed

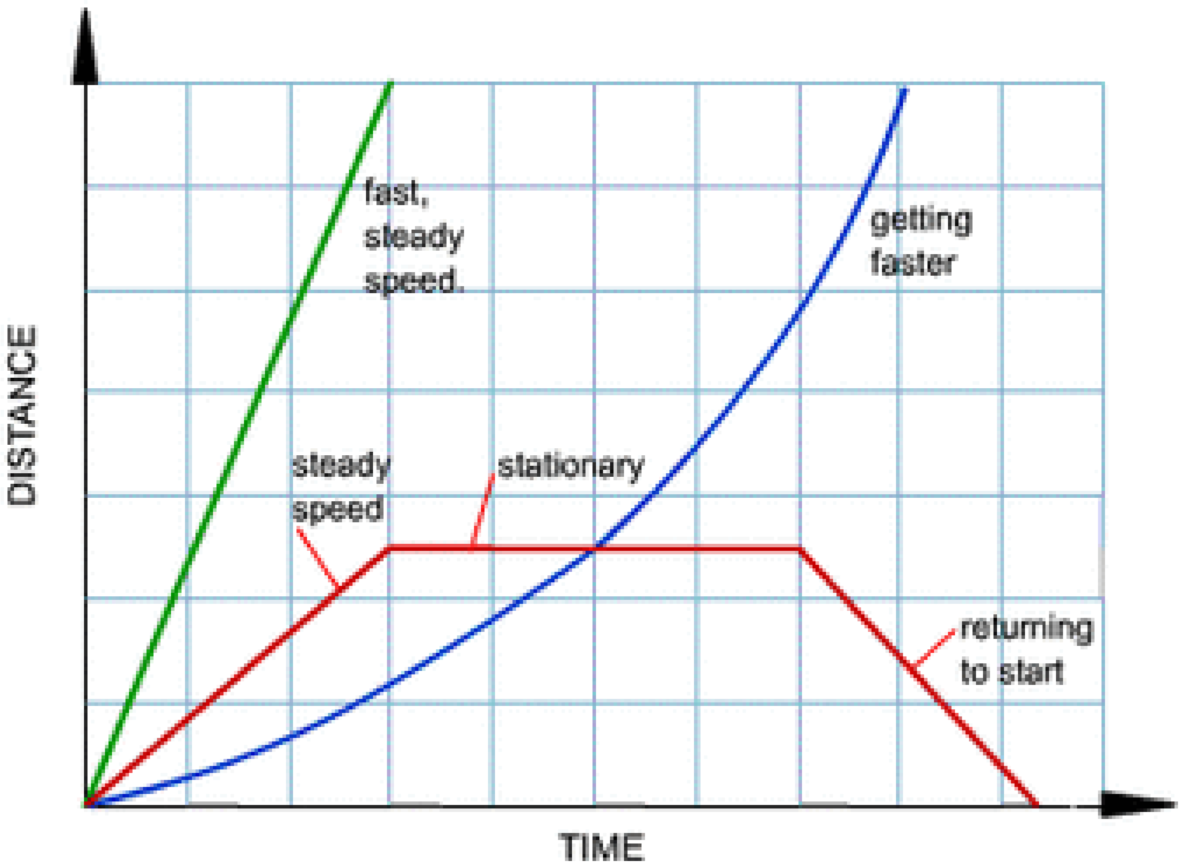
$$speed\left(\frac{m}{s}\right) = \frac{distance\ (m)}{time(s)}$$

$$m = \frac{m}{s}\ x\ s$$

2.7 Analyse distance/time graphs including determination of speed from the gradient

Distance-time graphs can be used to represent the motion of an object.

The different gradients (steepness) of line on the graphs show different motions of the object.



2.8 Recall and use the equation: acceleration (metre per second squared, m/s2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) v – u a t

Acceleration

$$acceleration\left(\frac{m}{s^2}\right) = \frac{change\ in\ velocity\ \left(\frac{m}{s}\right)}{time\ taken\ (s)}$$

$$a = \frac{(v - u)}{t}$$

2.9 Use the equation: (final velocity)^2 ((metre/second)^2, (m/s)^2) – (initial velocity)^2 ((metre/second)^2, (m/s)^2) = 2 × acceleration (metre per second squared, m/s^2) × distance (metre, m) $v^2 - u^2 = 2 \times a \times X$

$$v^2 - u^2 = 2\,x\,a\,x\;\times$$

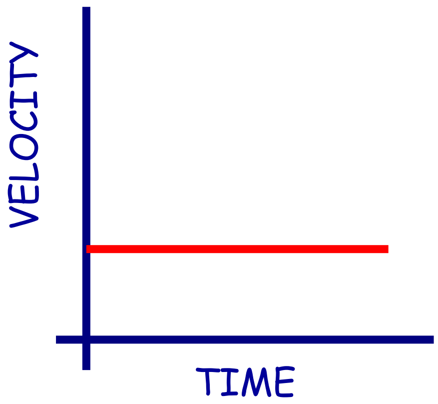
The equation is on the back of the booklet.

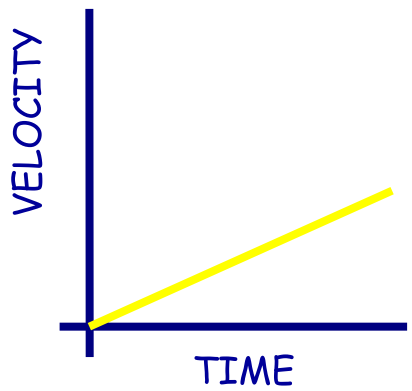
BE AWARE

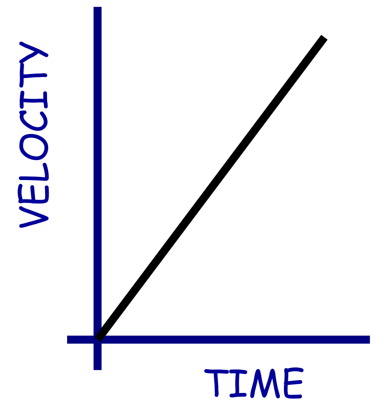
If the velocity is 2m/s then when substituting in make sure you write:

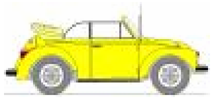
2^2m/s NOT 2m/s^2

2.10 Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)









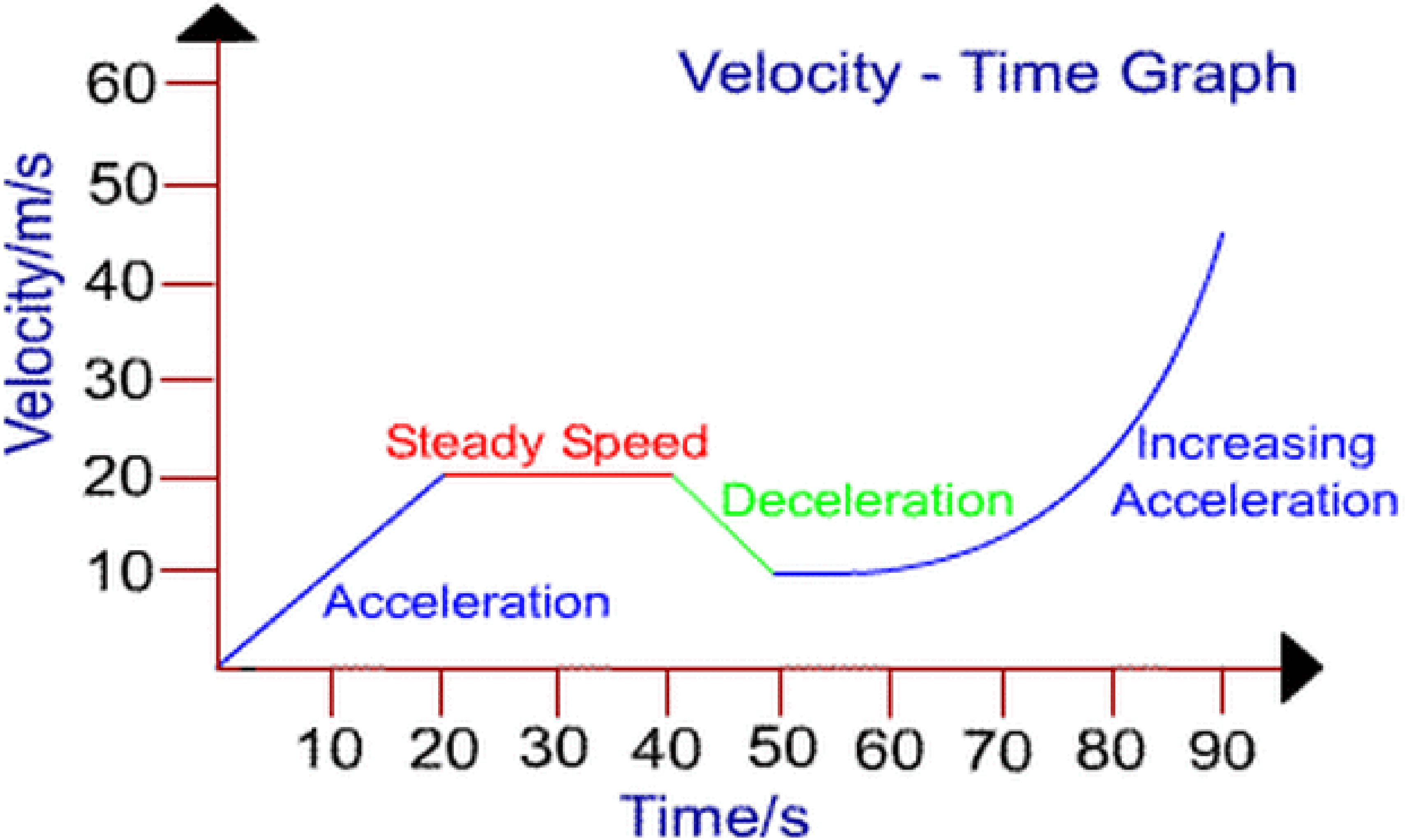
Velocity-time graphs can represent the motion of a body.

The steeper the slope of the graph, the greater the acceleration it represents

Constant velocity it is represented by a horizontal line.

Constant acceleration it is represent by a straight sloping line..

2.10 Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)



2.10 Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)

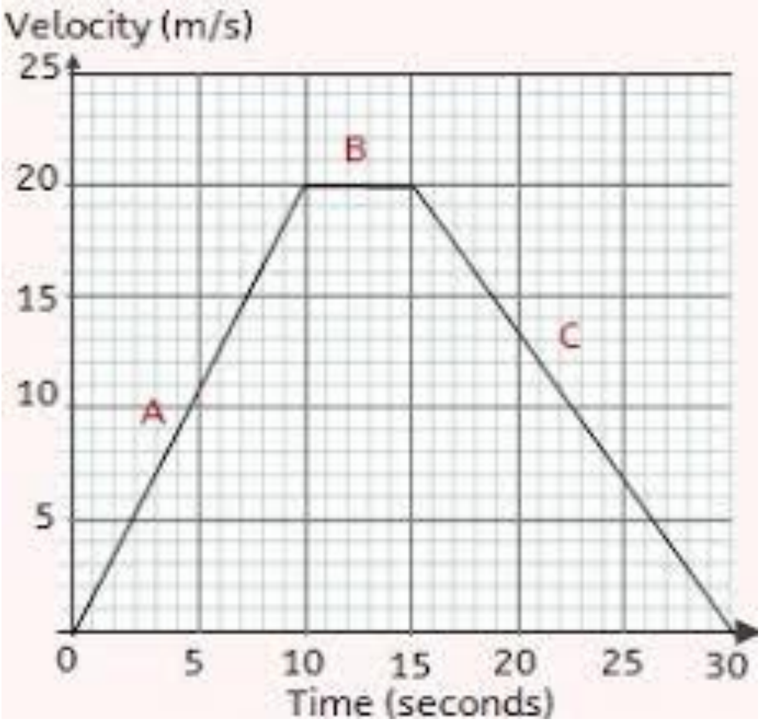
From a velocity-time graph can show you the velocity, the acceleration and the distance travelled of an object.

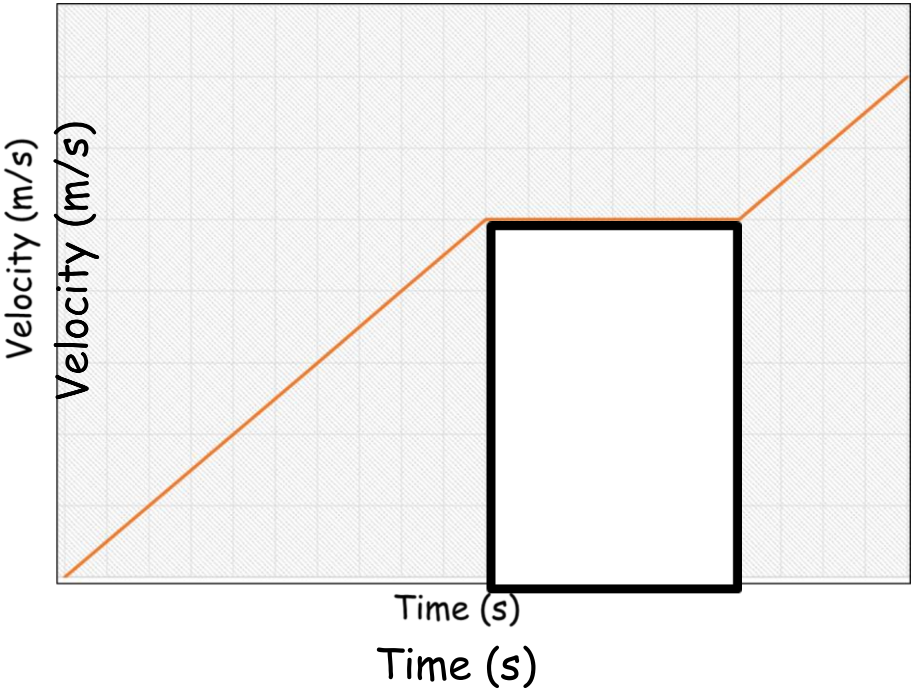
USE THE AXES

The velocity: From reading off the axes on the graph.

The acceleration: Found from the gradient of the line on the velocity-time graph.

The distance travelled: The area under the line on a velocity-time graph is the distance travelled.

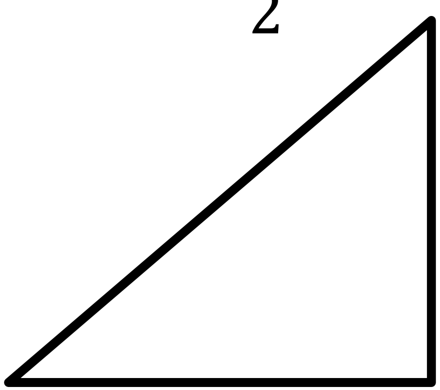




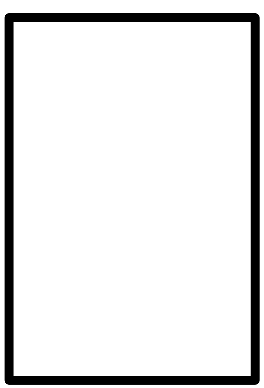
$$velocity = \frac{distance}{time}$$

$$distance = velocity\ x\ time$$

$$area = \frac{1}{2}\ x\ length\ x\ breadth$$



$$area = length\ x\ height$$



2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates

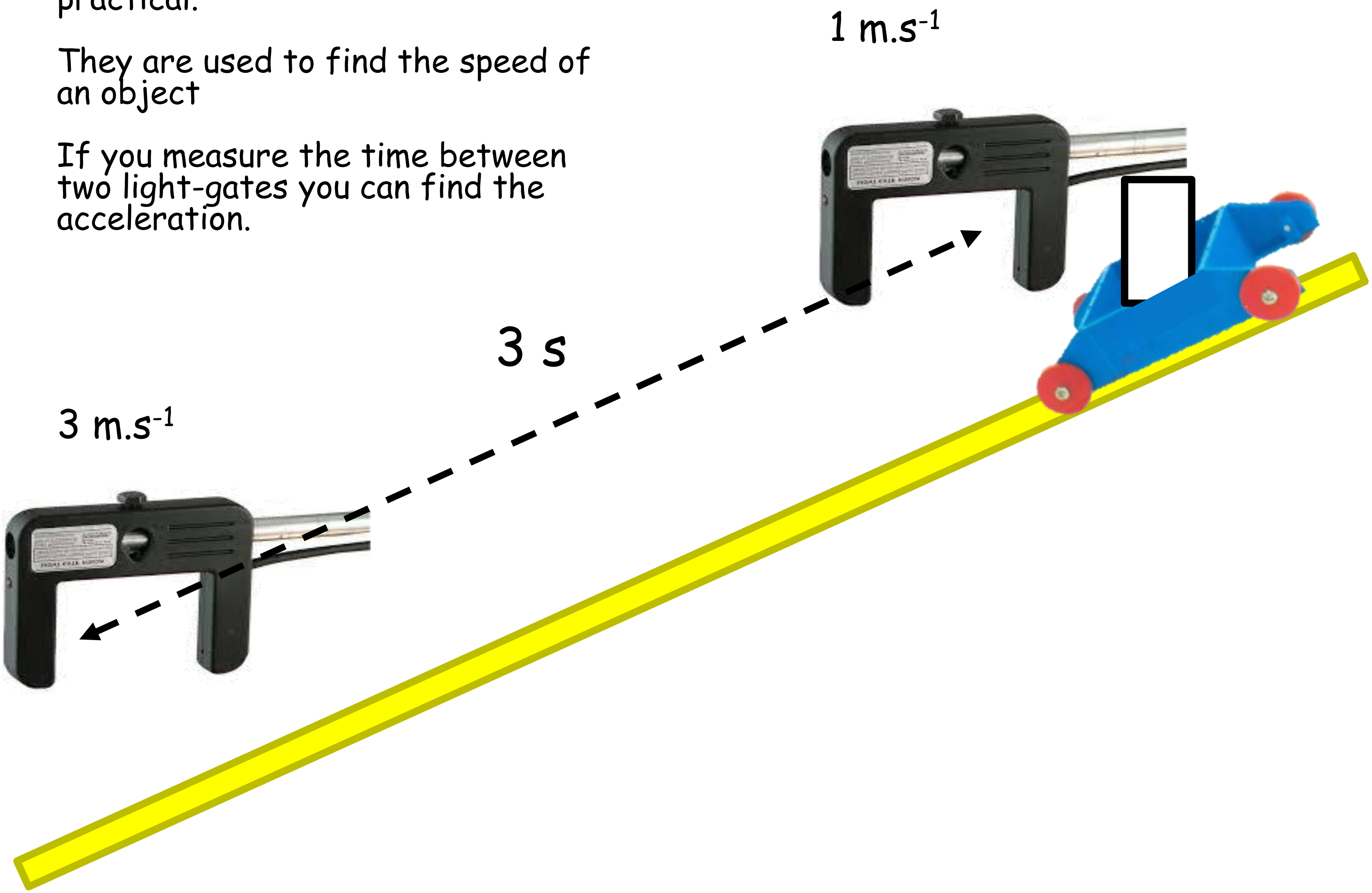
Equipment	Distance measurement	Time measurement
Ruler and stopwatch	Ruler measures distance travelled	Stopwatch measures time taken
Light gates	Size of object, measured with a ruler	Light gate connects to a timer, which gives the reading
Video analysis	Distance moved from frame to frame observed on a ruler in the pictures	The time between frames is known

2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates

Light gates are used in the core practical.

They are used to find the speed of an object

If you measure the time between two light-gates you can find the acceleration.



2.12 Recall some typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems

Method of travel	Typical speed (m/s)
Walking	1.5
Running	3
Cycling	6
Car	13 - 30
Train	50
Aeroplane	250

x2

The speed of sound in air is about 330m/s but this can change depending on the temperature and air pressure.

The speed of wind can range from 2m/s (light breeze) to 20m/s in a gale

2.13 Recall that the acceleration, g, in free fall is 10 m/s^2 and be able to estimate the magnitudes of everyday accelerations

Acceleration of a falling object is $10 m/s^2$.

Remember this for calculation questions – they don't say sometimes.

A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force.

When two forces act in a line the resultant force is the vector addition of the two vectors. Remember the direction is important.

R = 16 N to the right

R = 4 N to the right

2.15 Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s2) F = m x a

Force

$$force(N) = mass(Kg)x\ acceleration\ (\frac{m}{s^2})$$

$$\mathrm{F} = m\ x\ a$$

2.16 Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) W = m x g

9.8 Newtons per Kilogram on Earth (but they might say assume it is 10N/Kg)

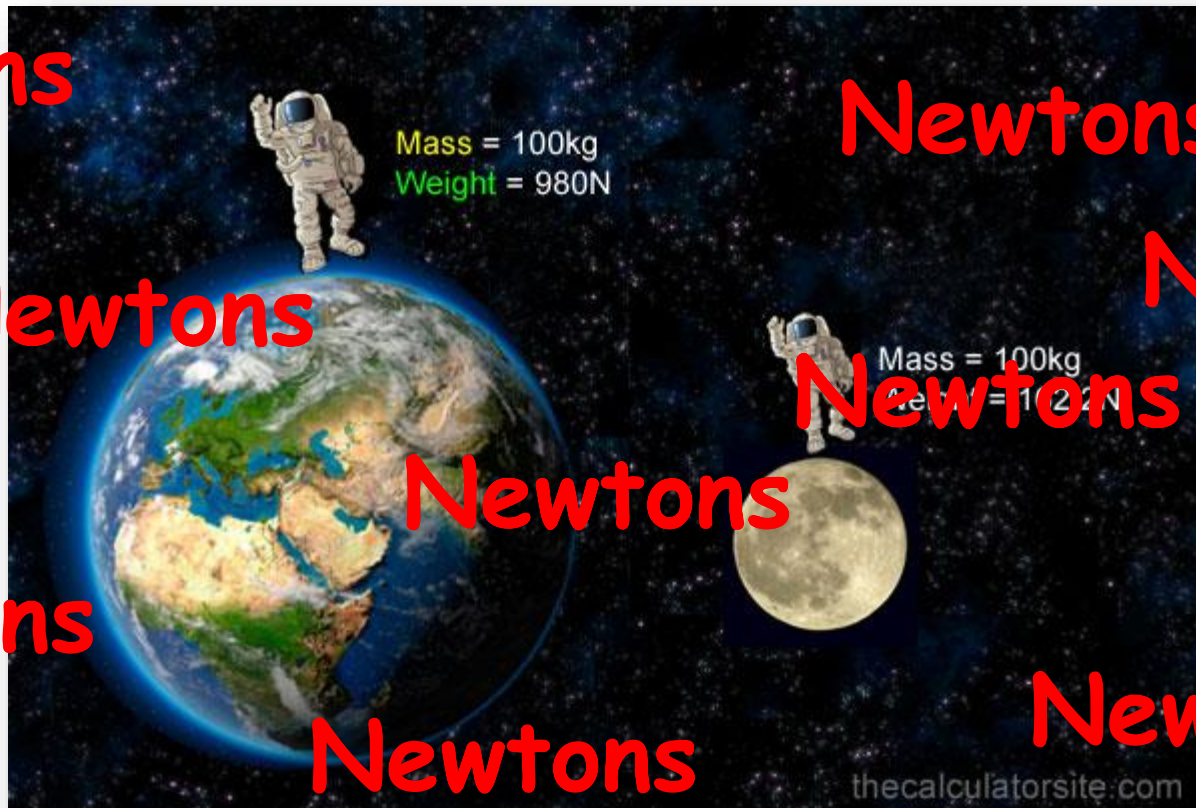
Weight

$$weight(N) = mass\ (Kg) x\ gravitational\ field\ strength(\frac{N}{Kg})$$

$$\mathrm{W} = m\ x\ g$$

2.17 Describe how weight is measured

$$W = m \times g$$



Newtons
Newtons
Newtons
Newtons
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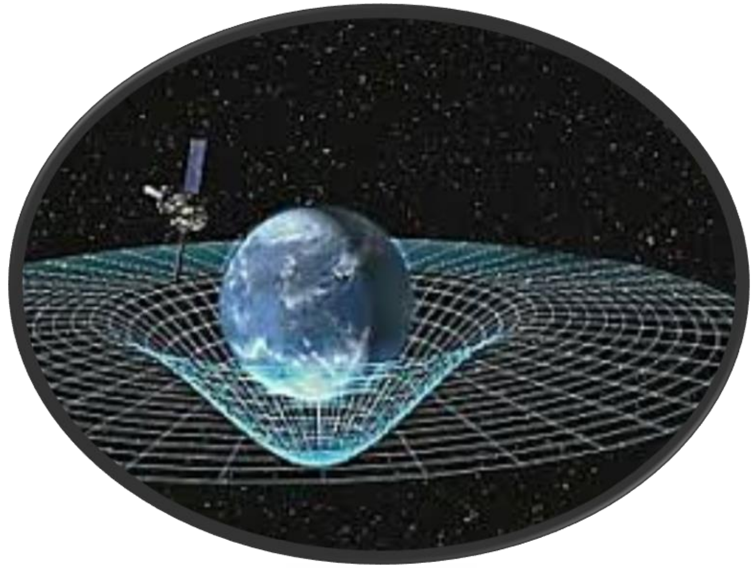
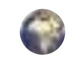
Newtons

2.18 Describe the relationship between the weight of a body and the gravitational field strength





25 Newtons per Kilogram

10 Newtons per Kilogram

2.19 Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys

Core practical 1: Investigating force, mass and acceleration

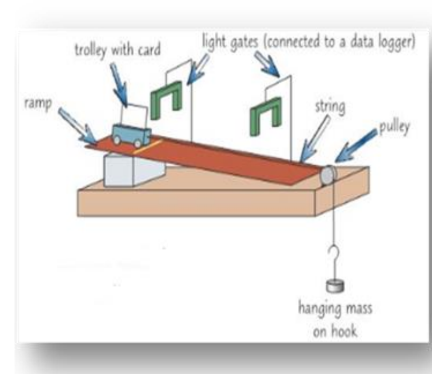
Set up the experiment so the slope of the ramp allows the cart to roll slightly. This controls for the force of gravity and friction.

Ensure your hanging masses have room to avoid hitting the floor. To keep the mass of the system constant, take masses from the trolley and add to the hanger.

Ensure the interrupt card on top of the cart can pass easily through the light gate. Using a light gate controls for human reaction time errors.

Use a stopwatch to time between the gates if you are using them to calculate speed. This will introduce human reaction time errors

Make sure you use the equation $a = \frac{\Delta V}{t}$ to calculate the answer. Remember to include this in your answers.



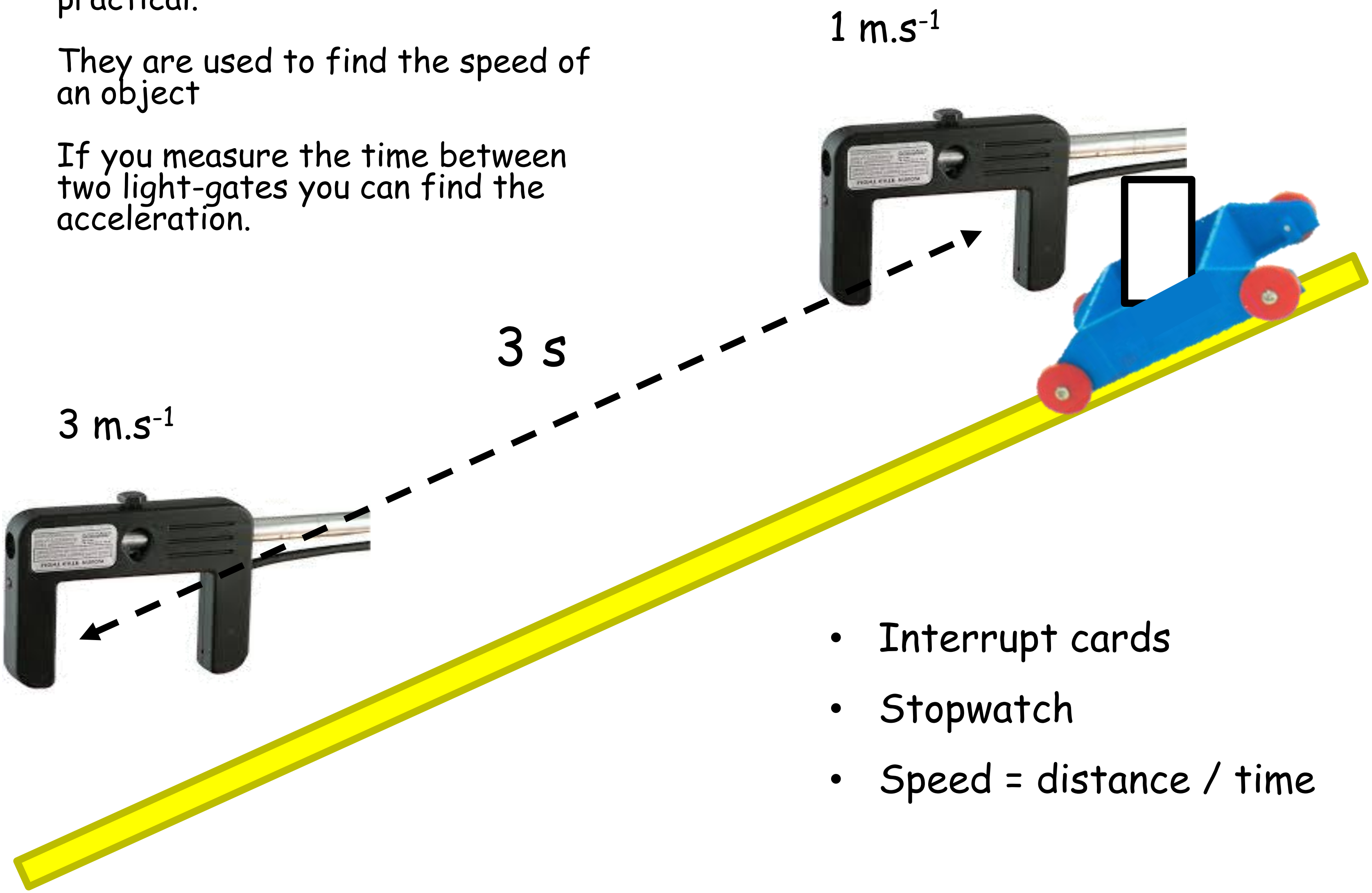
Ensure that when you are asked to improve this experiment that you review sources of error and how to use more accurate equipment.

2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates

Light gates are used ion the core practical.

They are used to find the speed of an object

If you measure the time between two light-gates you can find the acceleration.



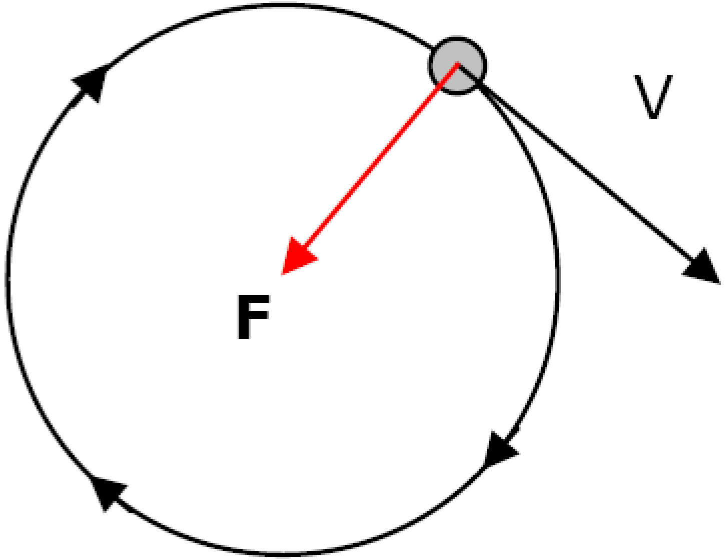
- Interrupt cards
- Stopwatch
- Speed = distance / time

2.20 Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)

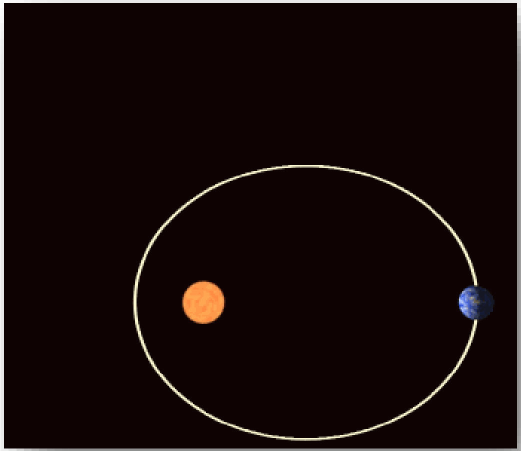
A swinging ball is constantly changing direction. Therefore it is also changing velocity.

Therefore it is also accelerating.

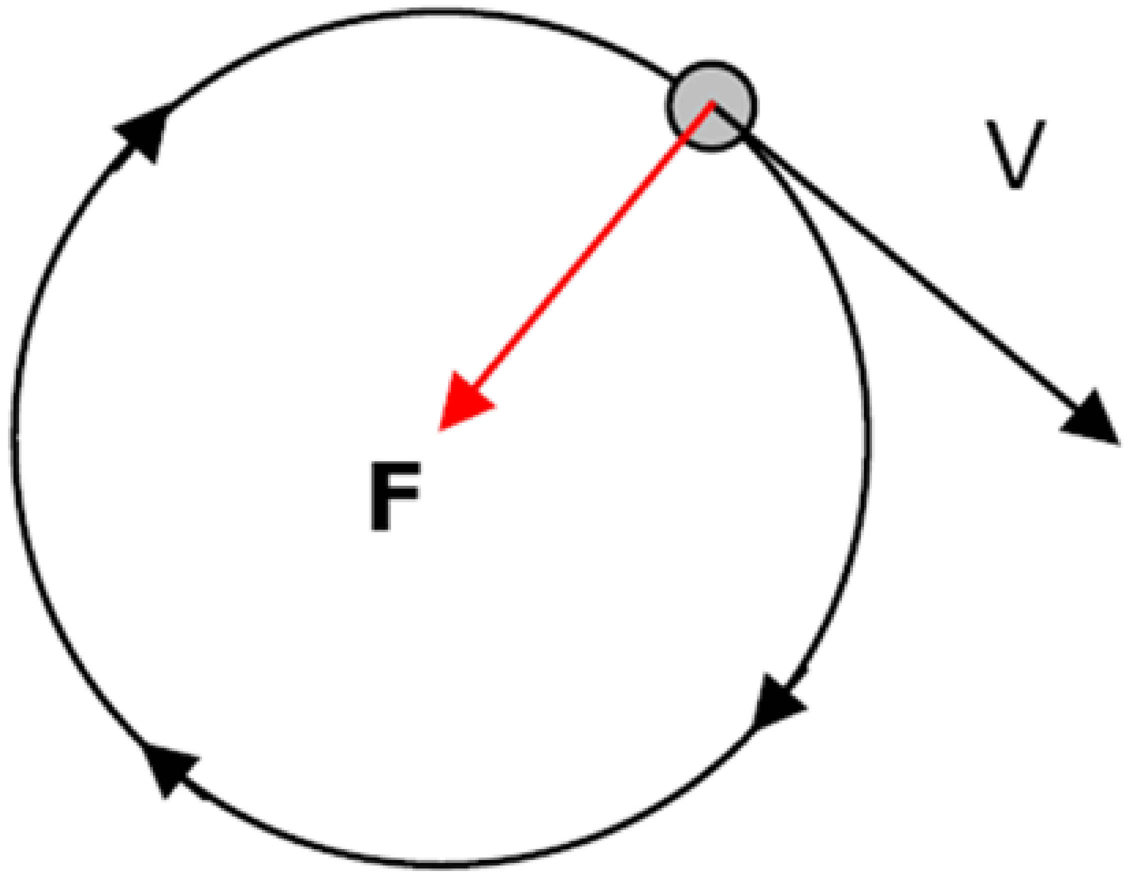
The resultant force that causes the change in direction is a centripetal force.



2.20 Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)



2.21 Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle



2.22 Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration

Inertia is a property of matter. It is the resistance of the object to change its motion (speed and/or direction).

Mass is a measure of the amount of inertia an object has.

The more inertia (or mass) an object has the harder it is to get that object to change its motion.

To find out which of two objects has the most inertia:

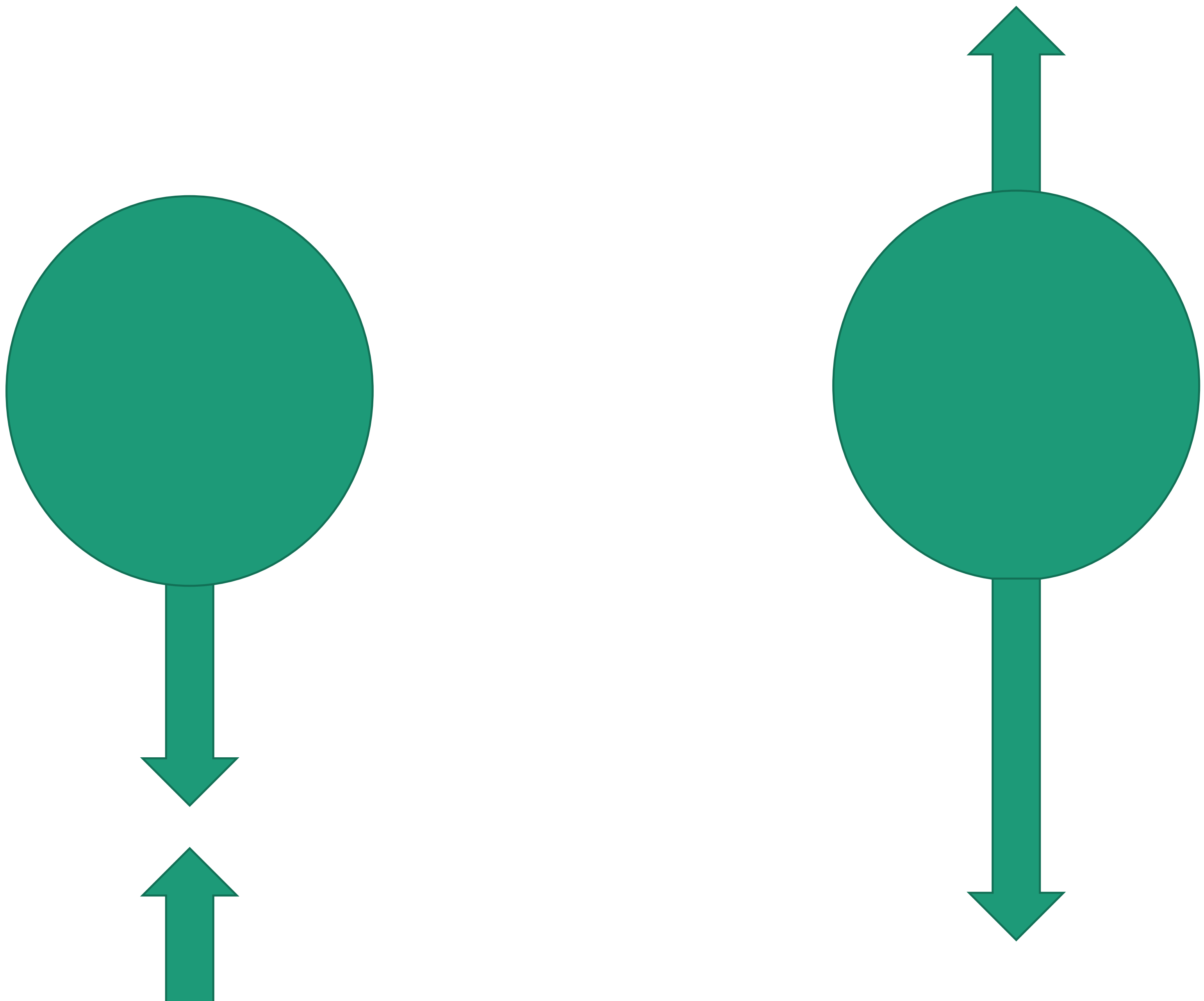
Apply an equal force to both of them when they are at rest.
The one that has the greatest acceleration has the lowest inertia – it was easier to get it to change its motion.

2.23 Recall and apply Newton's third law both to equilibrium situations and to collision interactions and relate it to the conservation of momentum in collisions

Actioni contrarium semper et aequalem esse reactionem; sive corporum duorum actiones in se mutuo semper esse aequales et in partes contrarias dirigi.

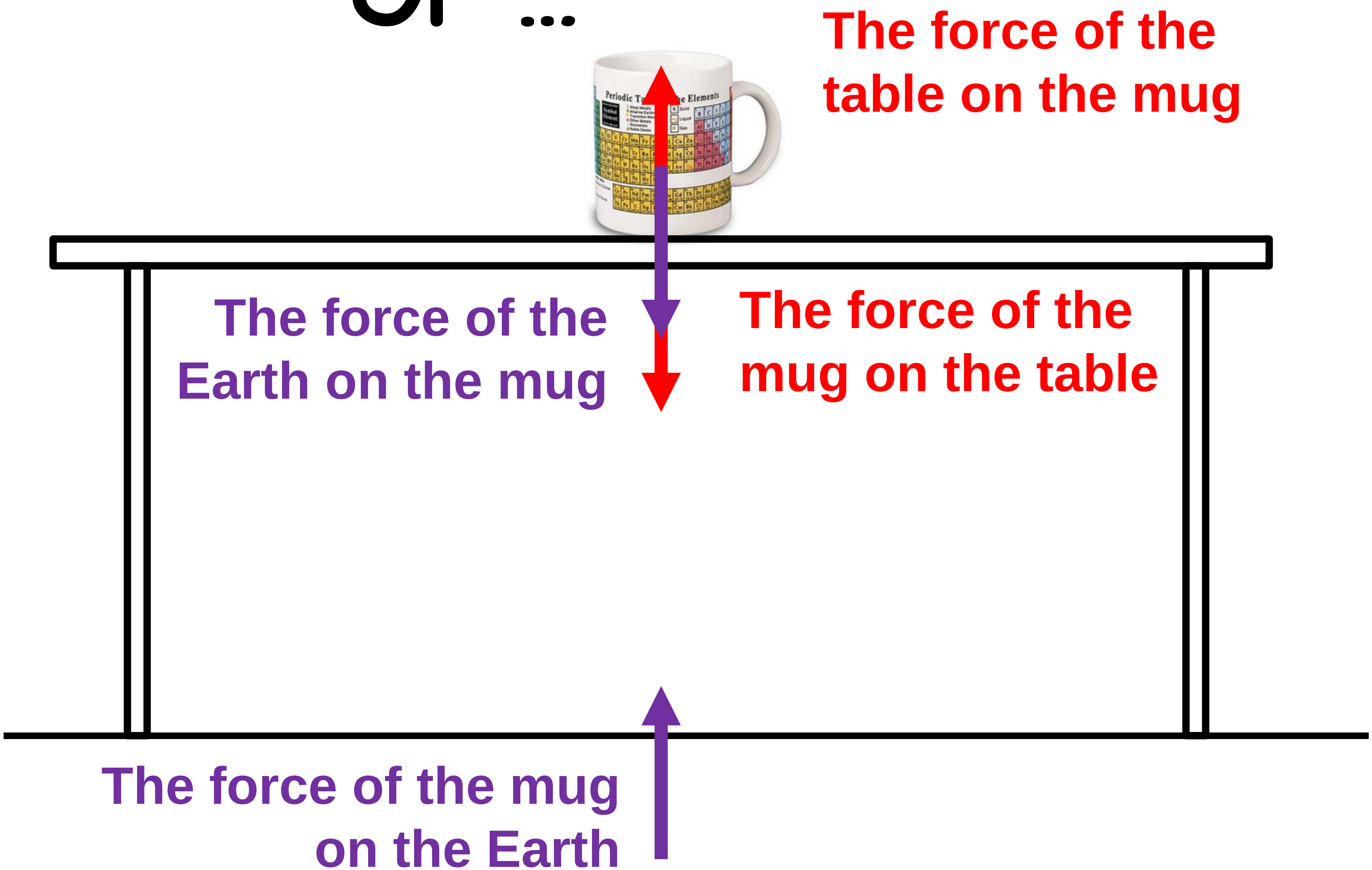
To any action there is always an equal and opposite reaction; or the actions of two bodies upon each other are at all times equal and always opposite in direction

2.23 Recall and apply Newton's third law both to equilibrium situations and to collision interactions and relate it to the conservation of momentum in collisions



2.23 Recall and apply Newton's third law both to equilibrium situations and to collision interactions and relate it to the conservation of momentum in collisions

Or …



2.24 Define momentum, recall and use the equation: momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s) p m v

Momentum

$$momentum\ (Kg.\frac{m}{s}) = mass(Kg)x\ velocity(\frac{m}{s})$$

$$\mathrm{p} = m\ x\ \mathrm{v}$$

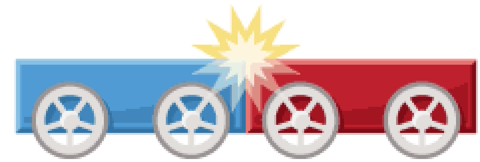
2.25 Describe examples of momentum in collisions

total momentum before an event = total momentum after the event

We assume no other forces are acting in the system

3 m/s   0 m/s

2 Kg   8 Kg



10 Kg

First calculate the momentum of both trolleys before the collision:

2 kg trolley = 2 × 3 = 6 kg m/s

8 kg trolley = 8 × 0 = 0 kg m/s

Total momentum before collision = 6 + 0 = 6 kg m/s

Total momentum (p) after collision = 6 kg m/s (because momentum is conserved)

Mass (m) after collision = 10 kg

2.25 Describe examples of momentum in collisions

total momentum before an event = total momentum after the event

We assume no other forces are acting in the system

Next, rearrange p = m x v to find v:

$$v = \frac{p}{m} \qquad v = \frac{6kg.m/s}{10Kg} \qquad v = 0.6\,m/s$$

The blue trolley was travelling to the right before the collision and has a positive value.

Because the velocity after the collision is positive, both trolleys must be moving to the right after the collision

2.26 Use Newton's second law as: force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s)

$$p = m \times v$$

$$f = m \times a$$

$$a = \frac{(v - u)}{t}$$

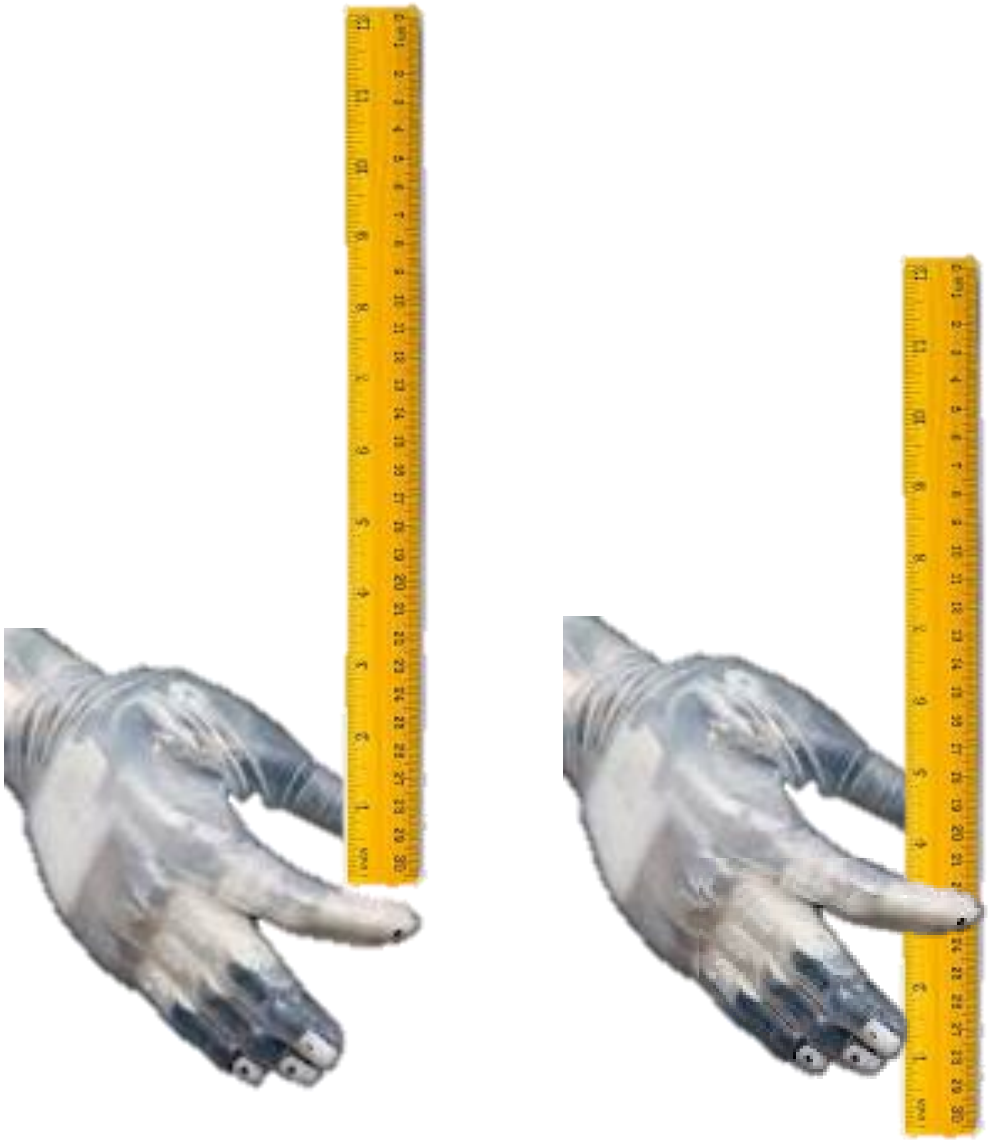
$$f = \left(\frac{(mv - mu)}{t}\right)$$

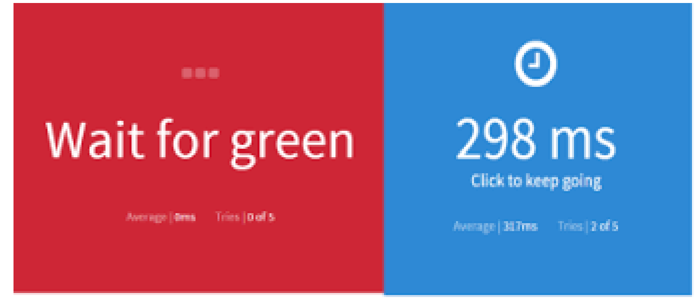
$$f = m \times \frac{(v - u)}{t}$$

$$f = \left(\frac{(mv - mu)}{t}\right)$$

$$f = \left(\frac{(\Delta p)}{t}\right)$$

2.27 Explain methods of measuring human reaction times and recall typical results





Testing reaction time:

Dropping a ruler and catching it:

The distance travelled can be converted into a reaction time.

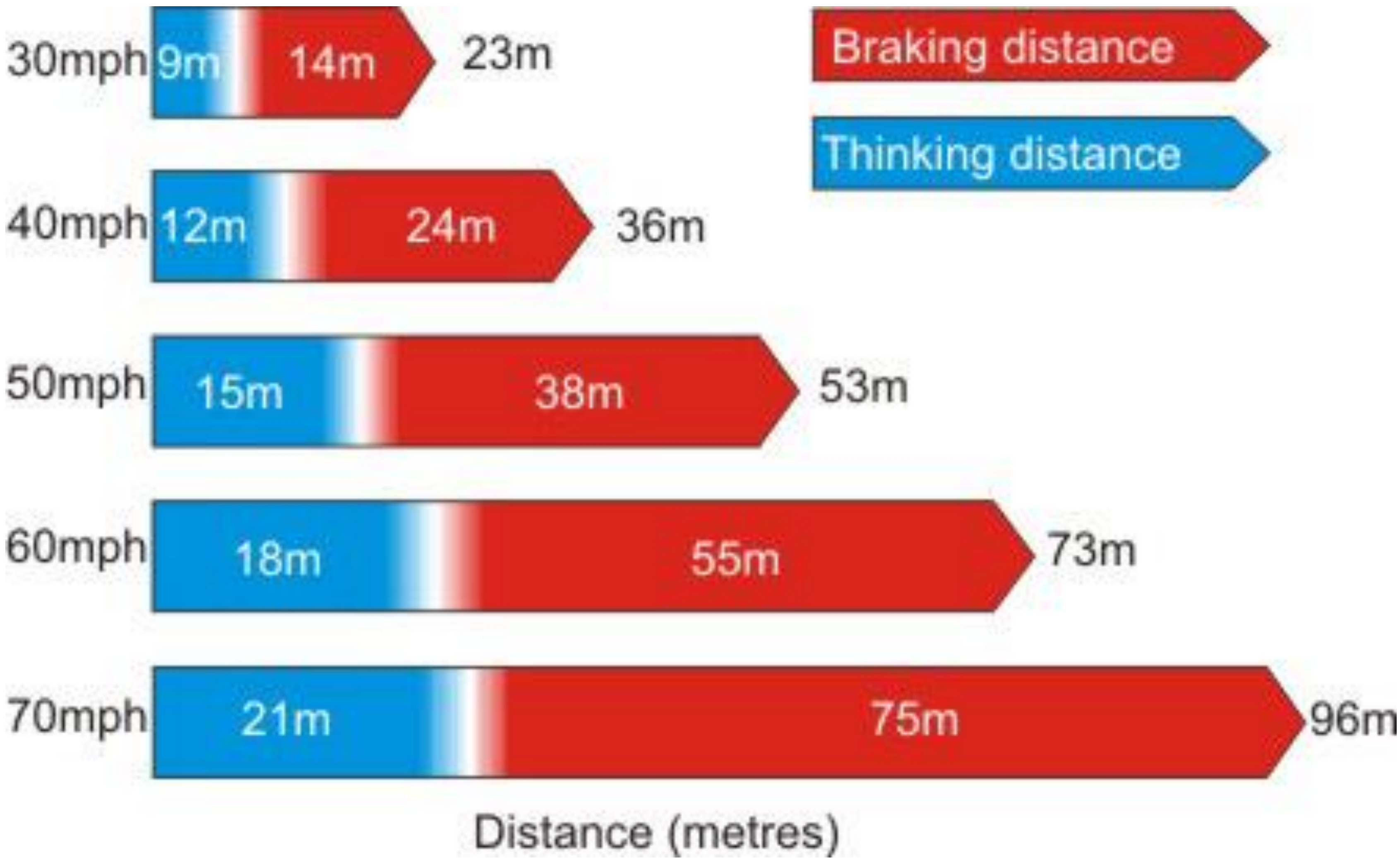
The quicker it's caught the faster the reaction time.

OR

Use an online timer. It makes you click and records the time between stimulus and reaction.

2.28 Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance

Stopping distance = thinking distance + braking distance



2.29 Explain that the stopping distance of a vehicle is affected by a range of factors including: a the mass of the vehicle b the speed of the vehicle c the driver's reaction time d the state of the vehicle's brakes e the state of the road f the amount of friction between the tyre and the road surface

Stopping distance = thinking distance + braking distance

The stopping distance is affected by many factors.

a the mass of the vehicle

b the speed of the vehicle

c the driver's reaction time

d the state of the vehicle's brakes

e the state of the road

f the amount of friction between the tyre and the road surface

2.29 Explain that the stopping distance of a vehicle is affected by a range of factors including: a the mass of the vehicle b the speed of the vehicle c the driver's reaction time d the state of the vehicle's brakes e the state of the road f the amount of friction between the tyre and the road surface

Factor Affecting Braking Distance	How this factor affects braking distance
Speed	Increasing speed increases braking distance
Weight of Vehicle	Increasing weight of vehicle increases braking distance
Icy Roads	Braking distance increases due to reduced friction between tyre and road
Wet Roads	Braking distance increases due to reduced friction between tyre and road
Poor Brake Condition	Braking distance increases
Bald Tyres	Braking distance increases when wet.







2.30 Describe the factors affecting a driver's reaction time including drugs and distractions

Stopping distance = thinking distance + braking distance

Factor	Affect on Reaction Time
Alcohol	Increases
Caffeine	Decreases
Tiredness	Increases
Distractions	Increases

2.31 Explain the dangers caused by large decelerations and estimate the forces involved in typical situations on a public road

When braking there is a force applied to the brakes. This reduces the kinetic energy of the vehicle and causes the brakes to heat up.

The faster a vehicle travels, the greater the braking force needed to stop it in a certain distance.

A greater braking force produces a greater deceleration.

Large decelerations may cause the brakes to overheat, and the driver may also lose control of the vehicle.

Topic 2 – Motion and forces

1. Define the term: scalar quantity
2. Define the term: vector quantity
3. Explain the difference between vector and scalar quantities
4. List some vector and scalar quantities
5. Define the term velocity
6. State the equation for acceleration
7. Describe three ways of measuring speed in a classroom.
8. State the general speeds of wind and sound, and for walking, running, cycling, driving and flying
9. State the acceleration due to gravity.
10. State Newton’s First law
11. State Newton’s second law. Include the general equation.
12. Define weight and include the equation.
13. Describe how weight is measured
14. Describe how changing mass changes acceleration.
15. Describe how to measure human reaction times.
16. State some typical reaction times in humans.
17. State the equation for stopping distance.
18. Describe some factors that affect stopping distance.
19. Describe some factors that affect human reaction time.

3.1 Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground:

Δ = Delta means change

$$\Delta GPE = m \times g \times \Delta h$$

- Change in GPE (J)
- Mass (Kg)
- Gravitational Field Strength (N/m^2)
- Change in height (m)

The blue box has greater GPE stores

True / False

3.2 Recall and use the equation to calculate the amounts of energy associated with a moving object:

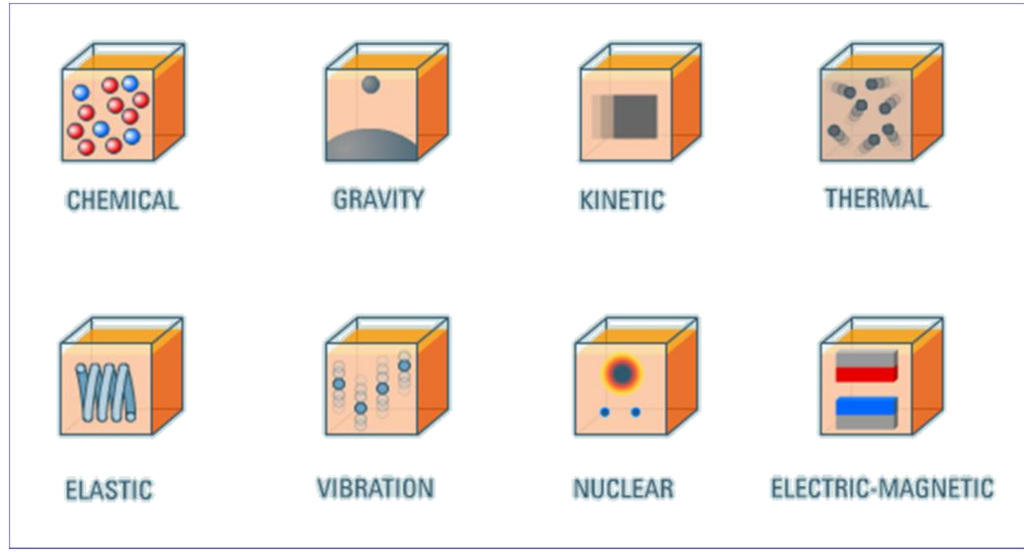
$$KE = \frac{1}{2} \times m \times v^2$$

Kinetic Energy (J) Mass (Kg) Velocity (m/s)

The elephant would hurt more True / False

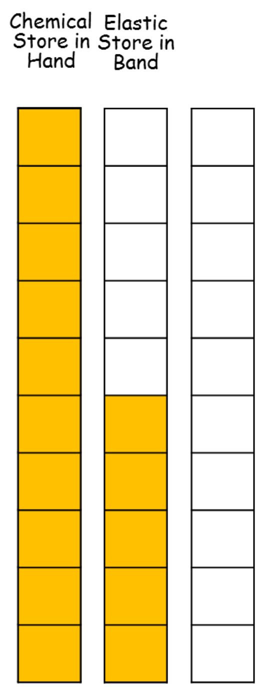
3.3 Draw and interpret diagrams to represent energy transfers

There are *processes* or *pathways* through which energy is shifted.

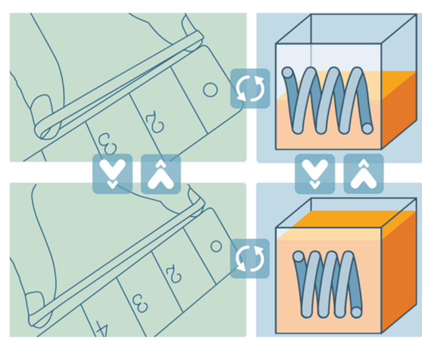


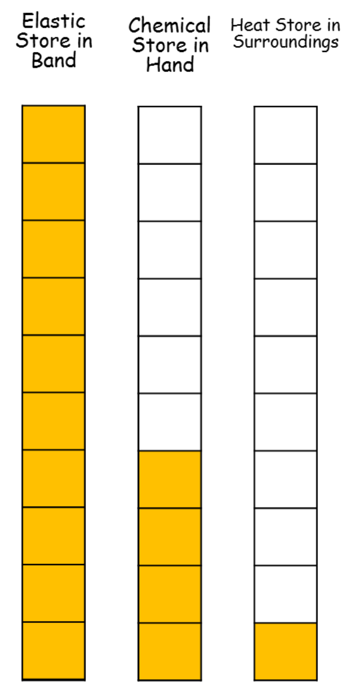
Energy can be shifted / transferred between stores by:

- Mechanical working (a force moves something)
- Electrical working (charge moves through p.d.)
- Heating by particles (conduction, convection)
- Heating by radiation (IR, light, other EM)
- Heating by vibration (air resistance, sound)



Describe the energy transfers in a stretching elastic band



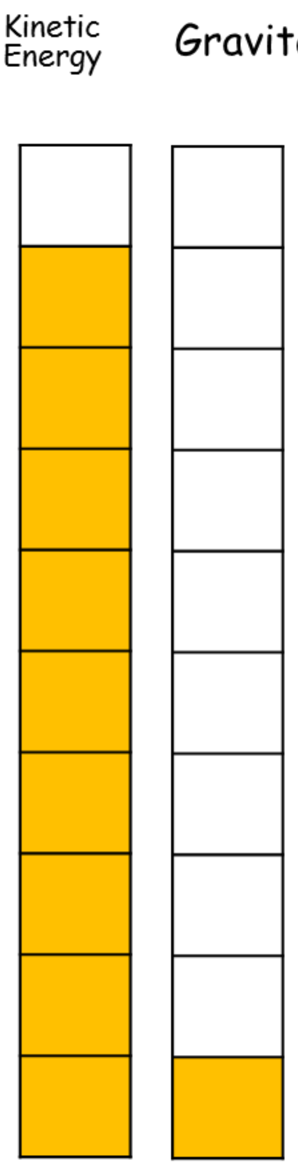


3.4 Explain what is meant by conservation of energy

The total amount of energy in a "closed system" does not change.

The STORES can change but they will always equal the original amount

3.5 Analyse the changes involved in the way energy is stored when a system changes,



<u>Describe the energy transfers in each of these situations</u>

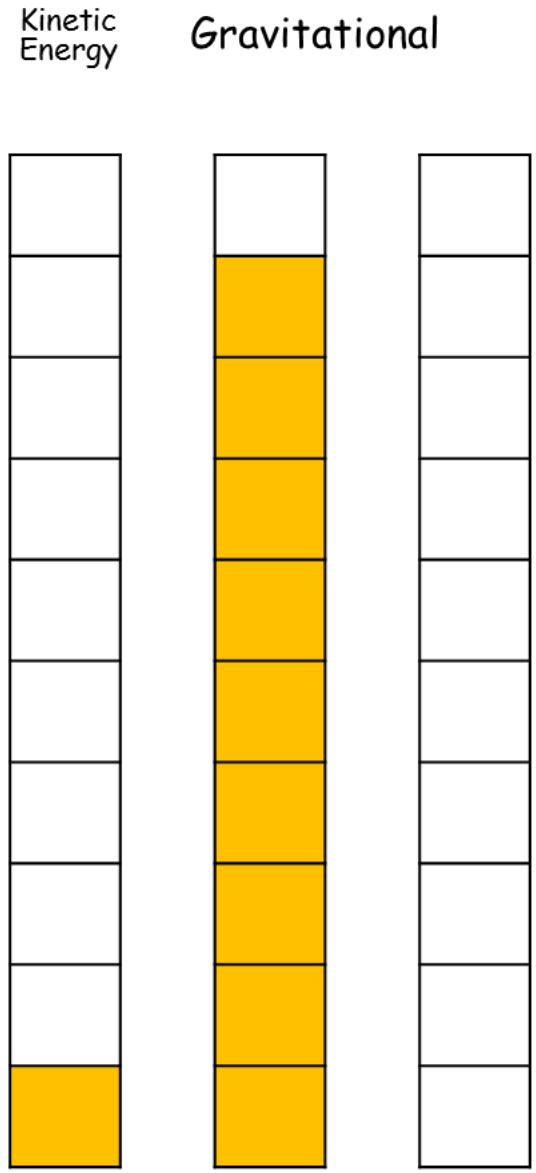
a) an object projected upwards or up a slope

b) a moving object hitting an obstacle

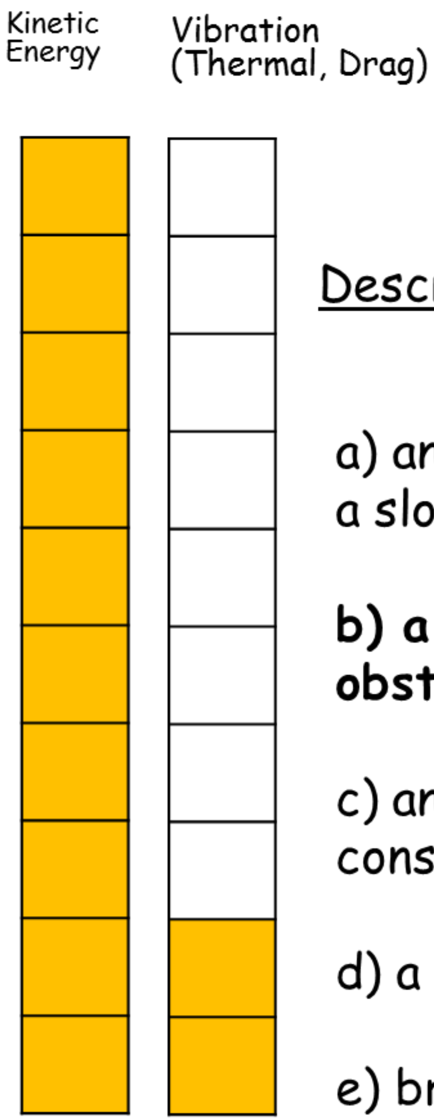
c) an object being accelerated by a constant force

d) a vehicle slowing down

e) bringing water to a boil in an electric kettle



3.5 Analyse the changes involved in the way energy is stored when a system changes,



<u>Describe the energy transfers in each of these situations</u>

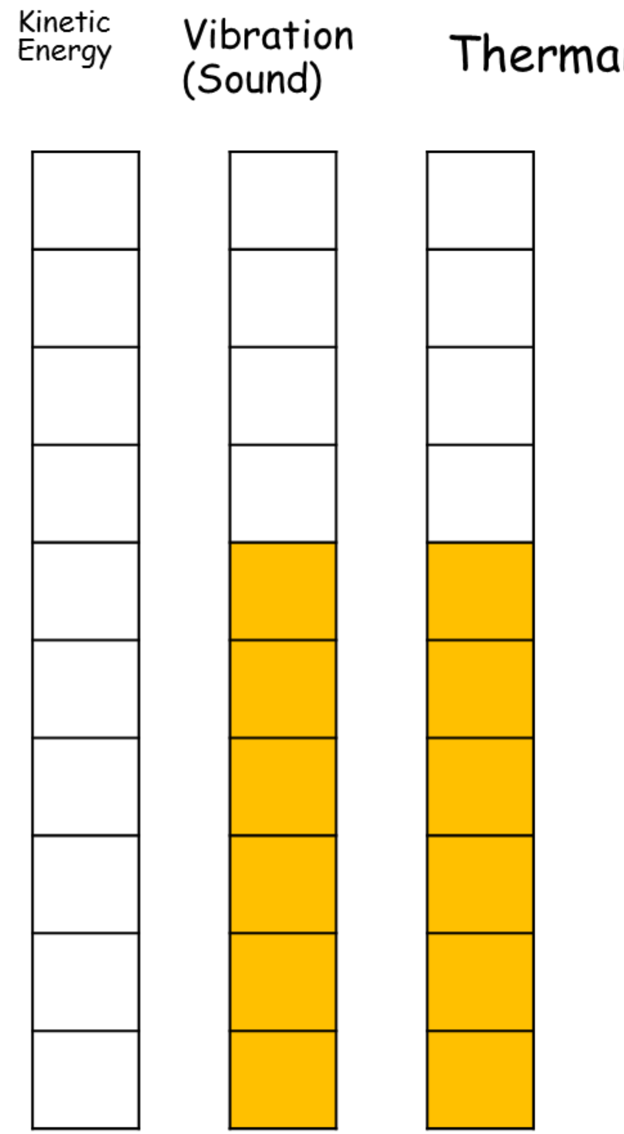
a) an object projected upwards or up a slope

b) a moving object hitting an obstacle

c) an object being accelerated by a constant force

d) a vehicle slowing down

e) bringing water to a boil in an electric kettle



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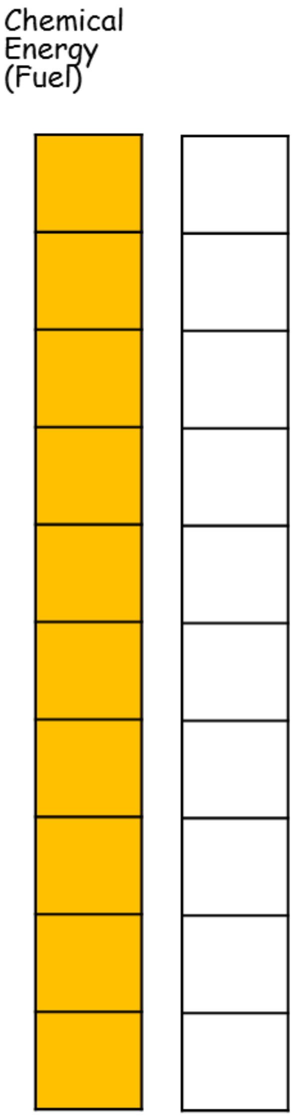

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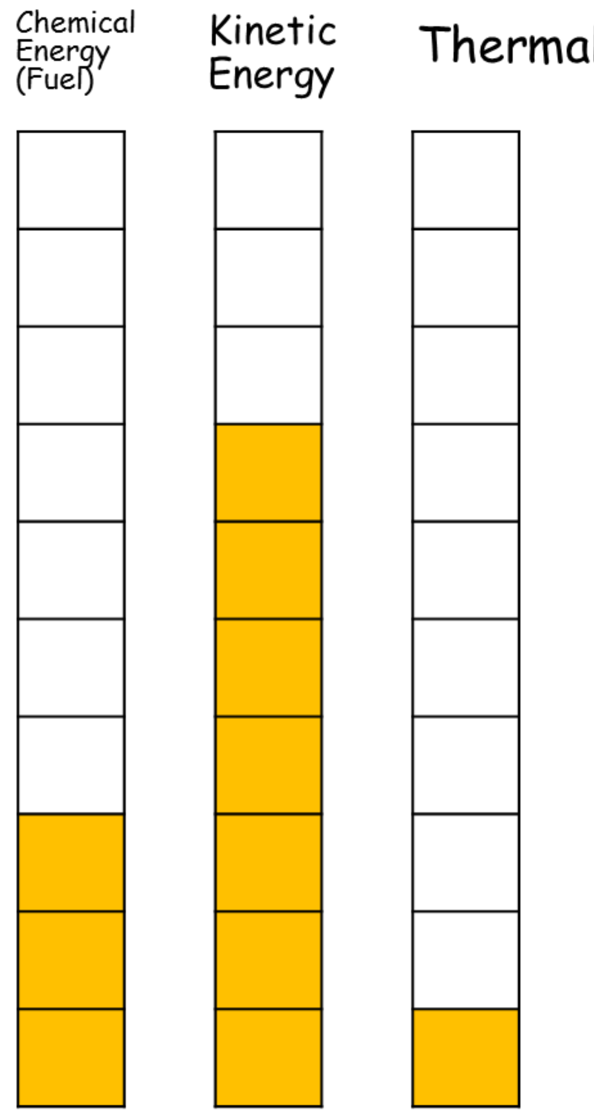

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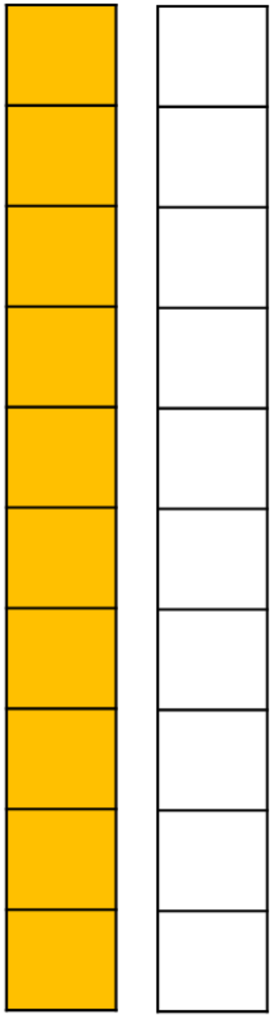
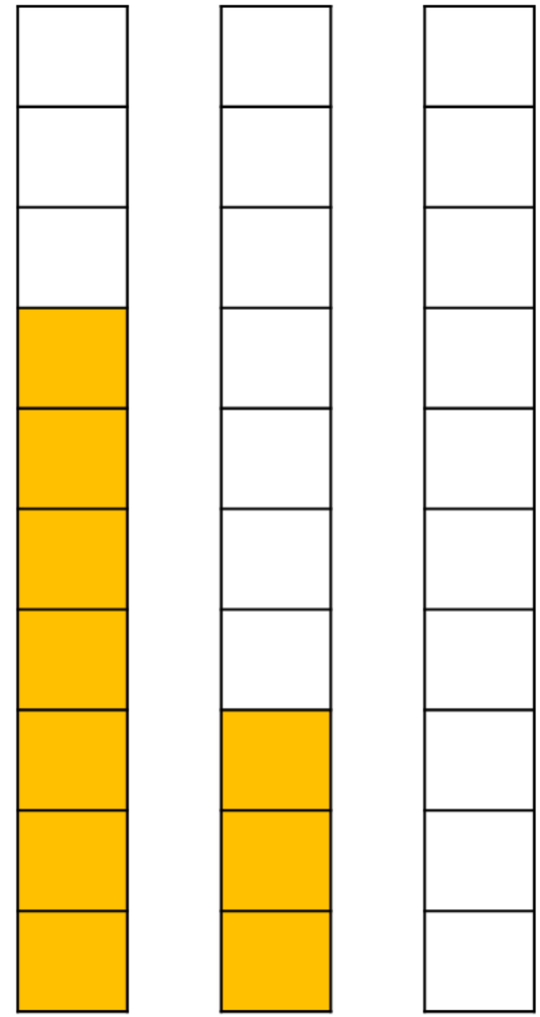
Kinetic energy



Kinetic energy

Thermal



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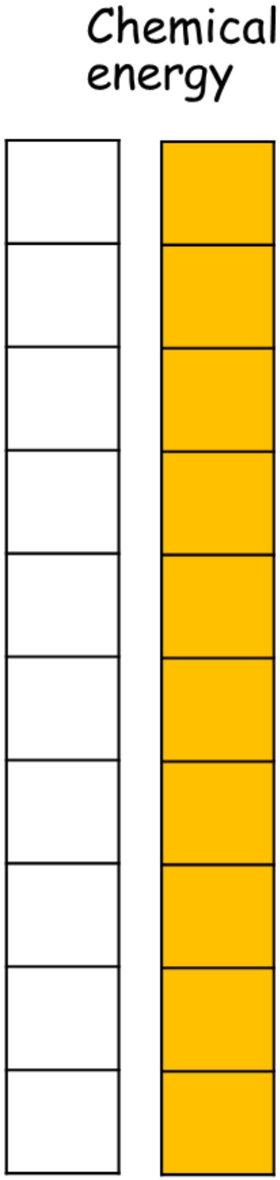

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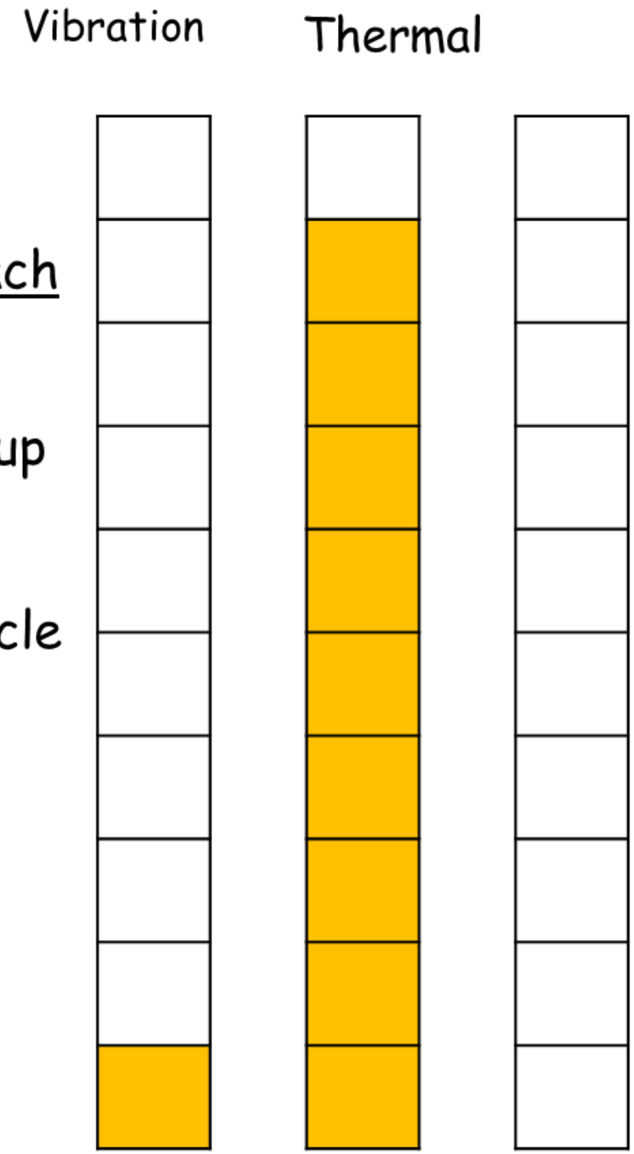
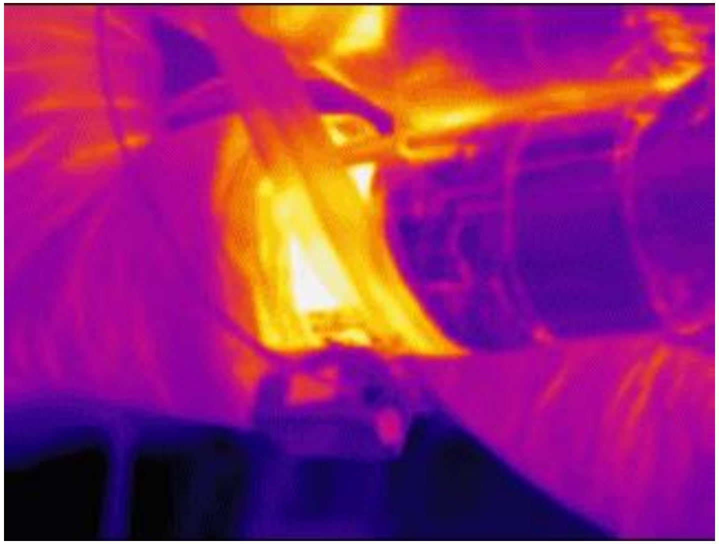
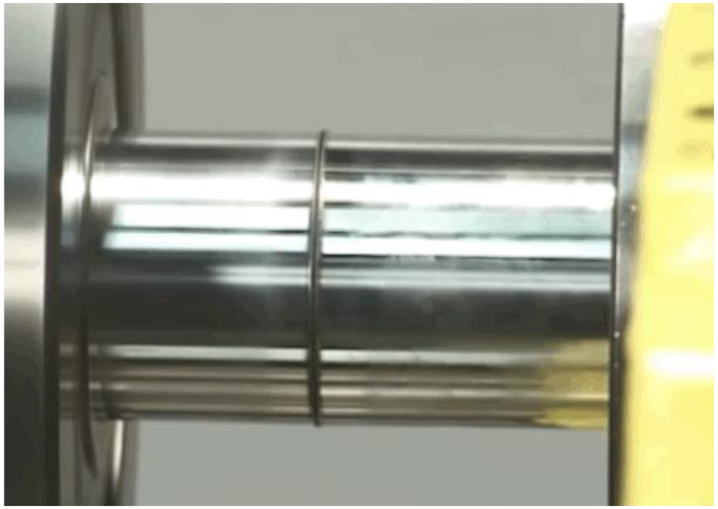


3.6 Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system

3.7 Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings





Unwanted energy transfers result in energy stores that are not useful.

In mechanical systems this is usually due to internal combustion or friction.

The waste energy that is dissipated is usually heat.

3.8 Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways

Different devices have different efficiency values. No device can be more 100% efficient.

Devices can waste in many ways, for example:

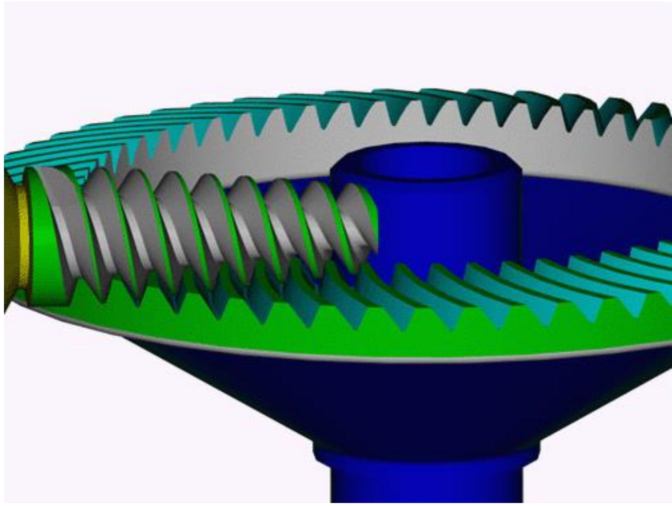
Friction (thermal energy) between the moving part of a car or motorbike

Sound energy when a hair drier is being used

Electrical circuits heating (thermal energy) up due to resistance

Thermal energy being lost from the roof or wall of a house

3.9 Explain ways of reducing unwanted energy transfer including through lubrication, thermal insulation



Mechanical devices can be made more efficient by lubrication this reduces energy transferred by friction
e.g. engine oil

Having good insulation reduces the rate of thermal energy transfers
e.g. loft insulation

3.10 Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling qualitatively

Thermal insulation is often used to reduce unwanted energy transfers.

All the energy used to heat a home is eventually transferred as thermal energy to the surroundings.
The diagram, shows the percentage energy lost through different parts of the building.

Material	Thermal Conductivity W/m C
Air	0.03
Polyurethane foam	0.03
Fibreglass	0.04
Wool felt	0.05
Wood	0.15
Plaster	0.50
Glass	0.80
Brick	1.00
Concrete	1.04

The higher the thermal conductivity, the quicker heat is transferred through the material.

Houses are often built from brick, concrete, wood and glass. All have quite high thermal conductivity values. Insulation uses materials with low thermal conductivity, such as fibreglass in the loft, foam in wall cavities and trapped gases in double glazing.

3.11 Recall and use the equation for efficiency

The amount of useful energy you get from an energy transfer, compared to the energy put in, is called the EFFICIENCY

This calculation will result in a decimal value which can be multiplied by 100 to give a percentage efficiency.

Efficiency = (useful energy transferred by the device) / (total energy supplied to the device)

The wind turbine produces 120 MW of electrical energy for every 500 MW of kinetic energy provided by the wind.

Efficiency = (useful energy transferred by the device) / (total energy supplied to the device)

$$= \frac{120}{500} = 0.24 \text{ efficient}$$

or 0.24 x 100 = 24 % efficient

3.12 Explain how efficiency be increased

To increase efficiency, more useful energy needs to be transferred.
This means reducing wasted energy.
Energy is usually wasted as dissipated heat.

$$Useful\ energy = Total\ energy\ - wasted\ energy$$

$$efficiency = \frac{useful\ energy\ transferred}{total\ energy\ transferred}$$

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

ENERGY RESOURCES	
Non-renewable	
Coal	Fossil fuels They are becoming more difficult to find and extract
Oil	
Gas	
Nuclear	Plentiful but difficult to extract / purify
Renewable	
Bio-fuel	Plant matter usually used as a fuel
Wind	Turbines spin a generator to produce electricity
Hydro-electric	Falling water spins a turbine to produce electricity
Tides	Rise and fall of the tide can be used to turn a turbine
Sun	To directly heat things or produce electricity

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

Non-renewable energy sources are those which will **eventually run out** – there is a finite supply. New supplies are more difficult to find and extract.
Renewable energy sources are those which can **replenish themselves in the short term**, and so will never run out.
Nuclear energy resources are technically non-renewable but they can be produced on an almost indefinite basis.

How energy resources are used.
Transport – cars, trains, buses, planes etc.
Electricity generation – industry, homes, commerce, lighting etc.
Heating – homes, industrial processes, schools and hospitals etc.

Energy use is usually divided between the four economic sectors - **residential**, **commercial**, **transportation**, and **industrial**.

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

Coal	**Coal is mined then burnt to provide heat or used to generate electricity.**	**Large reserves of coal which are relatively inexpensive to mine.** **All major coal mines have now closed in the UK.**	**Coal mining is dangerous and burning coal contributes to global warming.**
Oil	**Frequently burnt to produce electricity.** **Large quantities of oil are refined to provide fuels for transport.**	**Large reserves becoming more difficult to find and extract.** **Transport and refinement are relatively easy.**	**Oil reserves becoming more difficult to find and extract.** **The need for oil in developed countries means supplies are politically sensitive.** **Releases greenhouse gases when burnt.**

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

Gas	Extracted from underground gas fields sometimes alongside oil extraction. Mainly used for electricity production, domestic heating and industrial processes that require heat.	Cleaner than burning oil or coal. Relatively easy to transport and store.	UK has good gas reserves but extraction is expensive (often under the sea) and becoming more difficult to reach.
Nuclear	Nuclear supplies (Uranium) are mined and purified. The nuclear fission releases heat which is used to produce steam. This spins a turbine and generator to make electricity	Potentially in-exhaustable energy supply even though it is extracted form resources in the ground. Very efficient process which produces lots of electricity from little nuclear fuel.	Danger of nuclear accidents releasing radioactive materials into the air or water. Security of nuclear sites can be a problem. Start-up costs and decommissioning are very expensive and no real solution to managing radioactive waste has been found.

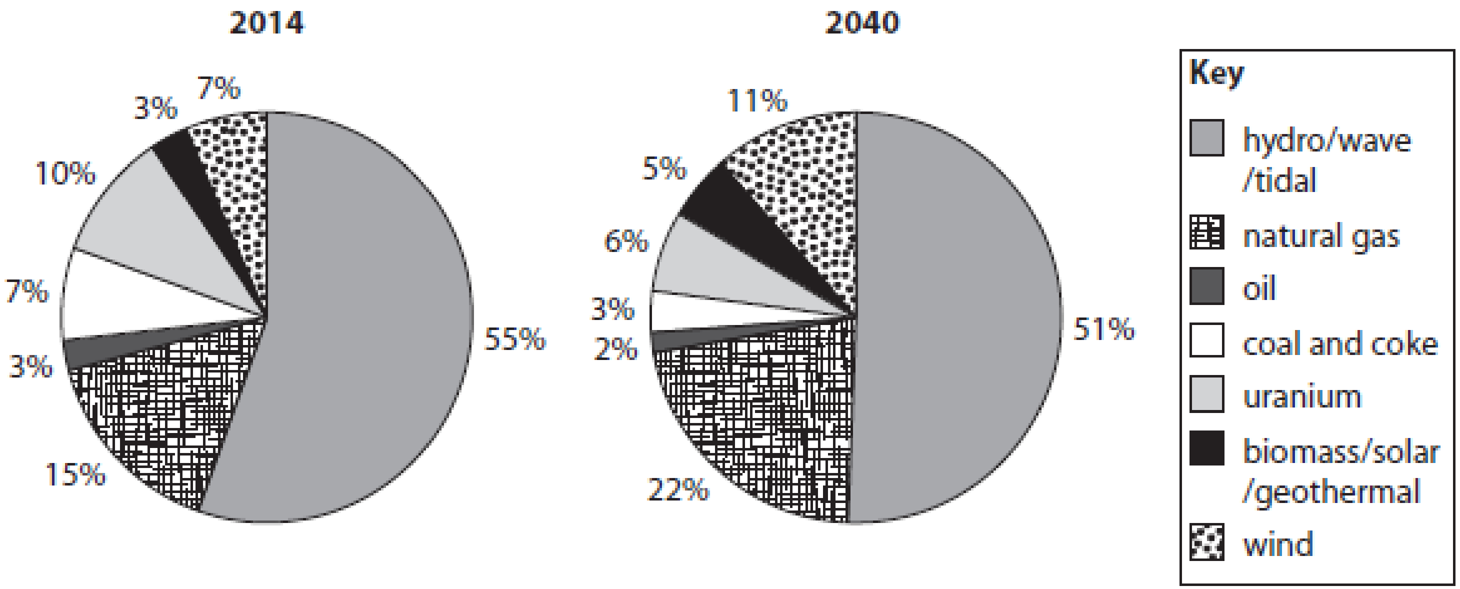
3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

Solar	**Energy from sunlight is captured in photovoltaic cells and converted into electricity. Hot water from solar panels**	**Renewable energy resource. Individual houses can have their own electricity/hot water supply.**	**Manufacture and installation of solar panels/cells can be costly.**
Wind	**Wind turbines turn wind energy into electricity by turning a generator.**	**Renewable energy resource and can be used as individual units.**	**Manufacture and installation of wind farms can be costly. Some consider an eyesore.**
Tidal	**The movement of tides drives turbines. A tidal barrage is built across estuaries to trap water.**	**Ideal for an island such as the UK to potentially generate a lot of energy. Tidal barrage can help prevent flooding.**	**Construction of barrage is very costly and can impact on wildlife. Only a few estuaries are suitable.**

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro- electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

Hydroelectric Power (HEP)	**Energy harnessed from the movement of water through rivers, lakes and dams. Used to turn turbines for electricity production.**	**Creates water reserves as well as energy supplies.**	**Costly to build. Can cause the flooding of surrounding communities and landscapes.**
Biomass	**An organic material, which can be burned to provide energy, eg heat or electricity. After treatment with chemicals it can be used as a fuel in vehicle engines.**	**It is a cheap and readily available source of energy. If replaced, biomass can be a long-term, sustainable energy source.**	**When burned, it gives off greenhouse gases. Growing takes up large amounts of arable land..**

3.14 Explain patterns and trends in the use of energy resources



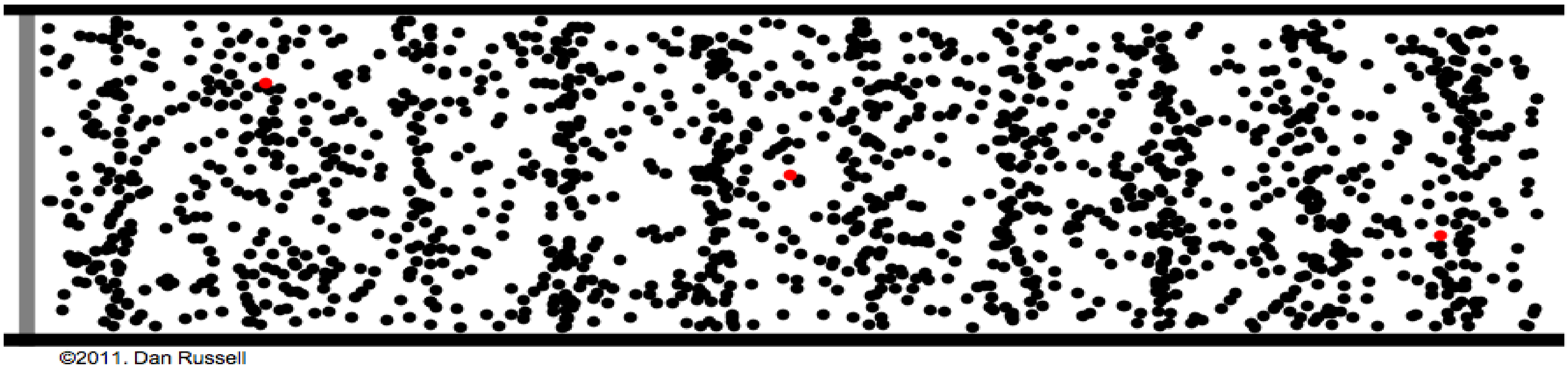
Non-renewable resources are increasing global warming and lead to much air pollution.
The non-renewable resources are also running out.

Alternative energy resources are being developed and are replacing traditional resources.
This is causing an increase in the percentage of renewable resources and decreasing the percentage of non-renewable resources.

Topic 3 – Conservation of energy

1. State the equation for gravitational potential energy.
2. State the equation for kinetic energy.
3. Describe the law of conservation of energy.
4. Describe the meaning of a closed system.
5. Describe what is meant by wasted energy.
6. Describe what happens to wasted energy.
7. Define the term dissipated.
8. Describe the effect of lubrication on energy dissipation.
9. Describe the effect of insulation on dissipation.
10. State the equation for efficiency
11. Describe how to increase efficiency (lubrication and insulation)
12. Define non-renewable energy
13. Define renewable energy
14. Describe 4 non-renewable energy sources
15. Describe 8 renewable energies.

4.1 Recall that waves transfer energy and information without transferring matter



Follow the red dot with your eyes.

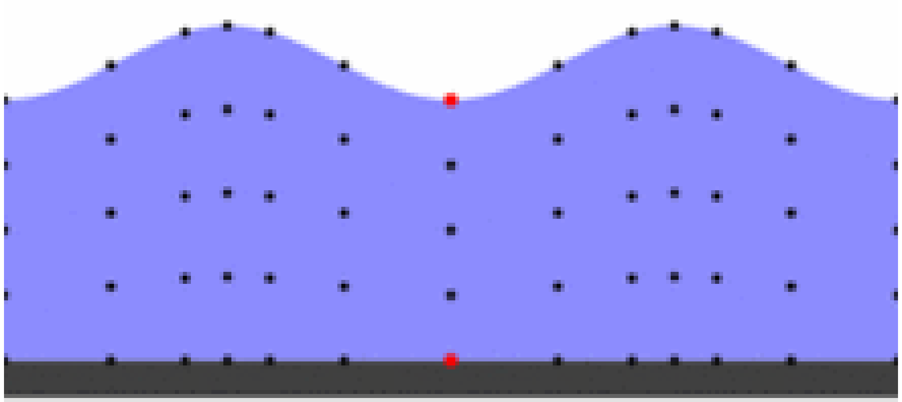
It OSCILLATES (vibrates) but does not move away from it's original place.

4.2 Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels

Water Waves

- If you throw a small rock into a duck pond (obviously avoiding the ducks)
- You will see **ripples** form and **move** across the waters surface
- The ripples cause water particles to vibrate up and down
- The duck does not get carried to the edge of the pond it just bobs up and down

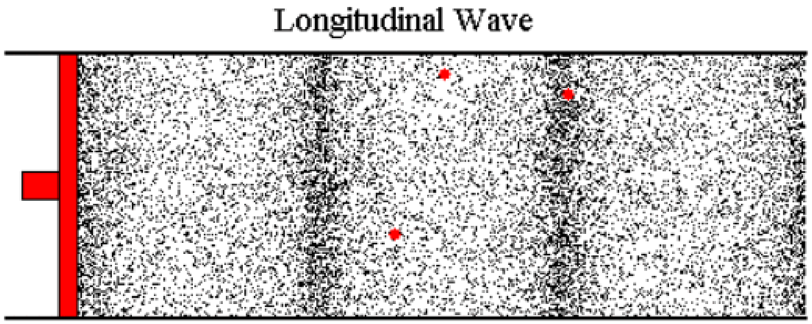
In this GIF the red dot represents the duck



Sound waves

- If you hit a drum you will create a **sound wave**
- The sound wave travels to your ear and you hear the drum sound
- Sound waves cause **air particles** to **vibrate back and forth**
- The air particles do not travel from the drum to your ear
- Only **energy** is transferred and **not** the particles

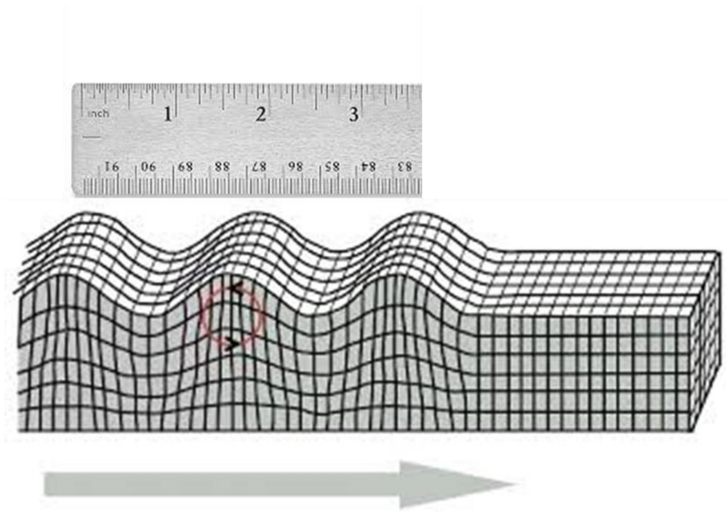
In this GIF the red dots represents air particles



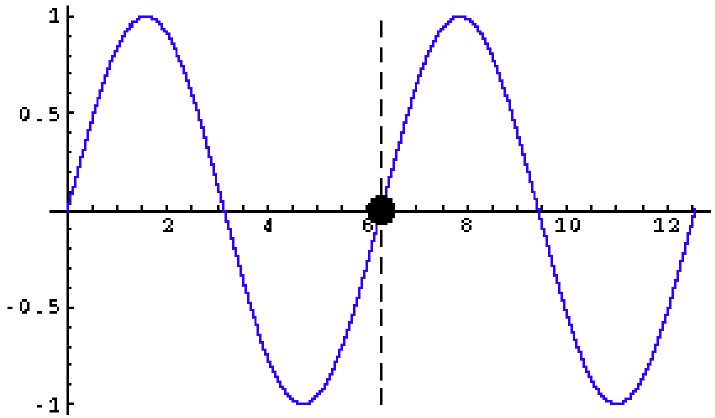
4.3 Define and use the terms frequency and wavelength as applied to waves

Frequency – the number of waves that pass a point per second.
How frequently did the buses pass the stop.

Wavelength – the distance between two points in waves
What is the wavelength of this earthquake?

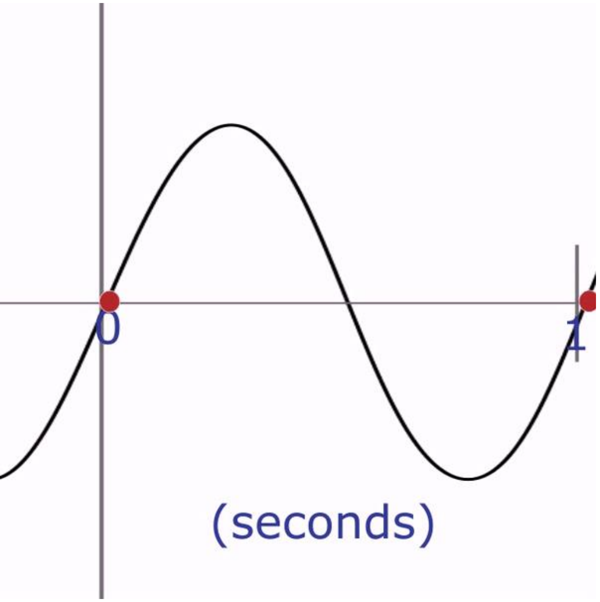


4.4 Use the terms amplitude, period, wave velocity and wavefront as applied to waves



Amplitude is how much the particle oscillates or how much energy is in an EM wave.

Look at the Y-axis, what is the amplitude. The scale is in meters.



The wave period is how long it takes one full wave to pass a certain point.
The equation is 1 / Frequency

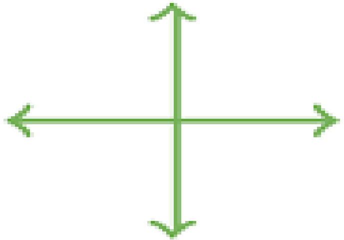
What is the period of this wave?

4.5 Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves

Waves can oscillate up and down or side to side.

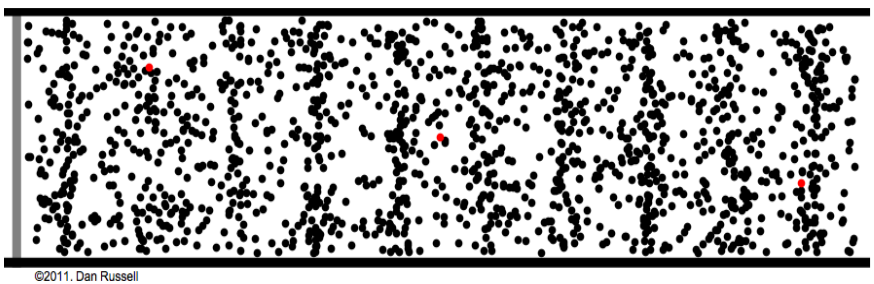
Up and down waves oscillate perpendicular to the direction of the wave

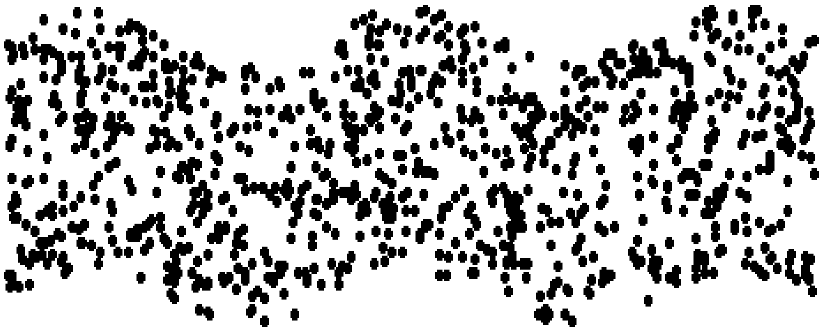
Side to side waves oscillate parallel to the direction of the wave.



Longitudinal
Parallel to direction of travel

Transverse
Perpendicular to direction of travel





4.6 Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) ´ wavelength (metre, m) v = f ´ l wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) v = x t

Wave velocity can be calculated using two equations.

Velocity (v) = frequency (f) × wavelength (λ)

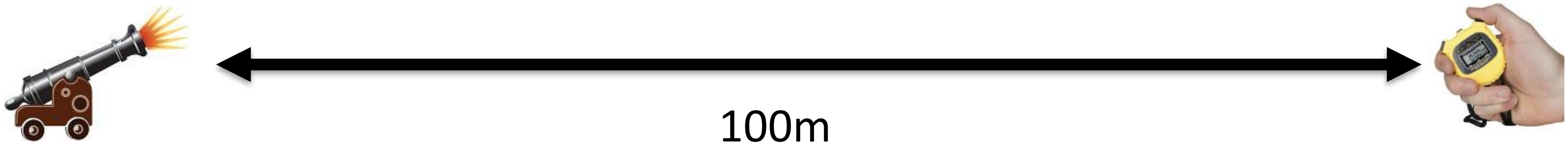
$$v = f \; x \; \lambda$$

And

Velocity (v) = distance (X) ÷ time (t)

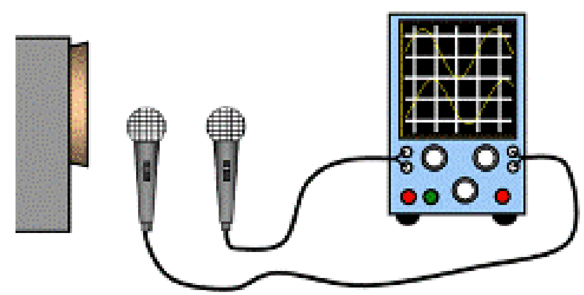
$$v = \frac{X}{t}$$

4.7 Describe how to measure the velocity of sound in air and ripples on water surfaces



The cannon fires and the stopwatch is started (you can see a flash of light which takes almost zero time to travel 100m). When the sound reaches the observer the stopwatch is stopped. The time was **0.3s** This will give the time for sound to travel **100m**.

In the laboratory, a sound from a loudspeaker passes two microphones a set distance apart. The time recorded for the sound to travel this distance is measured and speed is calculated using the same formula as above.

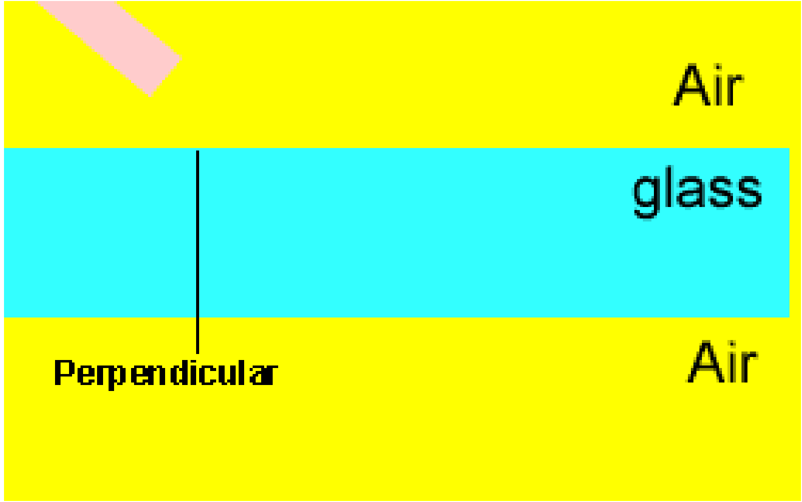


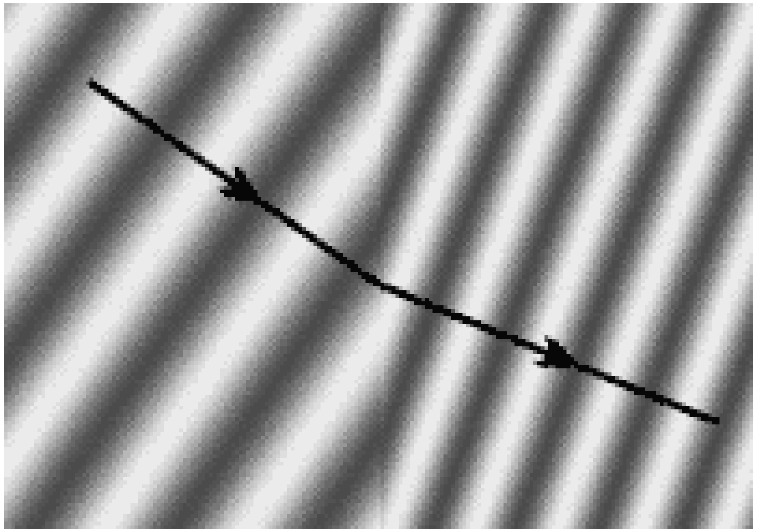
4.7 Describe how to measure the velocity of sound in air and ripples on water surfaces

- Place the first student at point A with the starting pistol.
- Use the trundle wheel to mark out 100m to point B.
- Place the second student at point B with a stopwatch.
- Student at point A fires the starting pistol.
- When students at point B sees the light, they start the stopwatch.
- When student at point B hears the shot they stop the stopwatch.
- Use v= X / t to find the time.

- Place a traffic cone at point A.
- Use a trundle wheel to mark out 20m and place another cone at point B.
- Count the number of waves that pass point A in 10 seconds. Divide by 10 to get the frequency.
- Take a photo of the waves between A and B. Use the scale of 20m to get a wavelength, measuring from tip to tip.
- Use $v=f \times \lambda$

4.10 Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**





Light wave fronts at an angle hit the new medium at different times and change speed and direction.

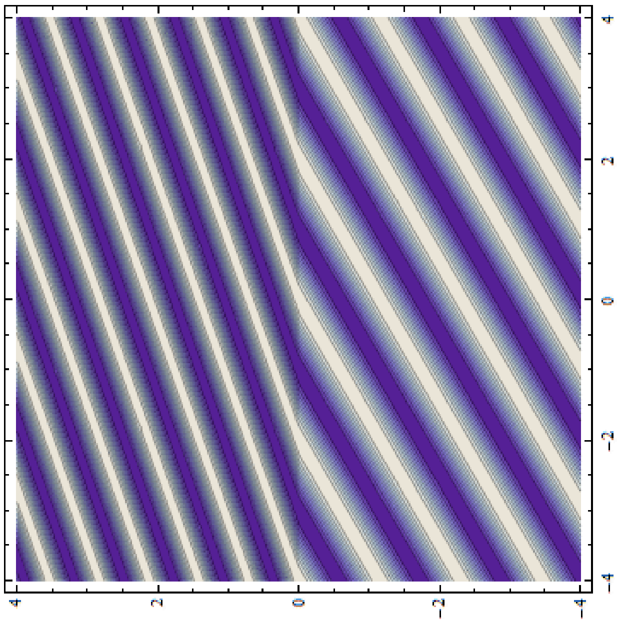
The speed changes, as does the wavelength, but the frequency does not.

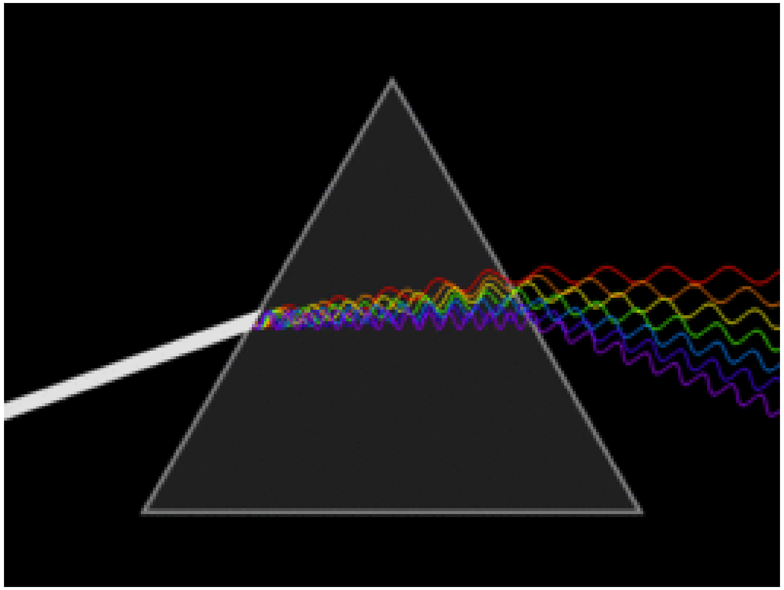
4.11 Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength

White light is made up of a mixture of colours.

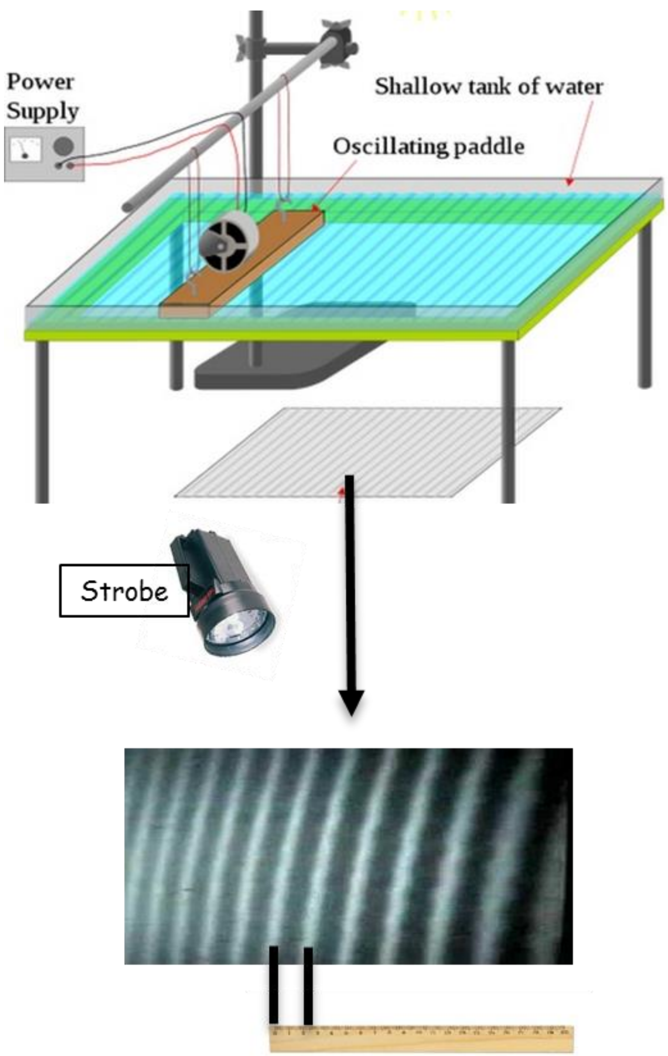
Different colours have different wavelengths. Red light has a longer wavelength than blue light. Red wavelengths travel faster through dense mediums than blue wavelengths.

This is why blue light refracts more than red.





4.17 *Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*



A ripple tank is used to make waves which are seen under the glass tank.

A strobe light has its frequency of flashes adjusted until the wave appears stationary – this is the frequency of the water wave.

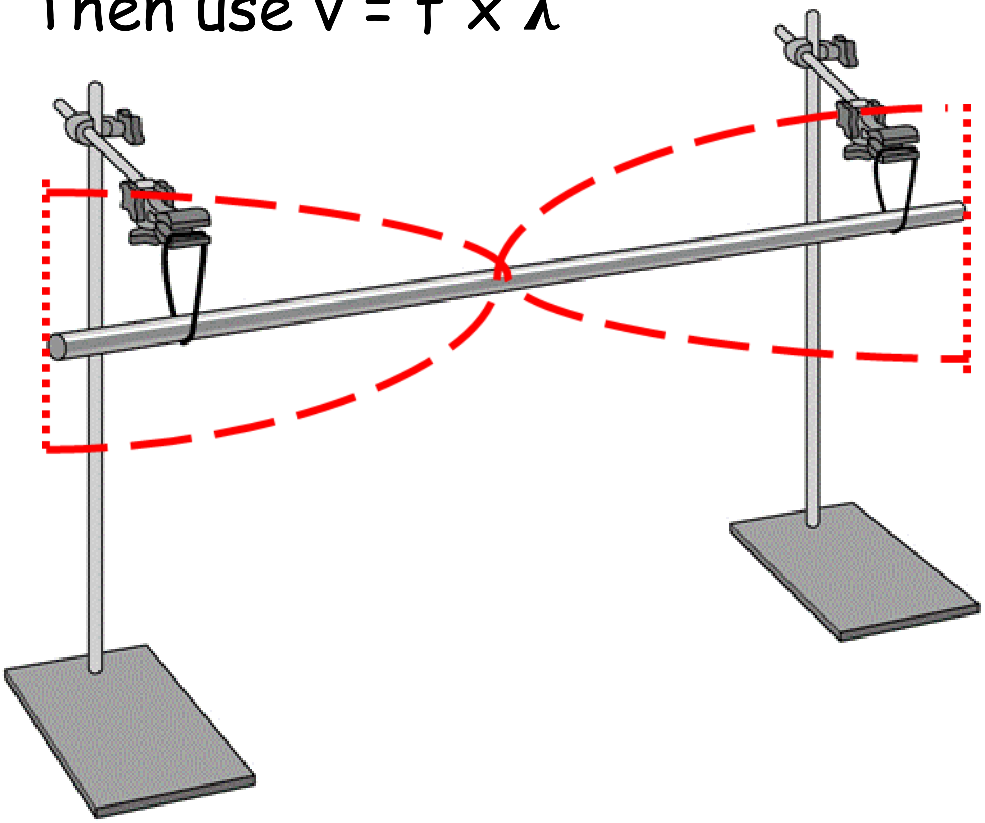
Then, the wavelength of the water wave is measured by using a ruler to measure the distance from one peak to the next peak (white line to white line). This is converted to metres.

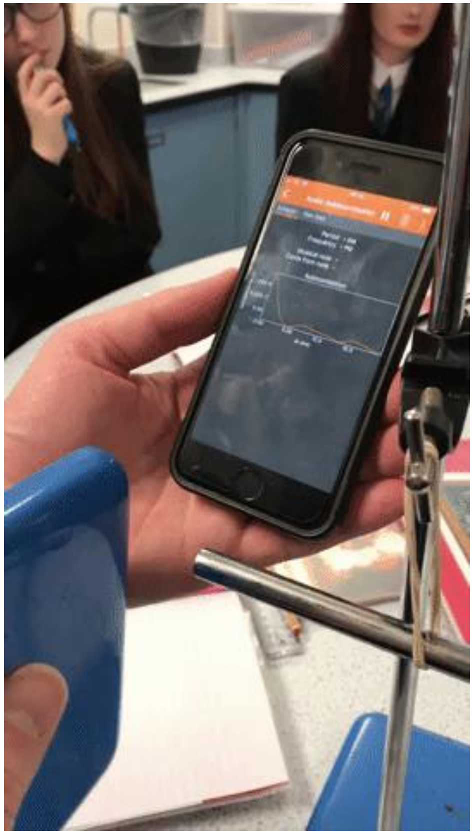
Wave speed (m/s) = Frequency (Hz) x Wavelength (m)

The ripple tank works the same way as this video. The light is a strobe light, it can turn on and off very fast. This means we can measure the wavelength easily with a ruler.

4.17 Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid

To measure the wavelength of the bar, you measure the length and multiply by two.
The is because the wave in a solid is called a "standing wave".
This means that the wave has echoes that make measuring the wave predictable.
Then use $v = f \times \lambda$

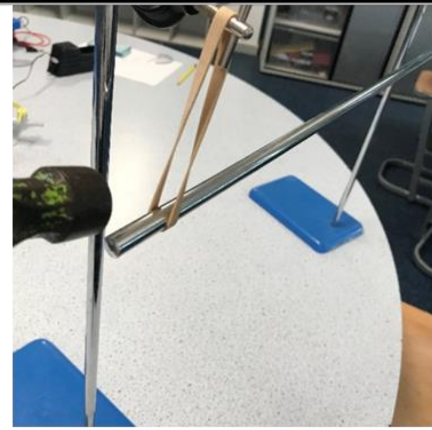




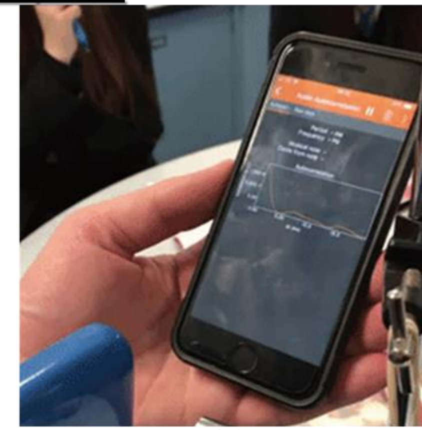
4.17 *Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*

Core practical 2: Measuring waves in solids and liquids

Hang a metal bar on rubber bands to allow it free movement. Measure the bar. The wavelength is twice the bar length

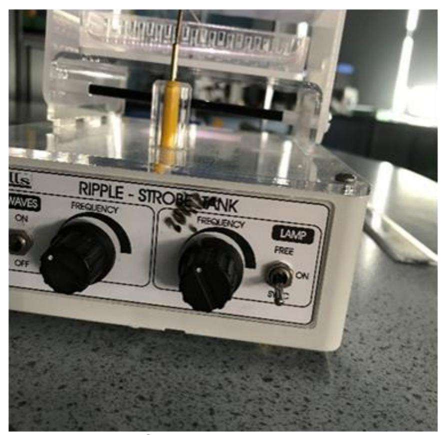


Hit the bar with a metal headed hammer, this will cause a sound wave to be created.

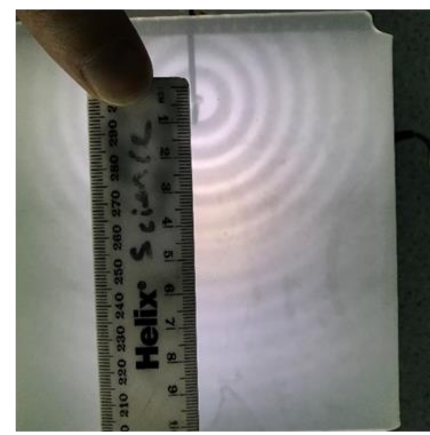


Use an app like "Phyphox" to measure the frequency of the wave. Use $v = f \; x \; \boldsymbol{\lambda}$

Set up the ripple tank with a synchronous strobe light so the waves appear stationary.



Use a known frequency on the wave generator by adjusting the knob.

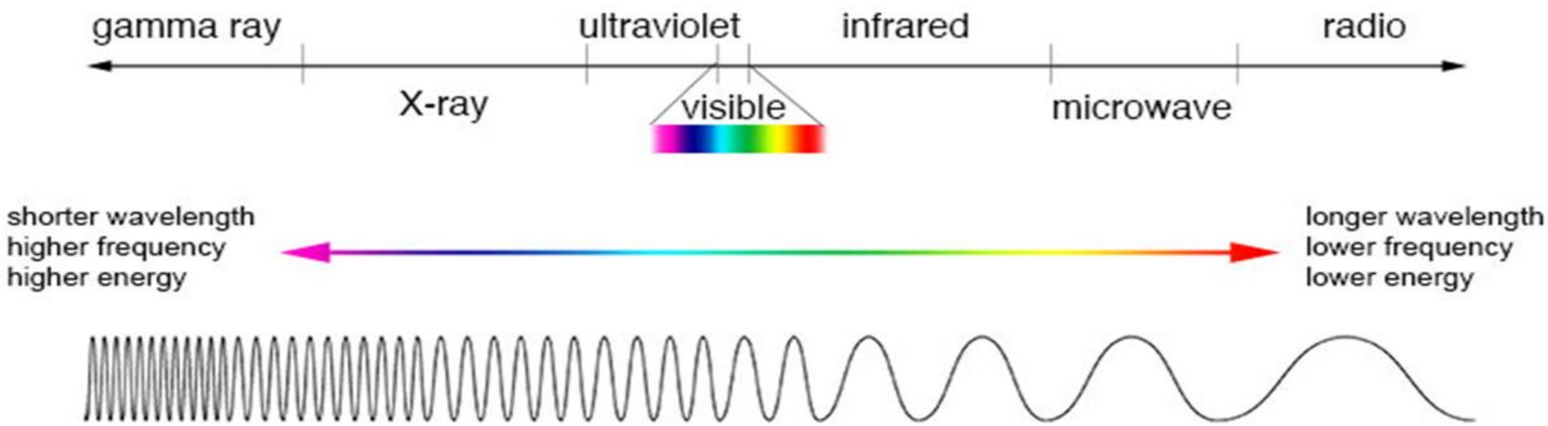


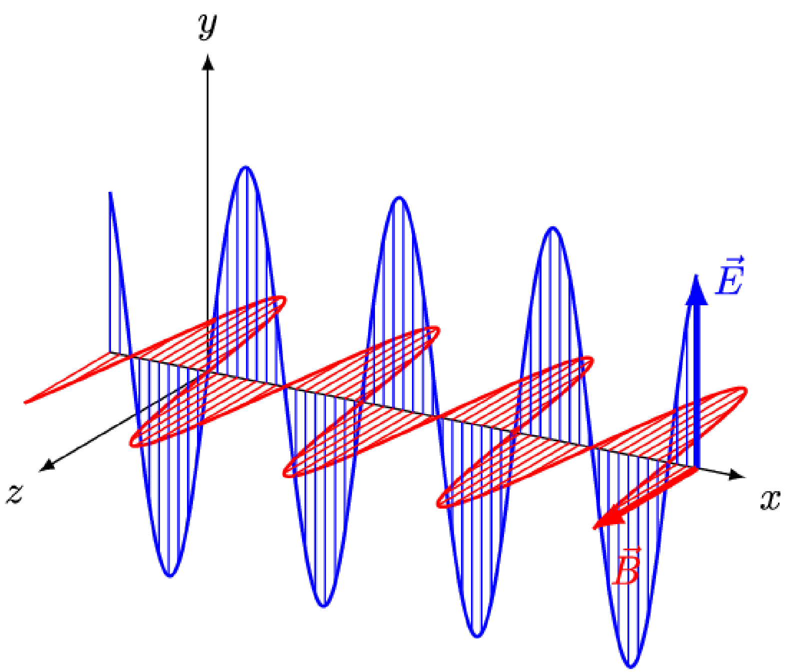
Measure the wavelength with a ruler. A callipers would be more accurate.

Topic 4 – Waves

1. Waves transfer _____________ and _____________ without transferring ____________
2. Define the term wavelength
3. Define the term frequency
4. Define the term amplitude
5. Define the term period
6. Define the term wave velocity
7. Describe longitudinal waves
8. Describe transverse waves
9. State whether these are longitudinal or transverse: sound, EM, P waves, S waves and water waves.
10. State the equation for wave speed when you have frequency and wavelength
11. State the equation for wave speed when you have distance and time
12. Define the term refraction
13. Describe what happens to the wave speed of different wavelengths when travelling through glass.
14. Describe how to measure angles of light rays
15. Define the term normal line
16. Define the term angle of refraction
17. Define the term angle of incidence.

5.7 Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum

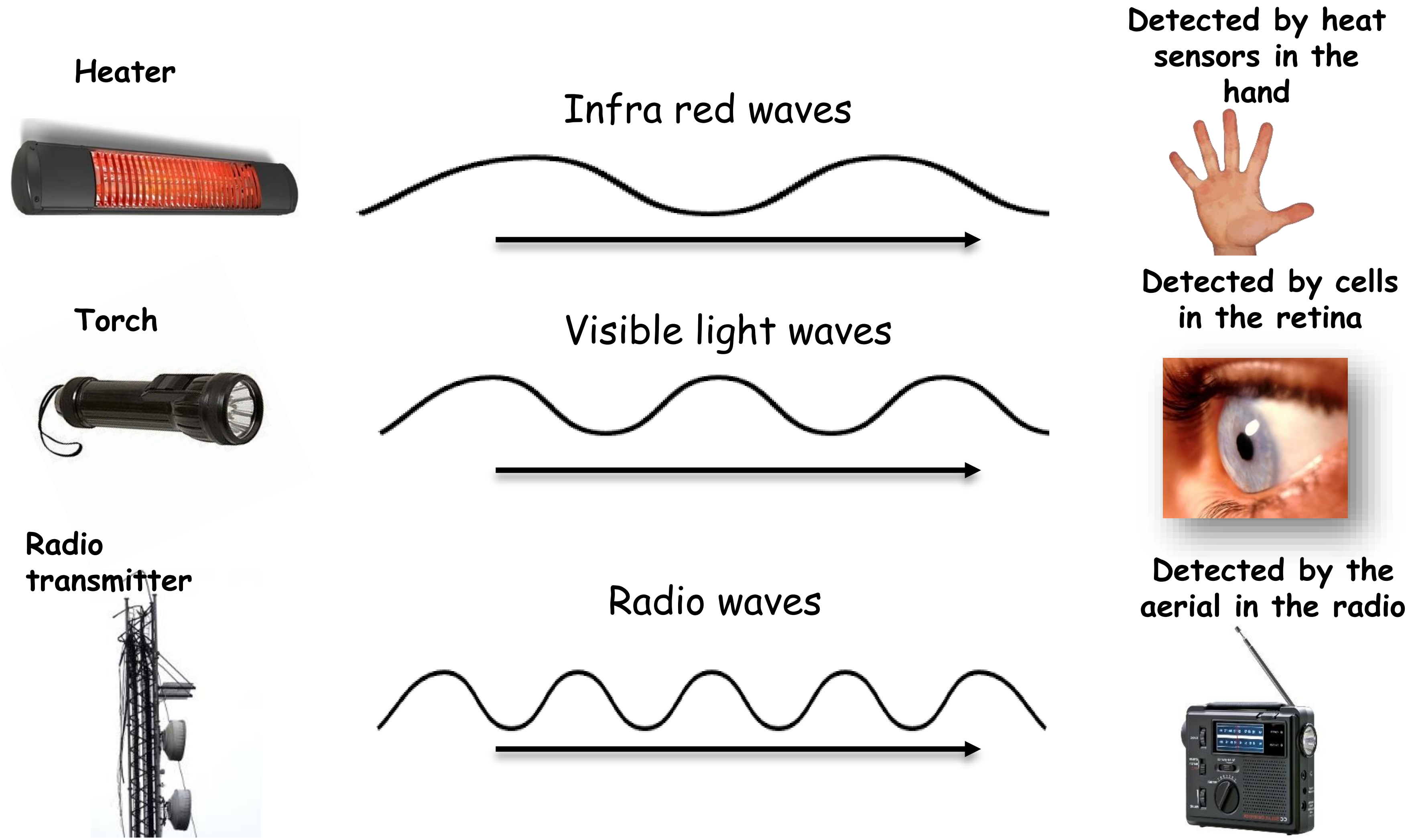




Electromagnetic waves are transverse waves that transfer energy from the wave source to an absorber.

All electromagnetic waves travel at the same velocity in a vacuum: 300 000 000m/s.

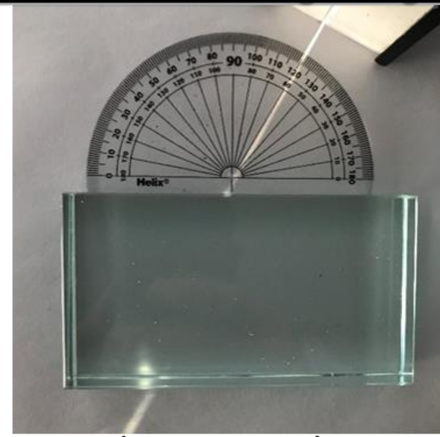
5.8 Explain, with examples, that all electromagnetic waves transfer energy from source to observer



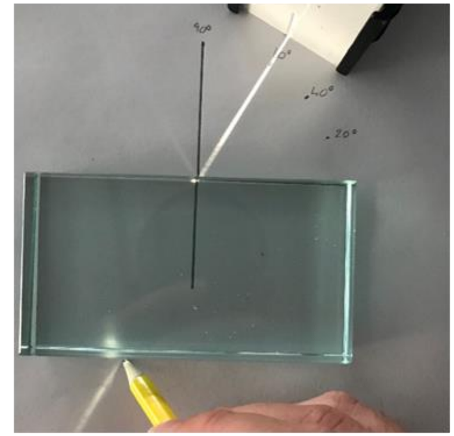
5.9 Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter

Core practical 3: Investigating refraction

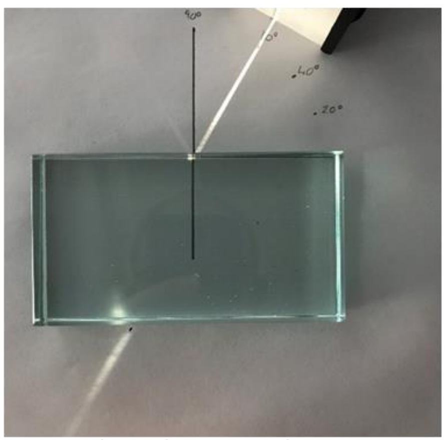
Draw a normal line. This is 90° to the medium boundary. Mark a spot on the boundary that the normal intersects



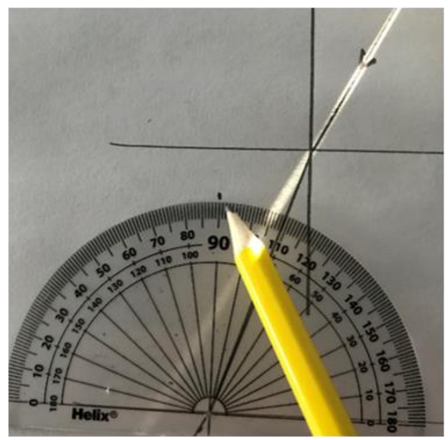
Mark out angles at 20° intervals from the normal using a protractor.



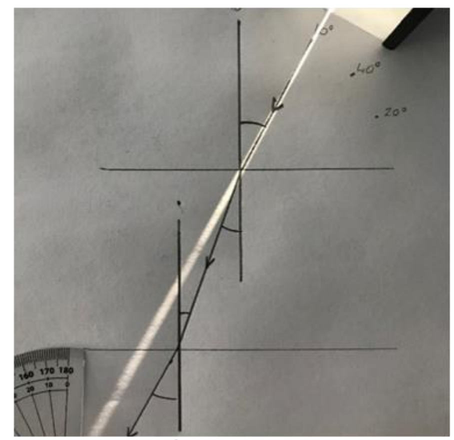
Shine the ray from the marked angles to the first spot on the boundary of the medium.



Mark where the ray exits the medium at two points so you can draw a line.

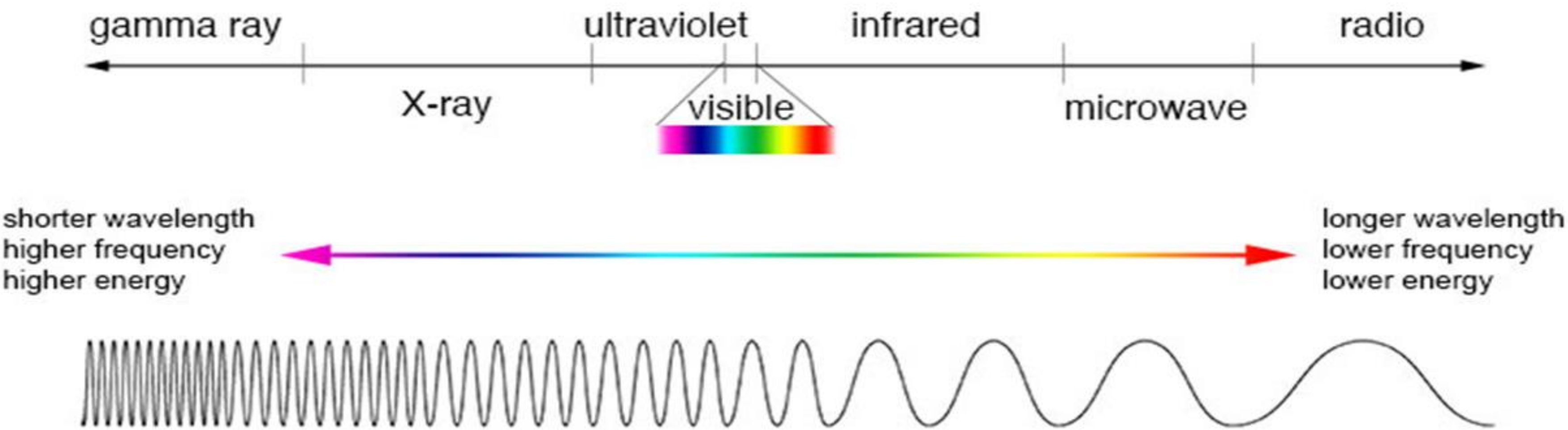


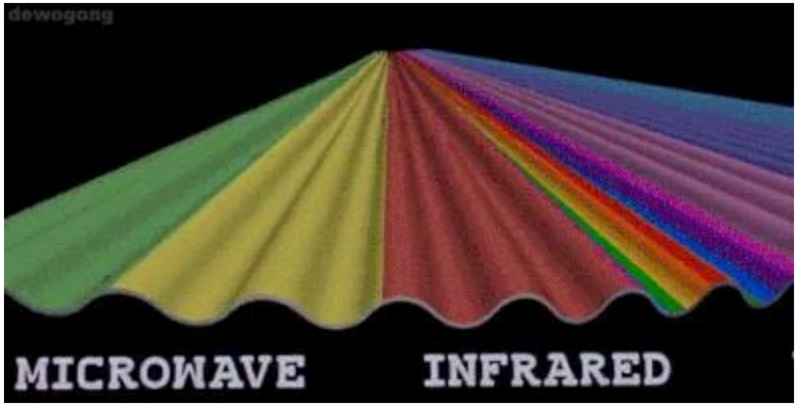
Draw another normal line at the point where the refracted ray exits the medium



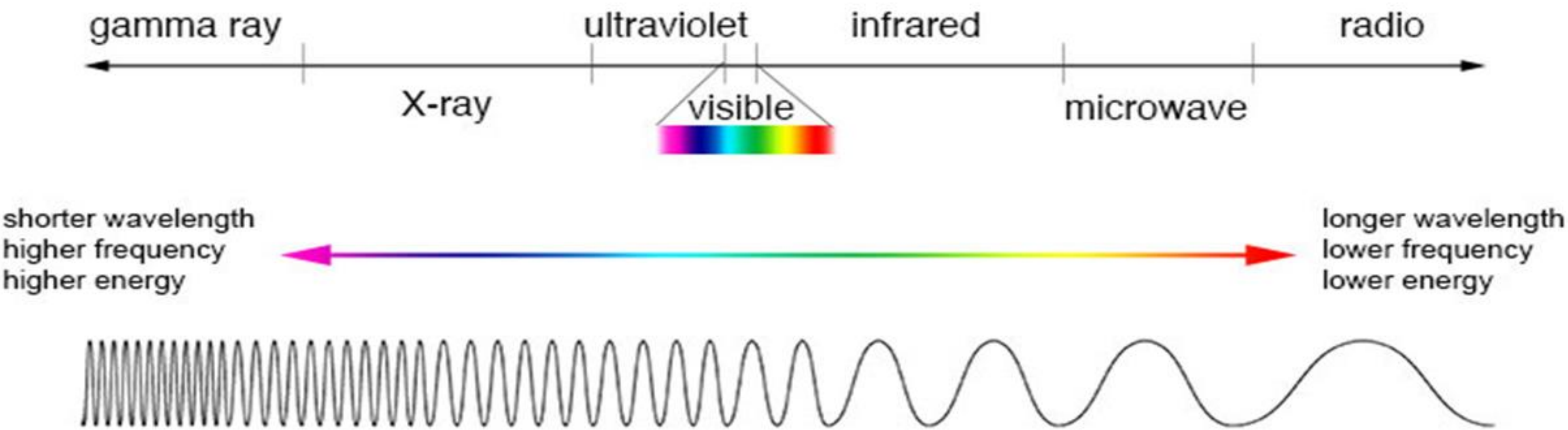
Connect the entrance point and exit point with a line. Measure the angles of inference and refraction from normal to the ray.

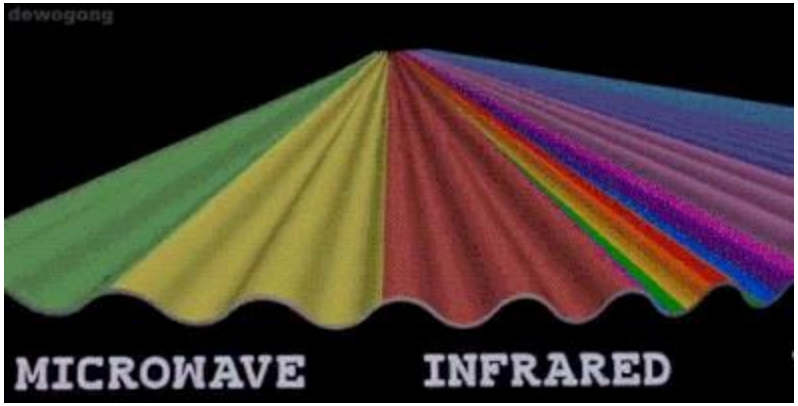
5.10 Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays



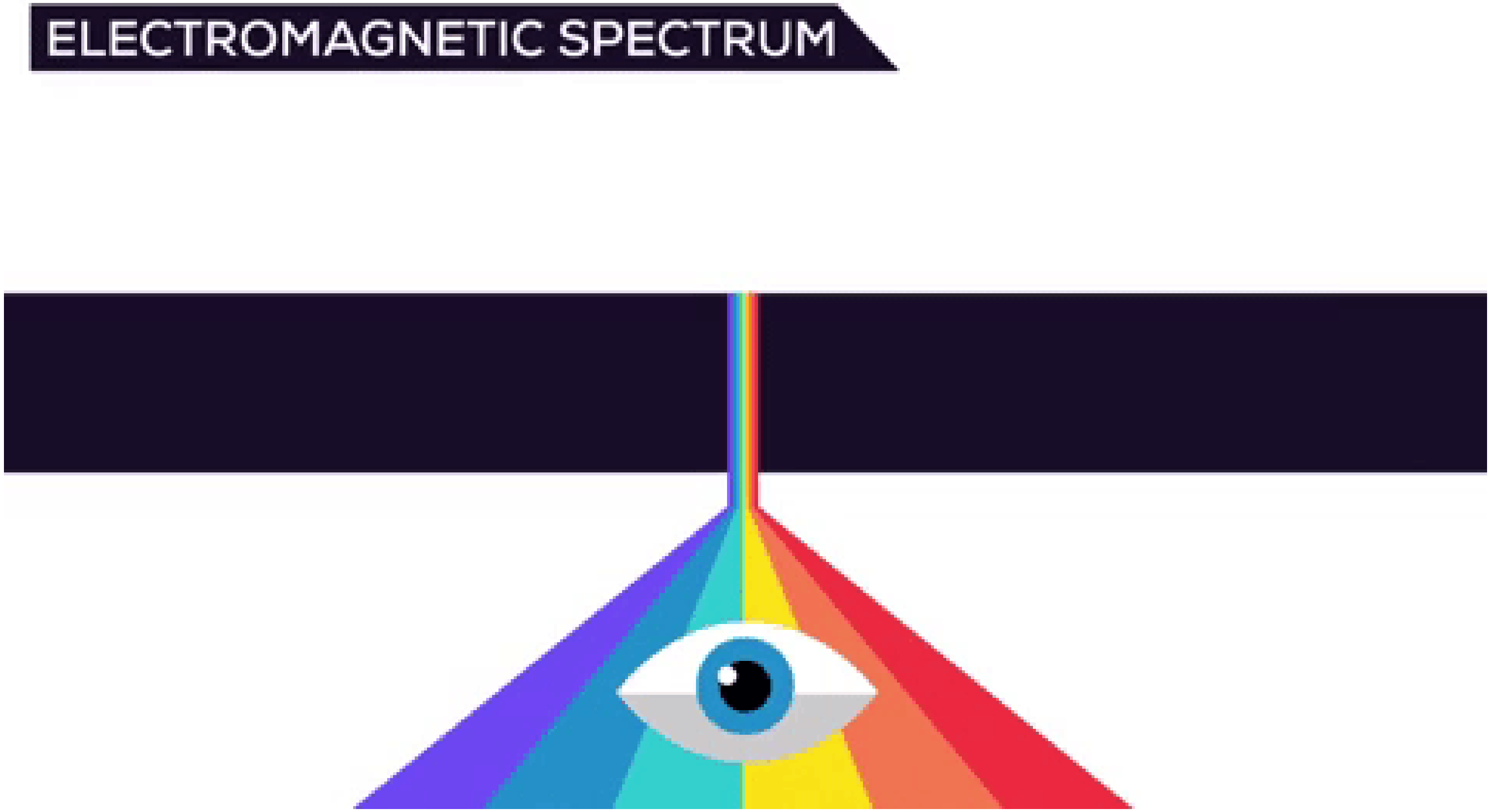


5.11 Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency



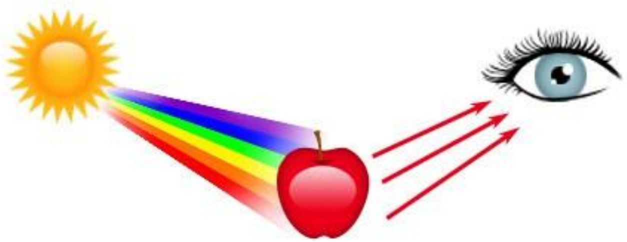


5.12 Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation



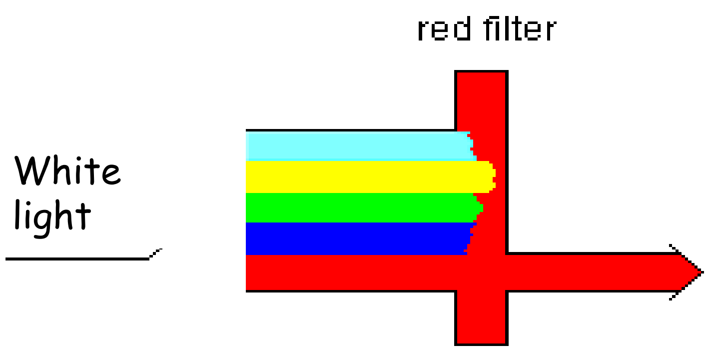
5.13 Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength

Most materials absorb some of the light falling on it. A white or shiny surface reflects most of the incident light whereas a black surface absorbs most wavelengths of light. **Absorbed light** is changed into a **heat** energy store so is not re-radiated as light.



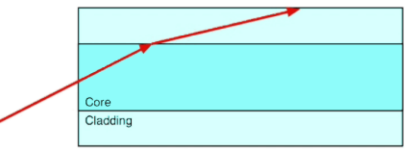
White light/sunlight is made from all the wavelengths of light in the spectrum.
A red object appears red in white light because it only **reflects** the red wavelengths of light, all other colours are absorbed.

If light **transmits** through a coloured object, the colour passing through is the colour we see. As with reflected light, all other wavelengths of light are absorbed by the transparent or translucent material.

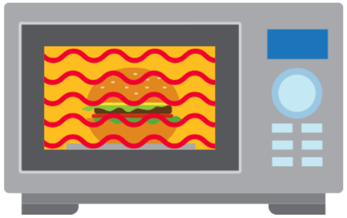


5.13 Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength

X-rays cannot be seen or felt. X-rays mostly pass through skin and soft tissue, but they do not easily pass through bone or metal. X-rays are used to produce shadow photographs of bones to check for damage such as fractures.



Infrared radiation and visible light: Because these can travel long distances through glass without becoming significantly weaker, these are used in optical fibre communications.



Microwave radiation has lower frequencies and longer wavelengths than visible light. Microwaves with certain wavelengths are absorbed by water molecules and can be used for cooking. Water in the food absorbs the microwave radiation, which causes the water to heat up and cook the food.

Microwave radiation can also be used to transmit signals such as mobile phone calls. Microwave transmitters and receivers on buildings and masts communicate with the mobile telephones in their range.

Radio waves are not strongly absorbed by the atmosphere so can be used to carry information for radio and TV programmes.

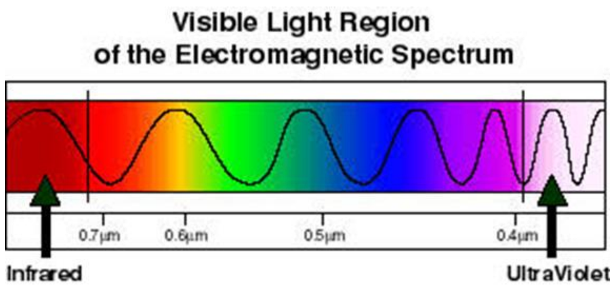
5.14 Explain the effects of differences in the velocities of electromagnetic waves in different substances

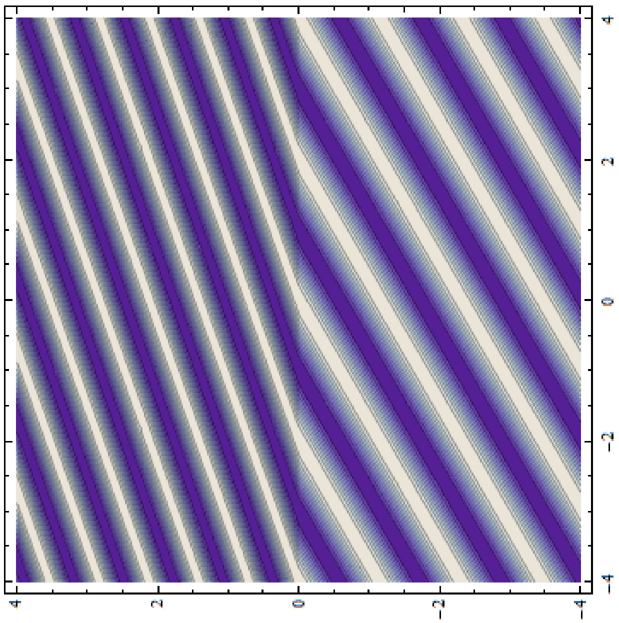
White light is made up of a mixture of colours.

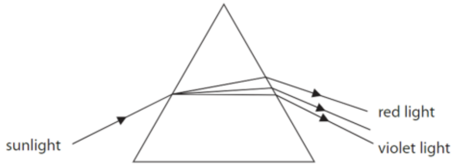
Different colours have different wavelengths. Red light has a longer wavelength than blue light.

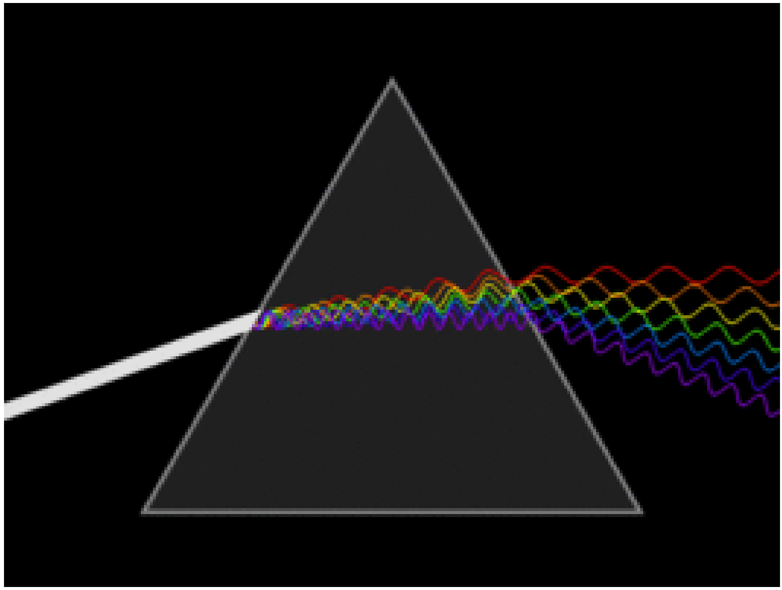
Each wavelength / colour is refracted by a different amount.

Short wavelengths are refracted more.

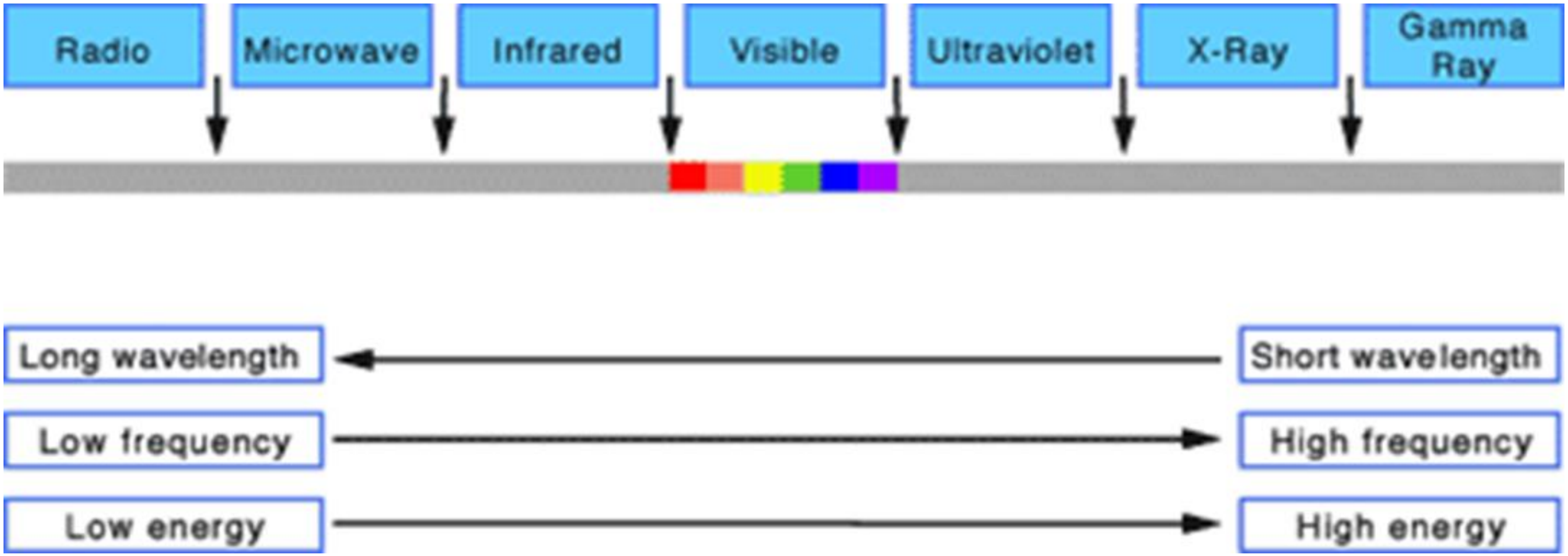








5.20 Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency



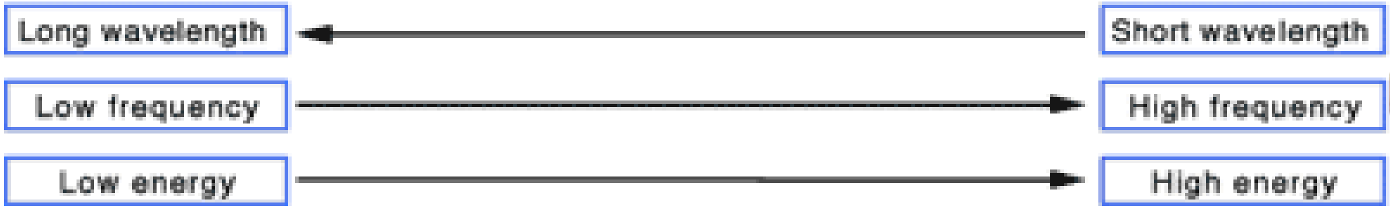
Less dangerous

More dangerous

5.21 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including: a microwaves: internal heating of body cells b infrared: skin burns ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions x-rays and gamma rays: mutation or damage to cells in the body

Health risks of high energy electromagnetic radiations: High frequency radiations have **high energy**. They can have a **hazardous** effect on **human tissue**.

- **microwaves**: can cause internal heating of body cells
- **infrared**: can cause skin burns
- **ultraviolet**: can damage the surface cells and eyes, leading to skin cancer and eye conditions
- **x-rays** and **gamma rays**: can cause mutation or damage to cells in the body

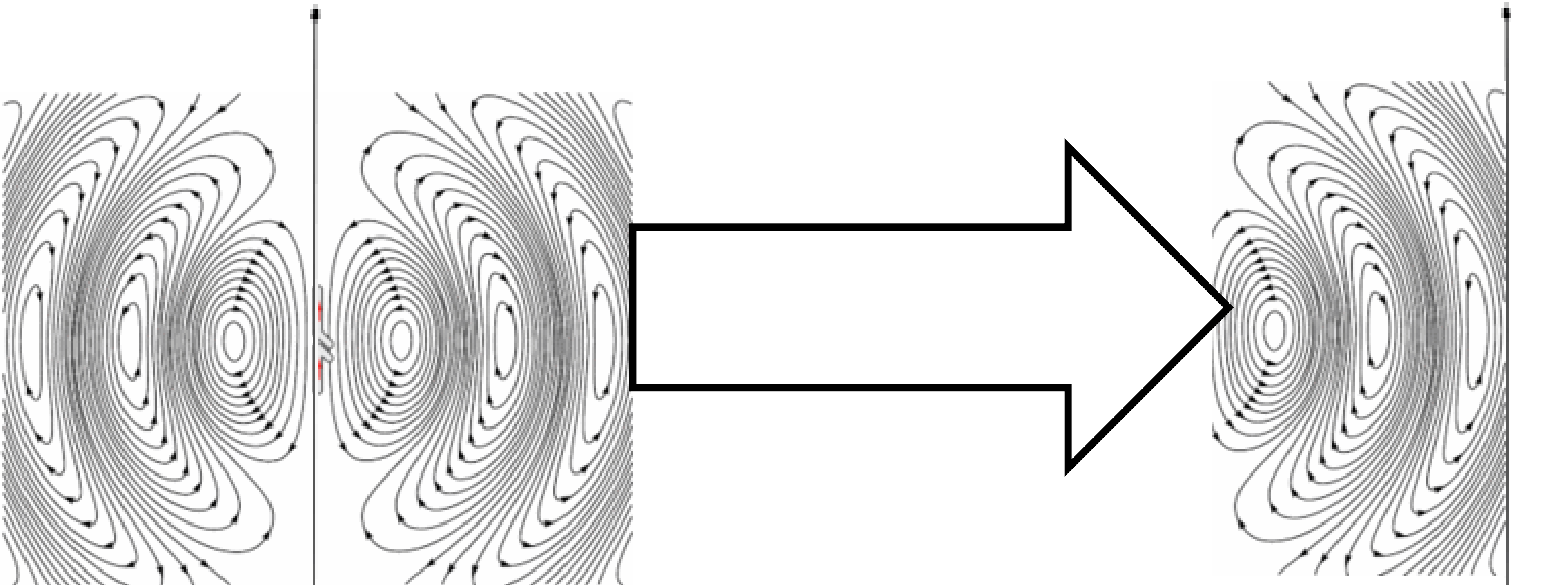


The hazard from high energy radiations also depends on the **dose**.
Radiation dose is a measure of the risk when exposed to these radiations.
Radiation dose is **measured in Sieverts**.

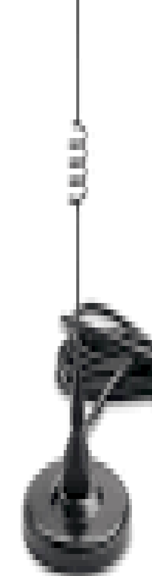
5.22 Describe some uses of electromagnetic radiation radio waves: including broadcasting, communications and satellite transmissions microwaves: including cooking, communications and satellite transmissions infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems visible light: including vision, photography and illumination e ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment

	Type	Application
Low frequency long wavelength	Radio	Television, radio broadcasting and satellite transmissions
	Microwave	Cooking, communications and satellite transmissions
	Infrared	Cooking, thermal imaging, short range communications, optical fibres, T V controls and security systems
	Visible	Vision, photography and illumination
	Ultraviolet	Security marking, fluorescent lamps, detecting forged bank notes and disinfecting water
	X-rays	Observing the internal structure of objects, airport security scanners and medical x-rays
High frequency short wavelength	Gamma rays	Sterilising food and medical equipment, and the detection of cancer and its treatment

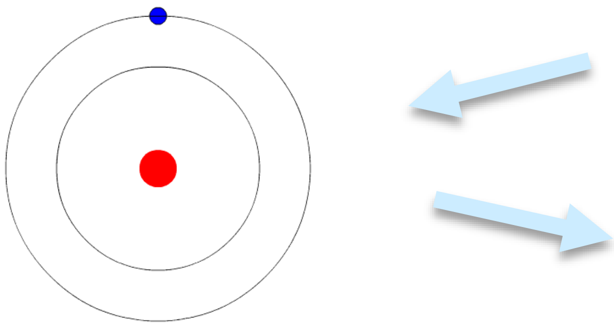
5.23 Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits



- Radio signals are produced when an **alternating current** is passed through a wire in a radio transmitter.
- The **oscillating (vibrating) particles** in the wire produce a **radio wave** which is modulated and boosted so it can carry the signal over a great distance.
- When this radio signal reaches another antenna (e.g. aerial on a radio) the **radio waves cause oscillations in the wire.**
- This produces an **alternating current** of the **same frequency** as the radio signal.



5.24 Recall that changes in atoms and nuclei can a generate radiations over a wide frequency range b be caused by absorption of a range of radiations



Input energy could be:
light, heat, electricity, X rays etc

Energy out will be a type of electromagnetic radiation i.e. X ray, ultra violet, visible, infra red, microwave or radio waves.

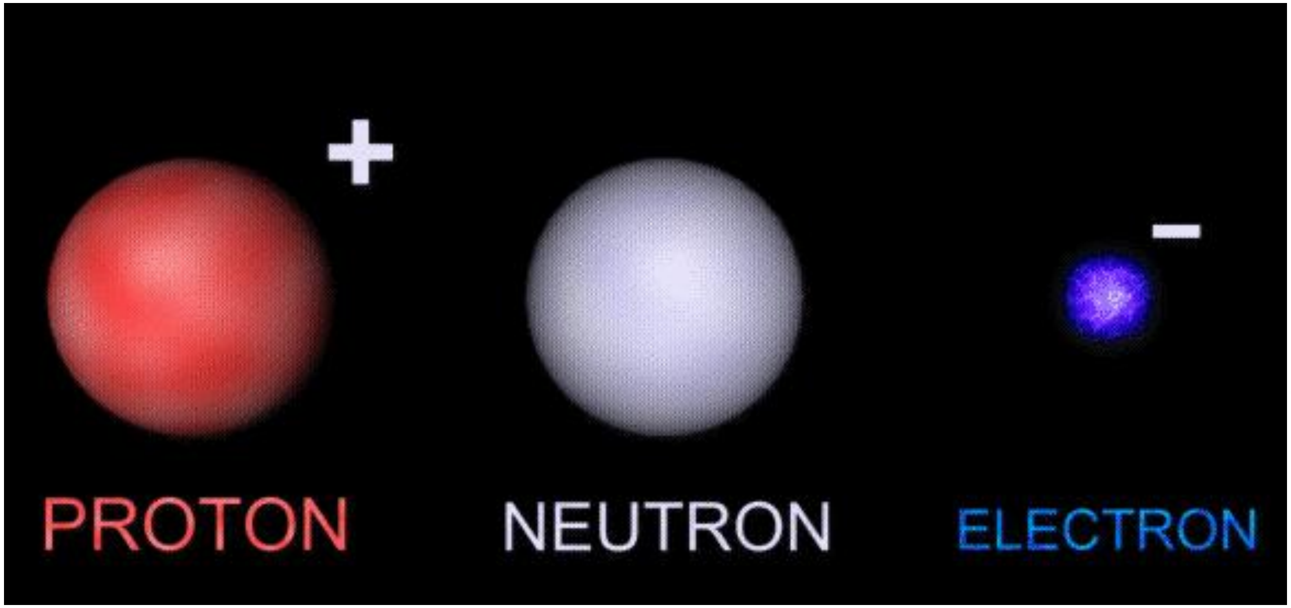
Changes within the nucleus of an atom can result in the emission of gamma waves. This occurs during the radioactive decay of some unstable atoms.

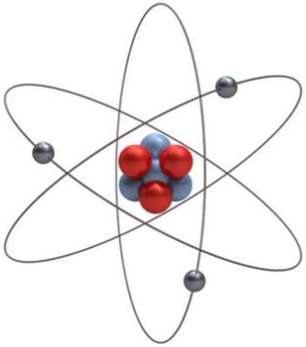
Atoms can receive energy from external sources.
This energy can cause electrons to "jump" to a **higher energy level**.
When the electron falls back to its original energy level it will release the stored energy in the form of a **photon of electromagnetic radiation**.

Topic 5 – Light and the electromagnetic spectrum

1. State whether EM waves are longitudinal or transverse
2. State the order of the EM spectrum from high wavelength to low wavelength.
3. State the order of the visible light spectrum from high to low frequency
4. State the type of EM wave that can be detected by eyes.
5. Describe some uses of the EM spectrum.
6. Describe how frequency can affect energy transfer
7. Define the term spectrum.
8. Describe the harmful effects of the three highest frequency EM waves.

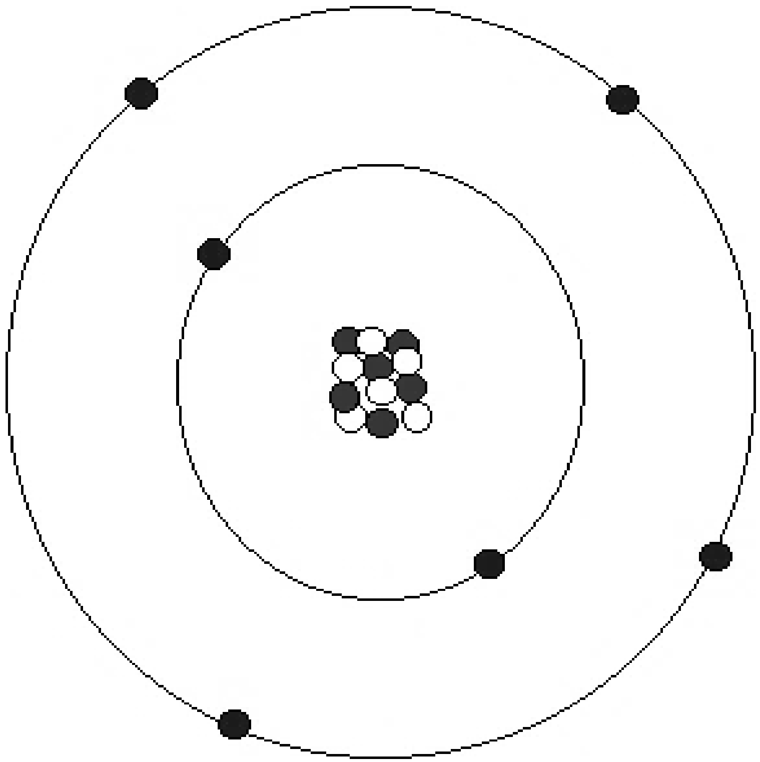
6.1 Describe an atom as a positively charged nucleus, consisting of protons and neutrons, surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus





	Mass	Charge	Location
Proton	1	+ (positive)	nucleus
Neutron	1	no charge	nucleus
Electron	1/1835 negligible	- (negative)	shells

6.2 Recall the typical size (order of magnitude) of atoms and small molecules



. ← 9×10^{13} atoms in this dot of ink

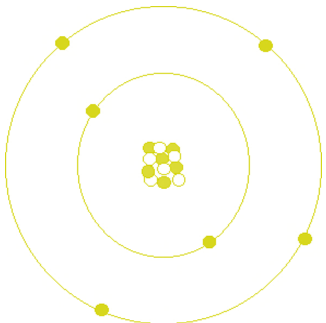
Radius of an atom **1×10^{-10}m**

6.3 Describe the structure of nuclei of isotopes using the terms atomic (proton) number and mass (nucleon) number and using symbols in the format using symbols in the format

The isotopes have the **same number of protons** and the **same number of electrons**. Only the number of **neutrons changes** in an isotope.

Carbon 12

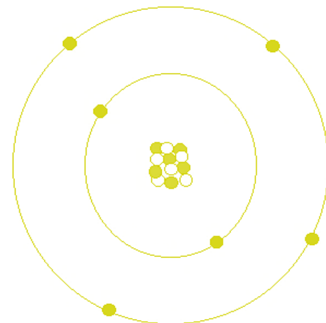
$^{12}_{6}C$



6 protons
6 neutrons

Carbon 13

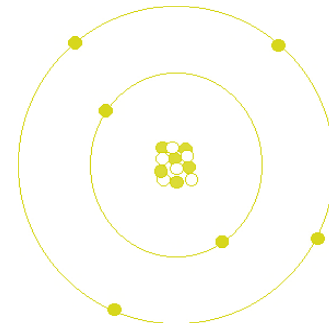
$^{13}_{6}C$



6 protons
7 neutrons

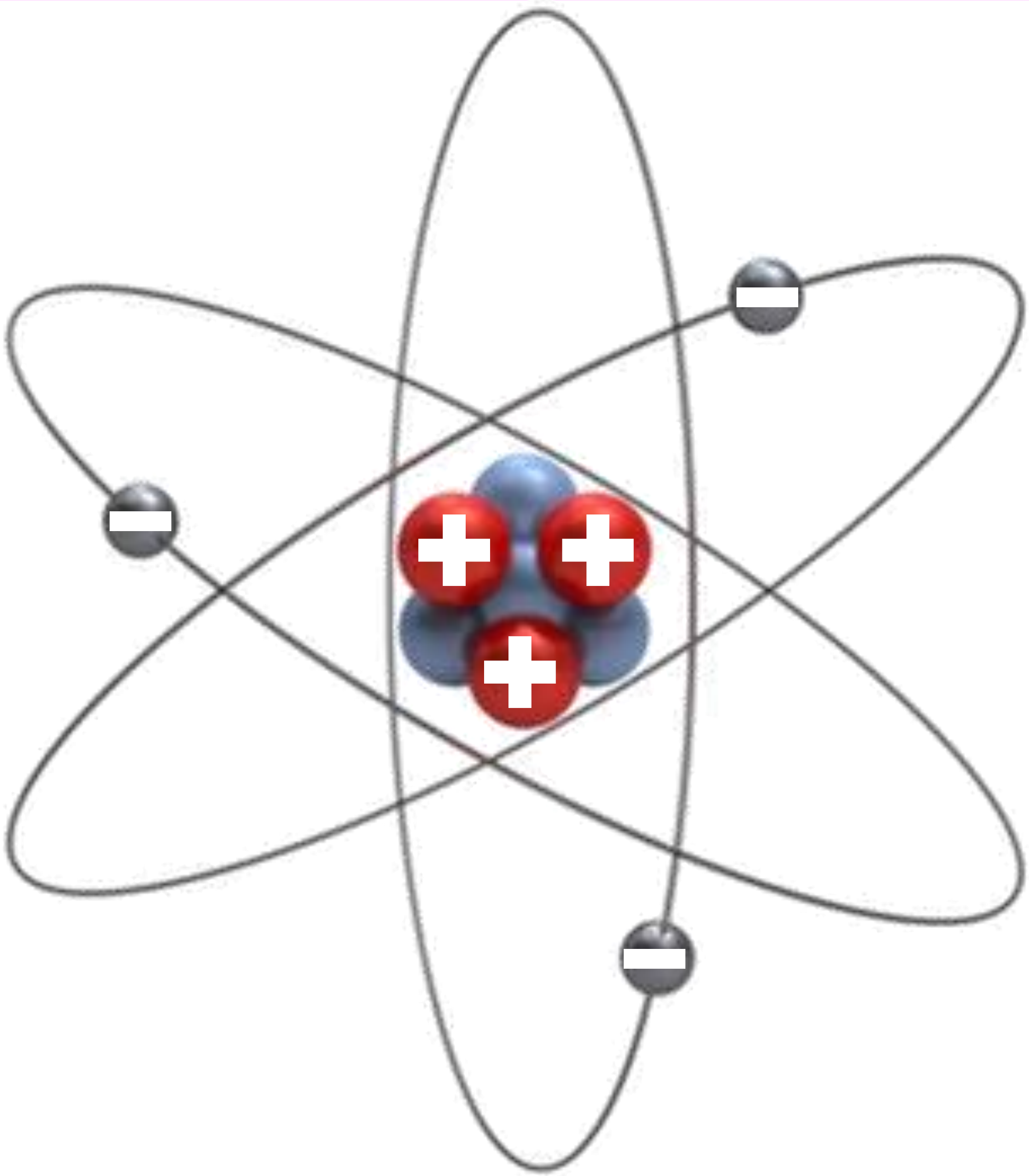
Carbon 14

$^{14}_{6}C$



6 protons
8 neutrons

6.4 Recall that the nucleus of each element has a characteristic positive charge, but that isotopes of an element differ in mass by having different numbers of neutrons



The nucleus is always positive.

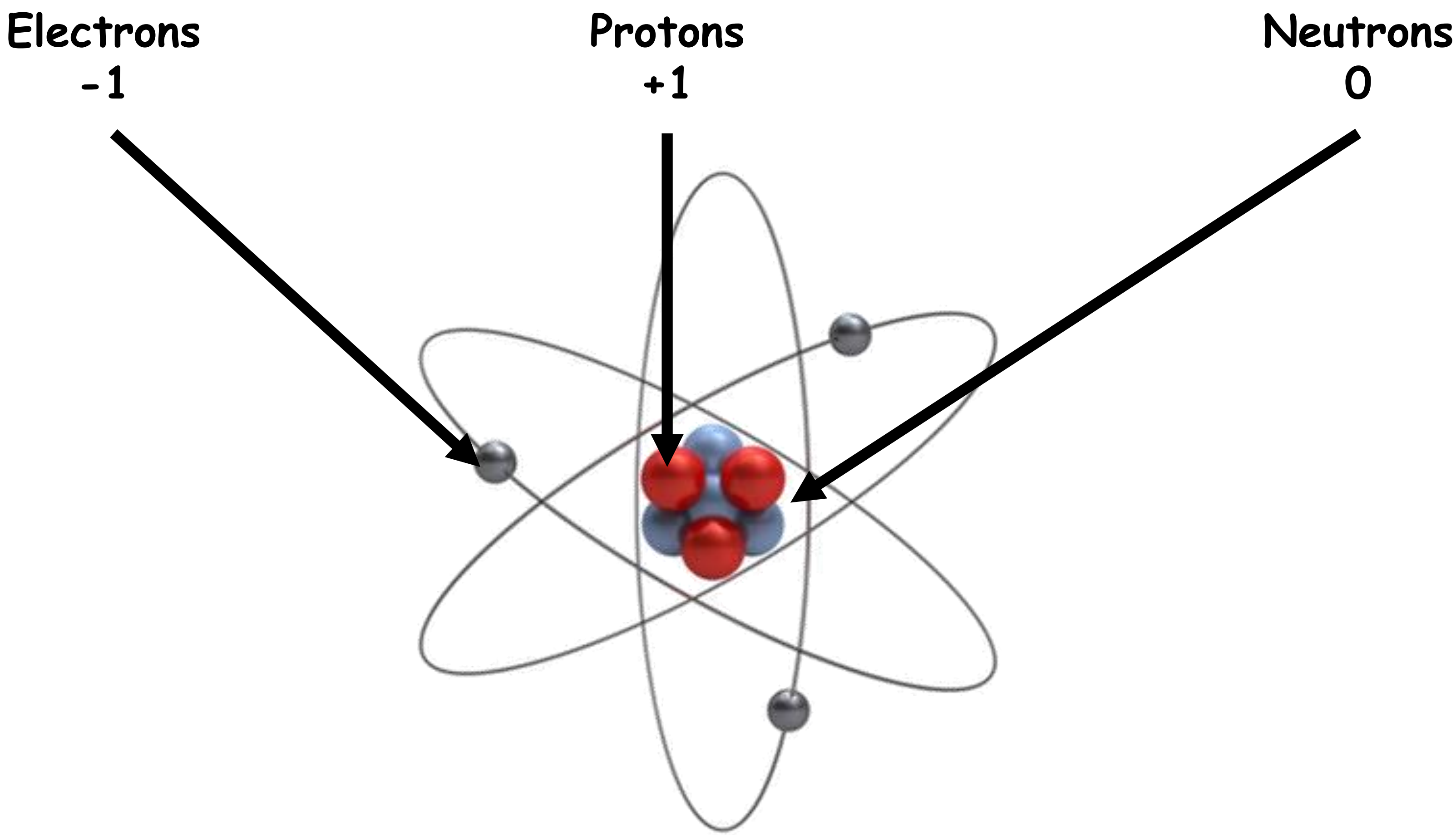
This is because the protons cannot easily escape the nucleus (unless there is a lot of energy put in – that's radiation!!)

6.5 Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons

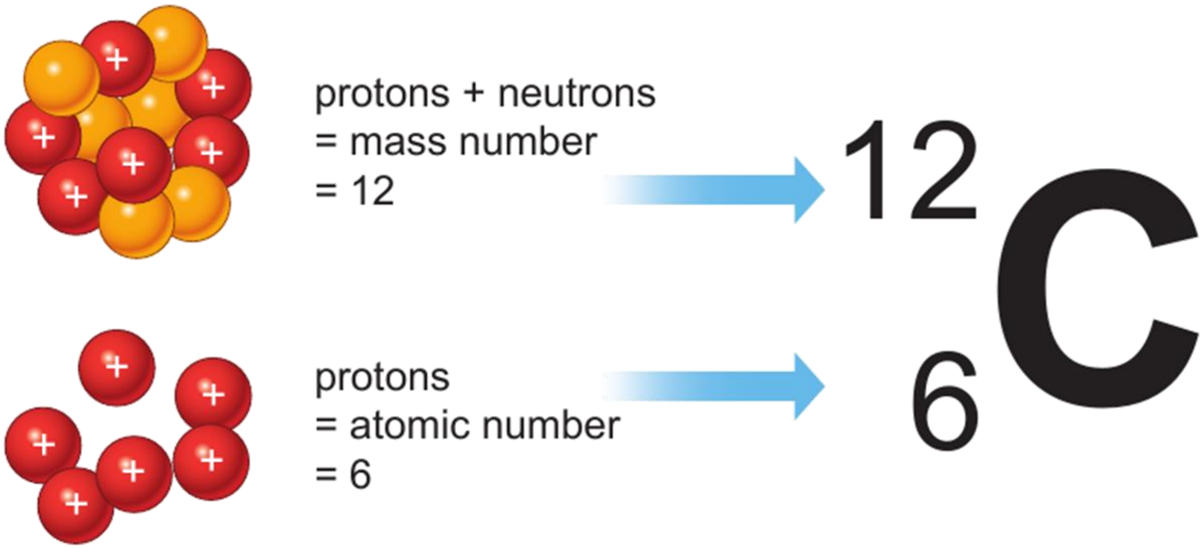
The type of atoms depends on the amount of protons.

The atomic number means the amount of protons

The mass number is the number of protons and neutrons.



6.6 Recall that in an atom the number of protons equals the number of electrons and is therefore neutral

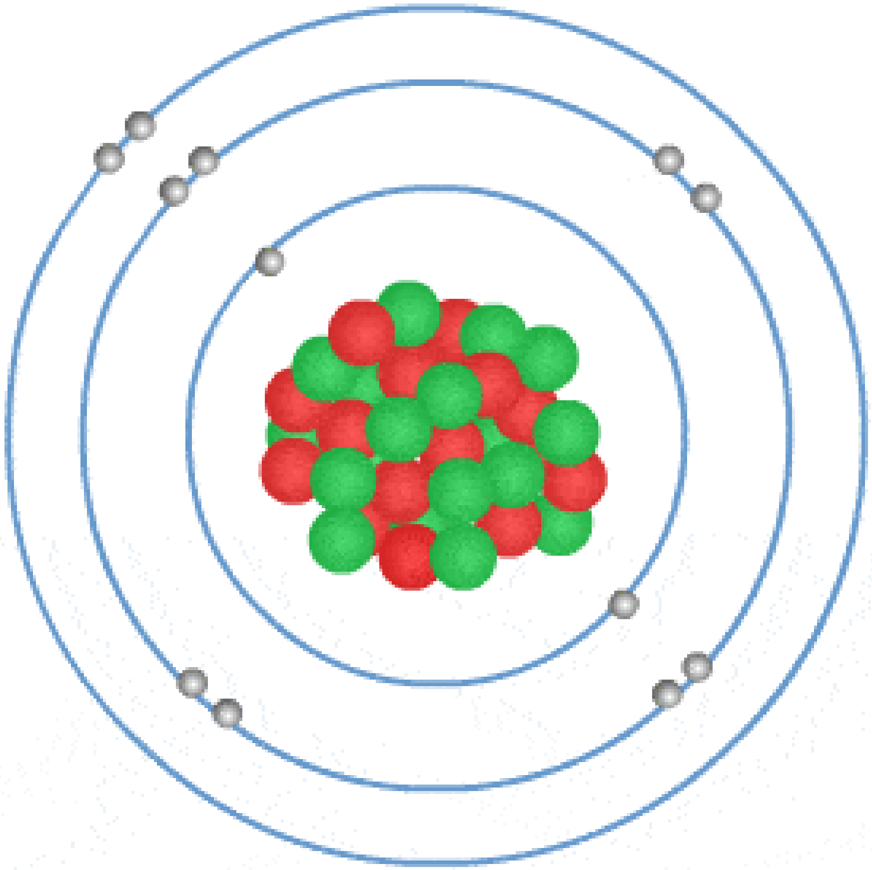


P: 6

E: 6

N: 6

6.7 Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus



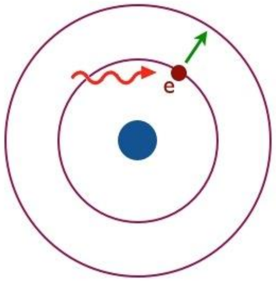
Electrons are arranged in **orbits or energy levels** around the nucleus.
Energy levels can hold a maximum of:
2 e^- in the first level
8 e^- in the second level
8 e^- in the third level

Electrons change **orbit** when there is **absorption** or **emission** of **electromagnetic radiation.**

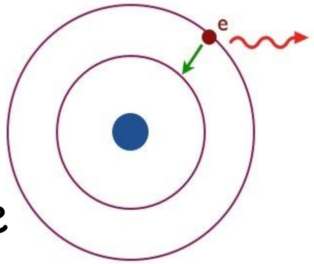
6.8 Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation

Electrons can absorb **electromagnetic radiation**. This excites the electron and can cause it to "jump" to a **higher energy level**.
It can then release this energy as an electromagnetic wave by falling back to its original energy level.

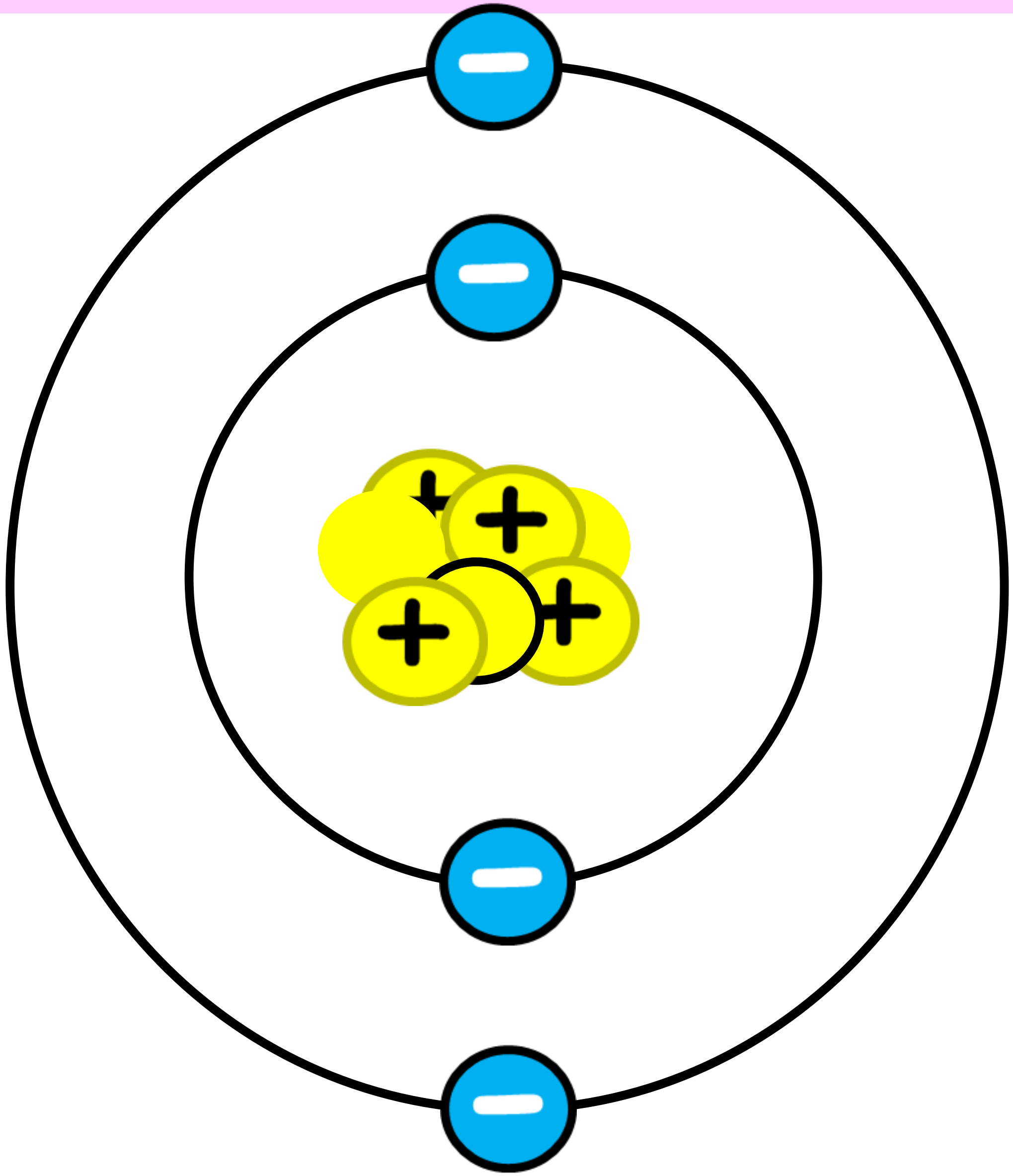
Electromagnetic radiation absorbed by the electron causes it to move to a higher energy level.



The electron can emit this stored energy as electromagnetic radiation.
As it loses energy the electron returns to its original energy level.

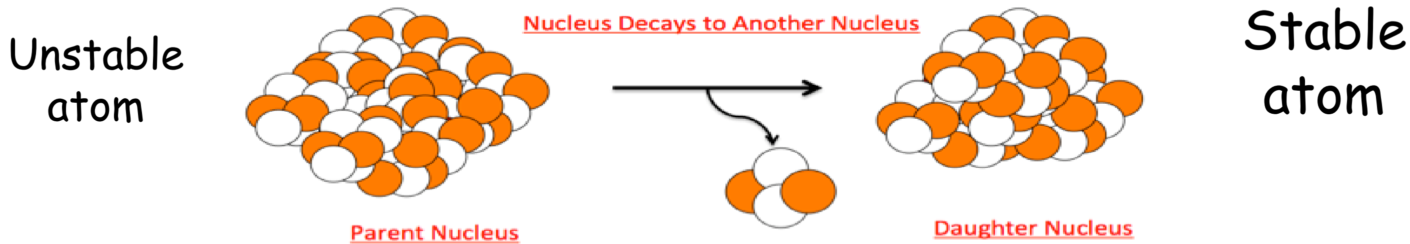


6.9 Explain how atoms may form positive ions by losing outer electrons



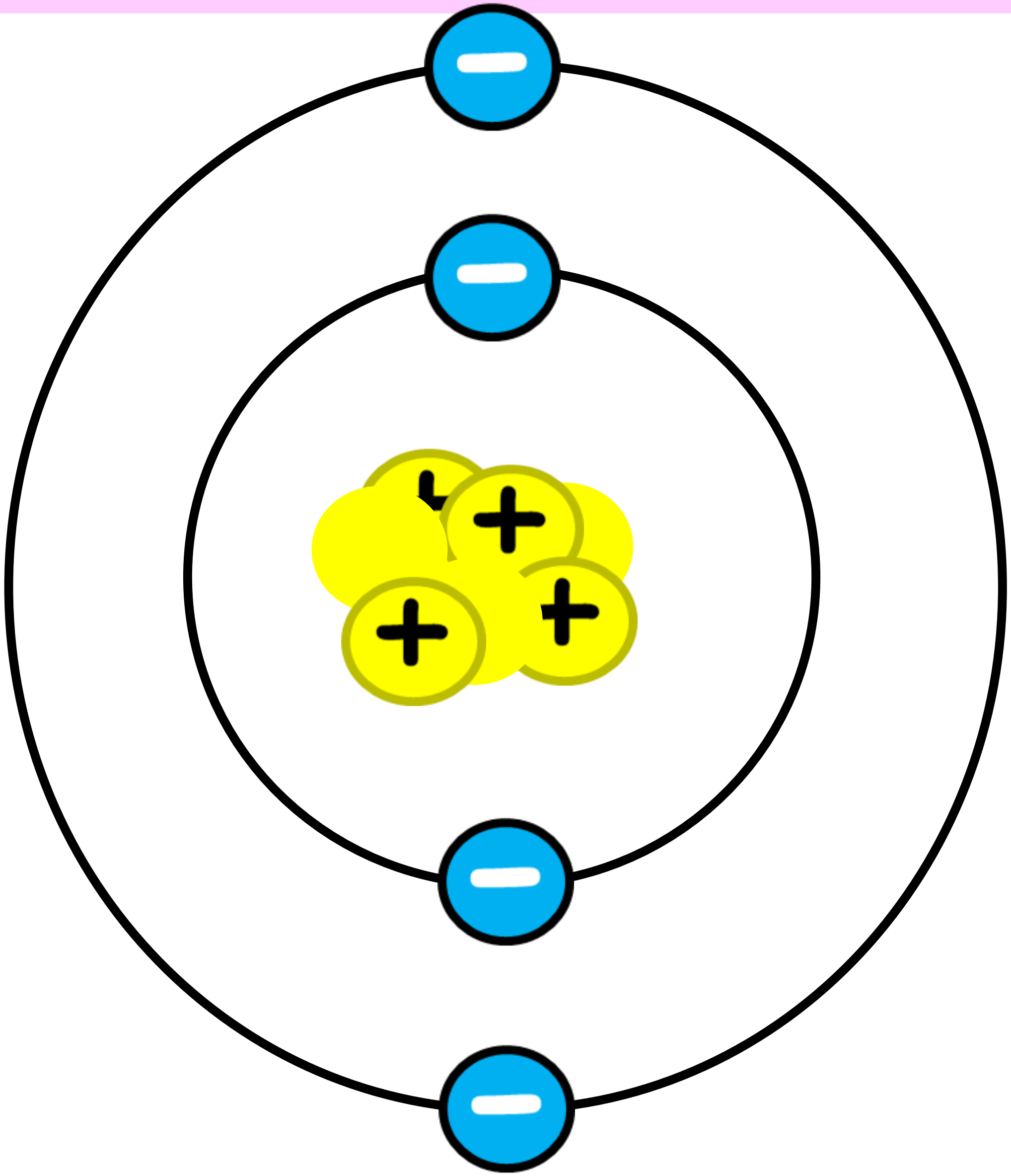
6.10 Recall that alpha, β− (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process

- **The nuclei of some atoms are unstable.**
- **To become more stable these nuclei give out radiation.**
- **This process is called radioactive decay.**



Different radioactive isotopes decay at different rates and emit different types of radiation.

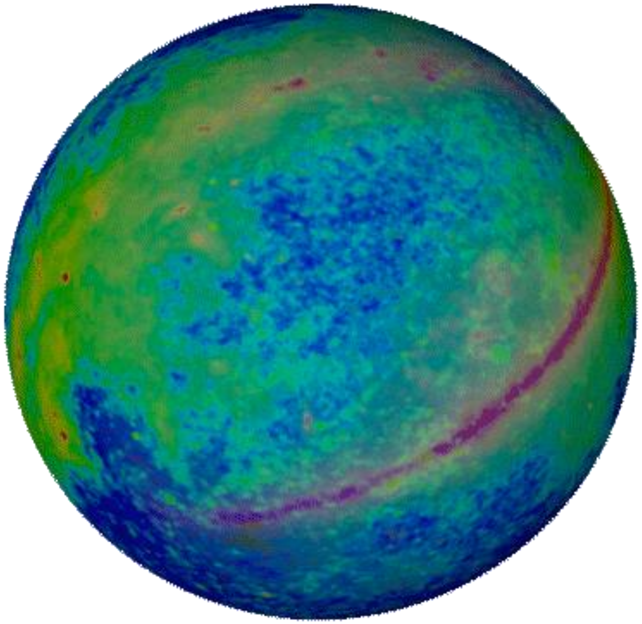
6.11 Recall that alpha, β– (beta minus), β+ (positron) and gamma rays are ionising radiations

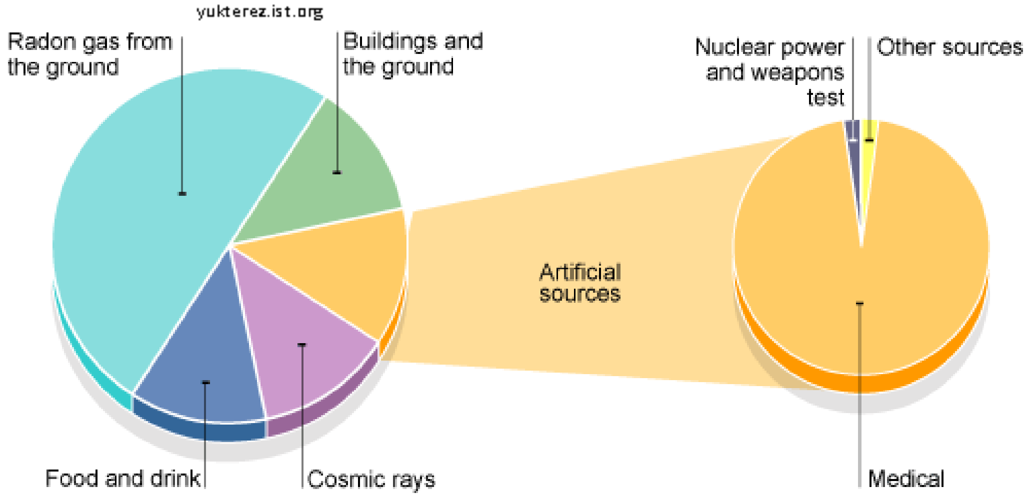


Alpha, Beta and Gamma radiation cause nucleons to be ejected from the nucleus. Causing an ion to be formed.

6.12 Explain what is meant by background radiation

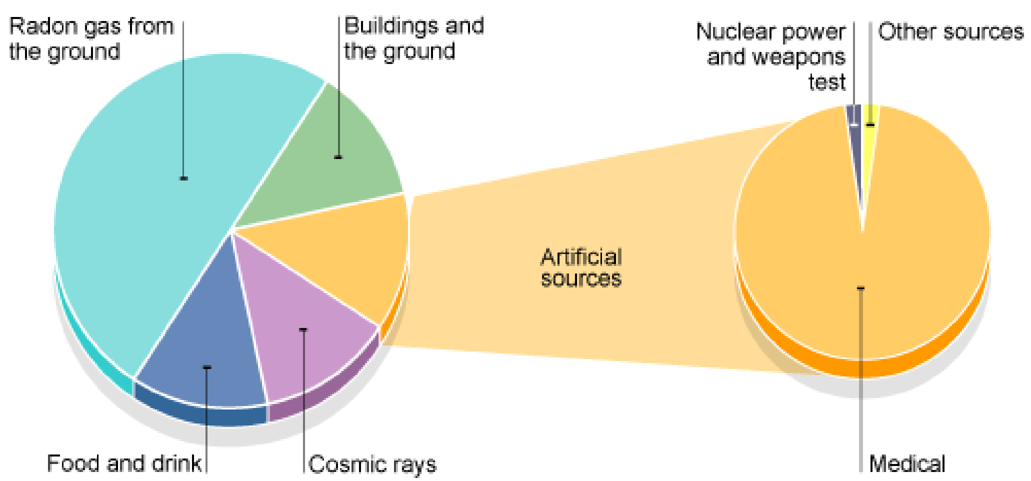
- **Background radiation** is the constant , low level radiation in the environment.





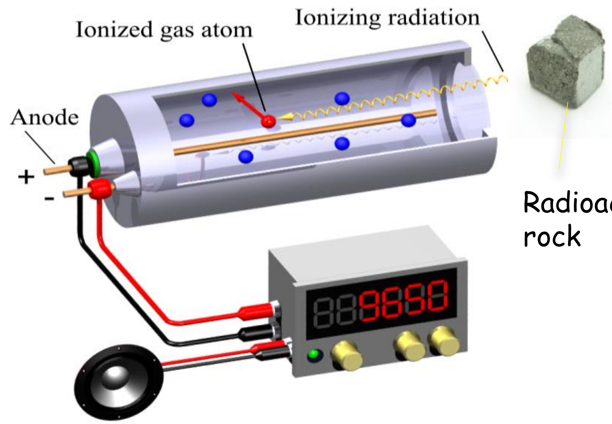
6.13 Describe the origins of background radiation from Earth and space

- This can be natural radiation from rocks, building materials, cosmic rays etc.
- **Radioactive pollution** from nuclear testing, nuclear power and industrial/medical waste also contributes to background radiation.
- Everyone receives background radiation but people who **work or live** in locations with high levels of radiation **receive additional doses of radiation**.
- Some nuclear workers, medical staff, military and industrial workers may have higher doses due to working with radioactive sources.

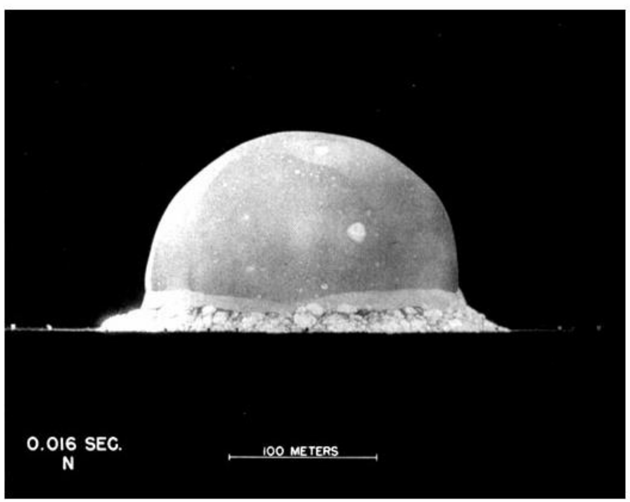


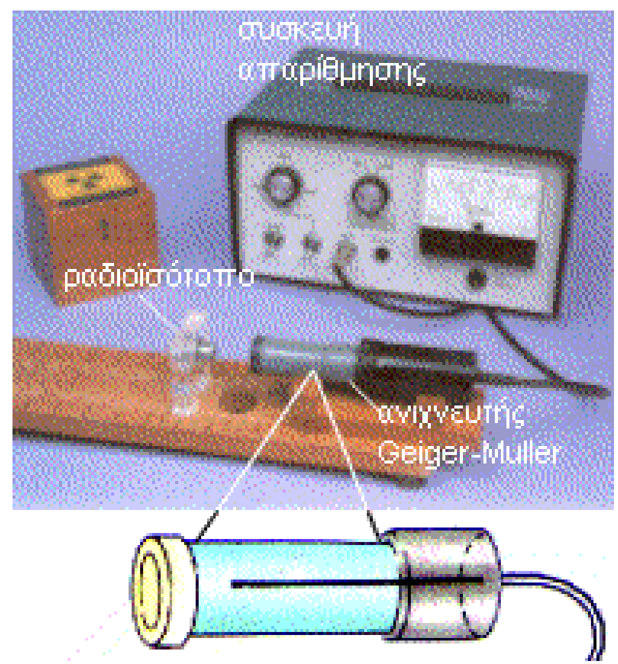
6.14 Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger-Müller tube

Activity = rate at which a source of unstable nuclei decays, measured in **becquerels (Bq).**

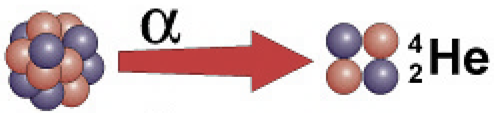


Count-rate = number of decays recorded each second by a detector (e.g. Geiger-Muller tube)





6.15 Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation



Alpha (symbol α or ^4_2He) consist of **2 protons and 2 neutrons** emitted from the nucleus. They have a **positive** charge as they contain 2 (+) protons.

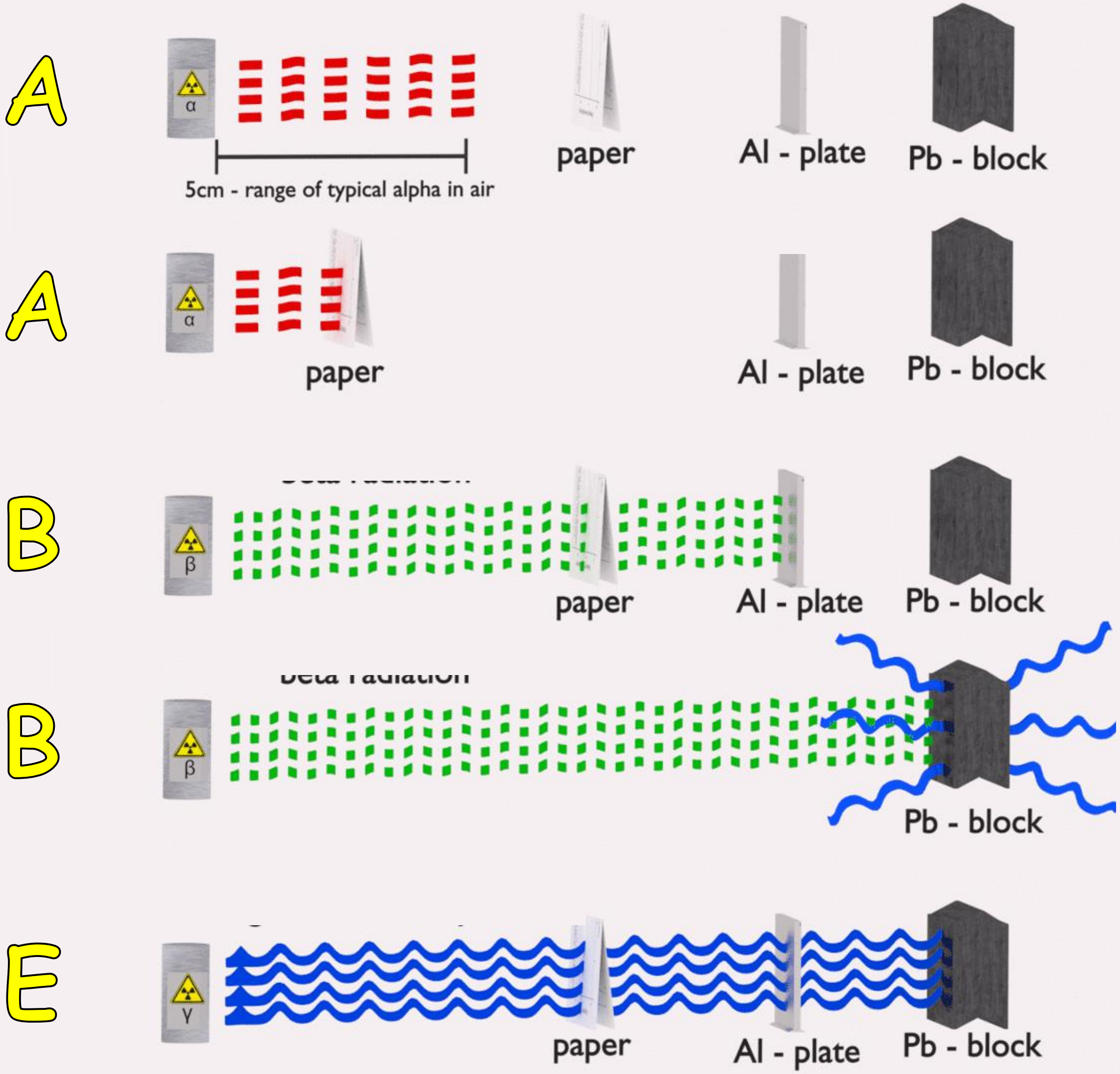
Beta Minus (symbol β^- o $^{0}_{-1}e$.) consist of an **electron** emitted from the nucleus. This results from a neutron splitting into a proton and an electron. Beta particles are **negatively** charged.

Positron (symbol β^+ or $^{0}_{+1}e$.) are released when a proton becomes a neutron and a positron. Positron particles are **positively** charged.

Gamma rays (symbol γ) are **electromagnetic radiation** emitted from the nucleus. Gamma radiation has **no mass** and **no electrical charge.**

6.16 Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionise

Alpha, beta and gamma radiation can penetrate different materials due to their differing nature.



Alpha – easily stopped by **a few sheets of paper**.

Beta – penetrates paper but stopped by a thin **sheet of aluminium**.

Gamma – only stopped by **thick lead** or several metres of **concrete**.

All three types of radiation cause **ionisation** of other atoms.

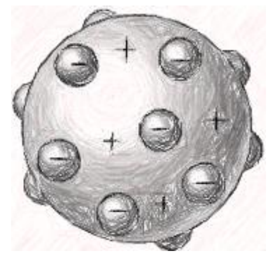
If these atoms are in **living cells** it can cause damage which could lead to **cancer**.

Alpha has the highest ionising power, then Beta. Gamma has the lowest.

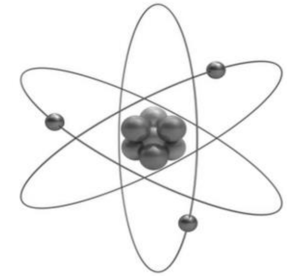
6.17 Describe how and why the atomic model has changed over time including reference to the plum pudding model and Rutherford alpha particle scattering leading to the Bohr model

Pre 1900

Pre 1911



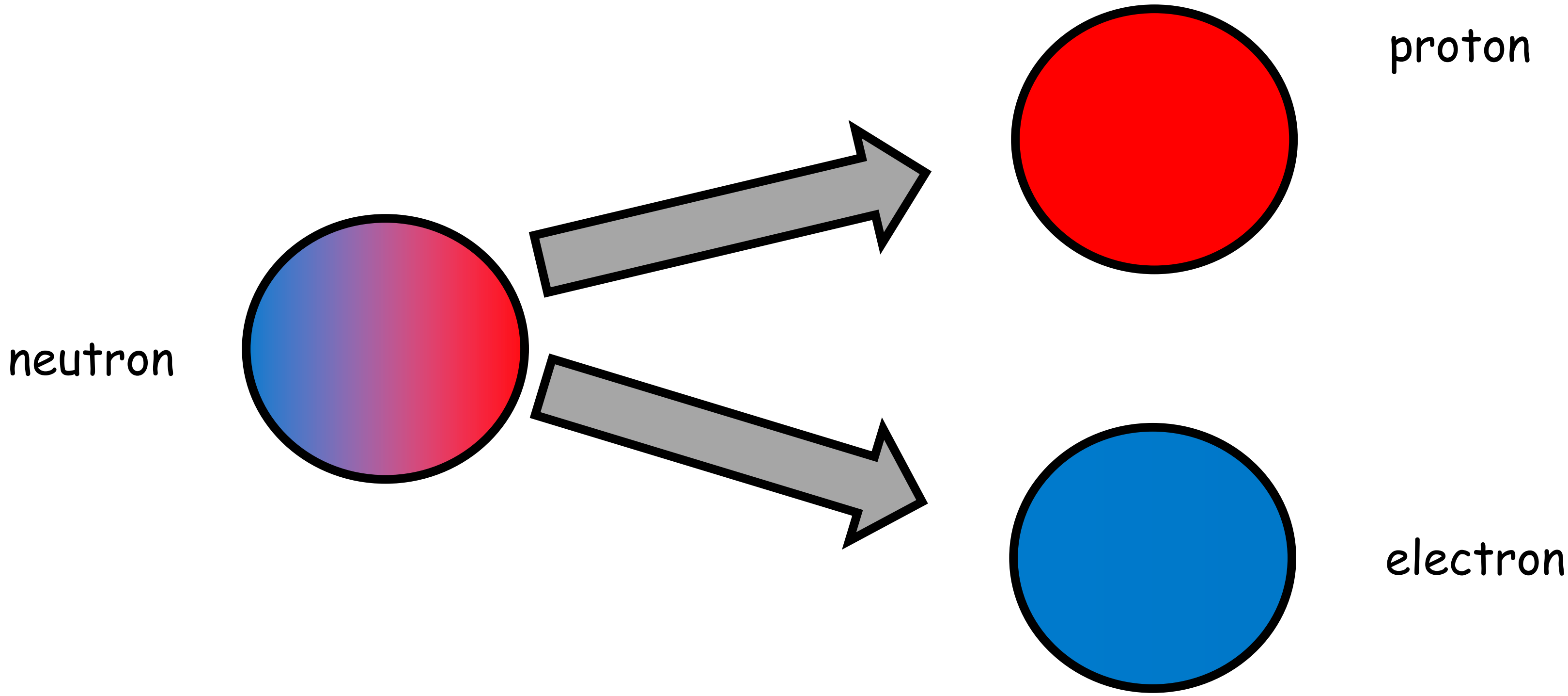
1911 to present



Sphere	Plum pudding model	Nuclear model
Before the **discovery of the electron**, atoms were thought to be **tiny spheres that could not be divided**.	The **discovery of the electron** led to the **plum pudding model** of the atom. The **plum pudding model** suggested the **atom is a ball of positive charge with negative electrons embedded in it**.	• **Alpha scattering experiment** – mass of the atom is concentrated in the **nucleus, which is charged**. • **Niels Bohr** – **electrons orbit nucleus** at **different distances**. • **Later experiments** – **positive charge in nucleus** divided into whole number of **smaller particles with positive charge**. • **James Chadwick** – 20 years after nucleus accepted – provided evidence for existence of **neutrons in nucleus**.

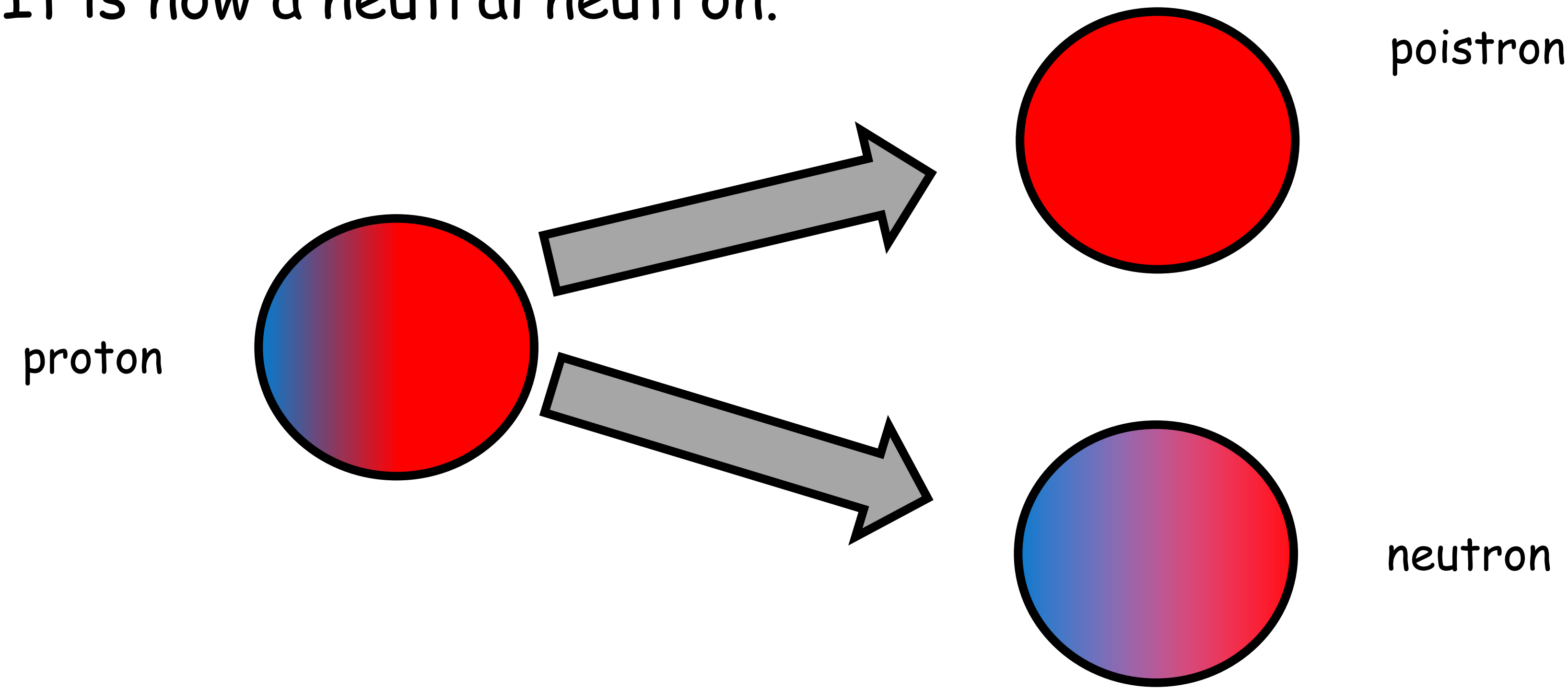
6.18 Describe the process of β– decay (a neutron becomes a proton plus an electron)

- Neutrons split to form a proton and an electron.
- Imagine the neutron contains an equal amount of **positive** and negative charge
- This is why they are neutral.
- When the neutron splits, the negative charge is removed and the positive remains.



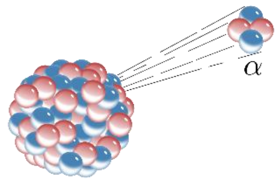
6.18 Describe the process of β- decay (a neutron becomes a proton plus an electron)

- Protons split to form a neutron and a positron.
- Imagine the neutron contains 2 parts of **positive** and 1 part **negative** charge
- This is why they are positive.
- When the proton splits, the positive charge is removed and equal parts negative and positive charge remain.
- It is now a neutral neutron.



6.20 Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission)

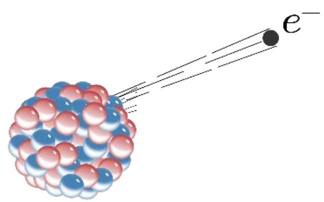
Alpha emission



Nucleus **loses 2 protons** and **2 neutrons**.
Atomic number will reduce by 2 and atomic mass by 4.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

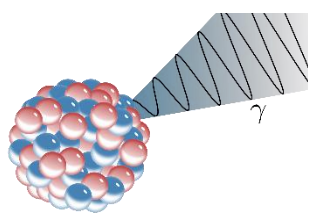
Beta emission



Nucleus **loses an electron** which is produced when a neutron turns into a proton. So **mass stays the same** but **atomic number of the product increases by one**.

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

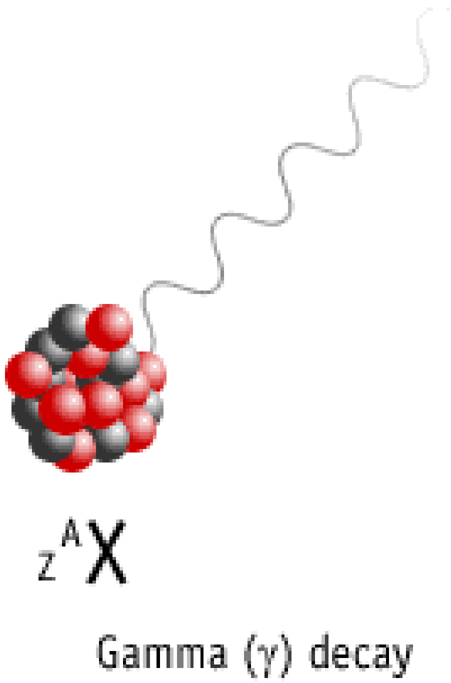
Gamma emission



No particles are emitted so there is **no change to the nucleus**. Atomic mass and atomic number stay the same.

$$^{99}_{43}Tc \longrightarrow {}^{99}_{43}Tc + \gamma$$

6.21 Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation



Nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation

No particles are emitted during gamma ray release.

6.22 Use given data to balance nuclear equations in terms of mass and charge

1.Americium- 241 decays by alpha emission.

$$^{241}_{95}Am \rightarrow ^{237}_{93}Np + {}^{4}_{2}\alpha$$

2.Carbon – 14 decays by beta emission.

$$^{14}_{6}C \rightarrow ^{14}_{7}N + {}^{0}_{-1}\beta$$

3.Bismuth – 211 decays by alpha emission

4.Polonium – 204 decays by alpha emission

5.Radon – 224 decays by alpha emission

6.Uranium – 235 decays by alpha emission

7.Neptunium – 237 decays by alpha emission

8.Strontium – 90 decays by beta emission

9.Phosphorus – 32 decays by beta emission

10.Nickel – 63 decays by beta emission

11.Lead – 209 decays by beta emission

12.Hydrogen – 3 decays by beta emission

3. $^{211}_{83}Bi \rightarrow ^{207}_{81}Tl + {}^{4}_{2}\alpha$

4. $^{204}_{84}Po \rightarrow ^{200}_{82}Pb + {}^{4}_{2}\alpha$

5. $^{224}_{86}Rn \rightarrow ^{220}_{84}Po + {}^{4}_{2}\alpha$

6. $^{235}_{92}U \rightarrow ^{231}_{90}Th + {}^{4}_{2}\alpha$

7. $^{237}_{93}Np \rightarrow ^{233}_{91}Pa + {}^{4}_{2}\alpha$

8. $^{90}_{38}Sr \rightarrow ^{90}_{39}Y + {}^{0}_{-1}e$

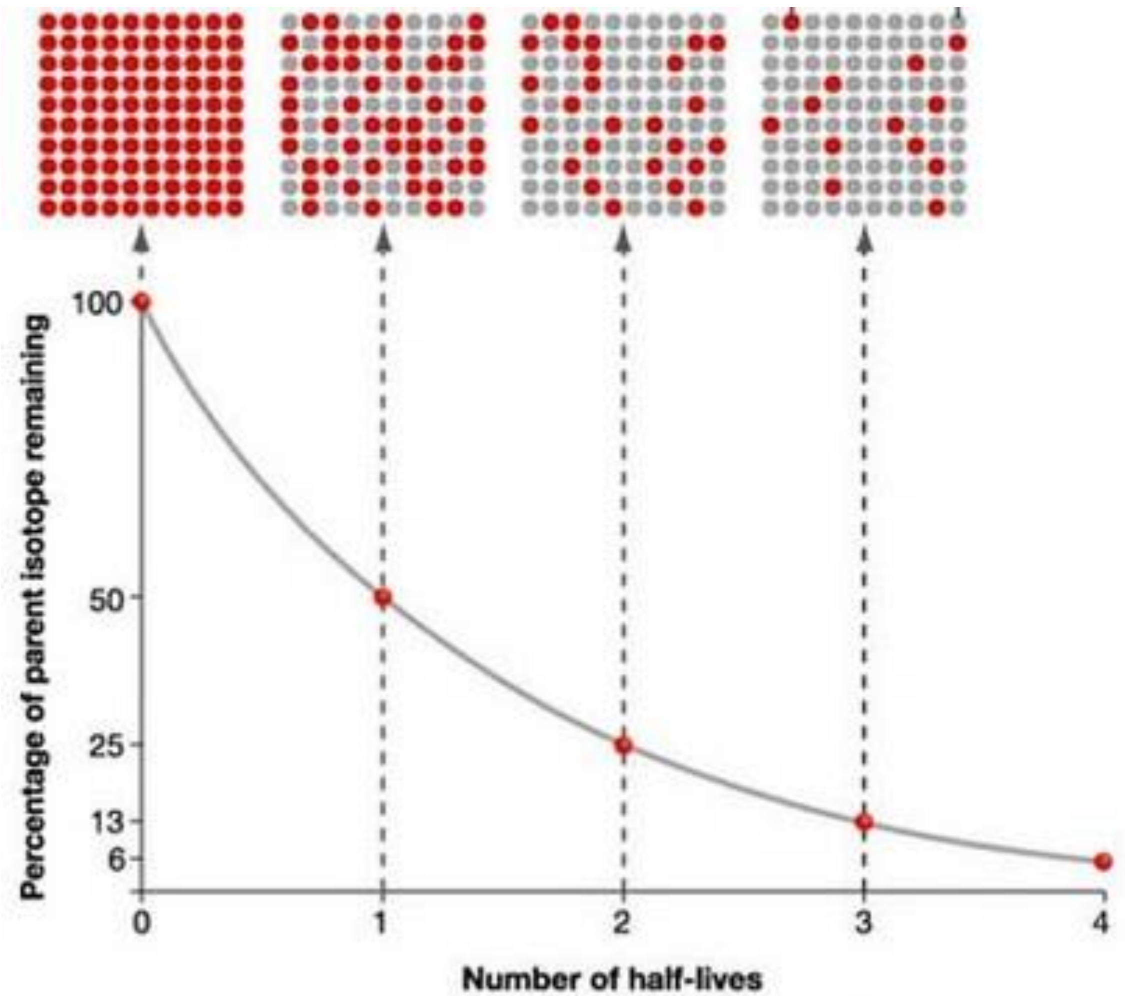
9. $^{32}_{15}P \rightarrow ^{32}_{16}S + {}^{0}_{-1}e$

10. $^{63}_{28}Ni \rightarrow ^{93}_{29}Cu + {}^{0}_{-1}e$

11. $^{209}_{82}Pb \rightarrow ^{205}_{83}Bi + {}^{0}_{-1}e$

12. $^{3}_{1}H \rightarrow ^{3}_{2}He + {}^{0}_{-1}e$

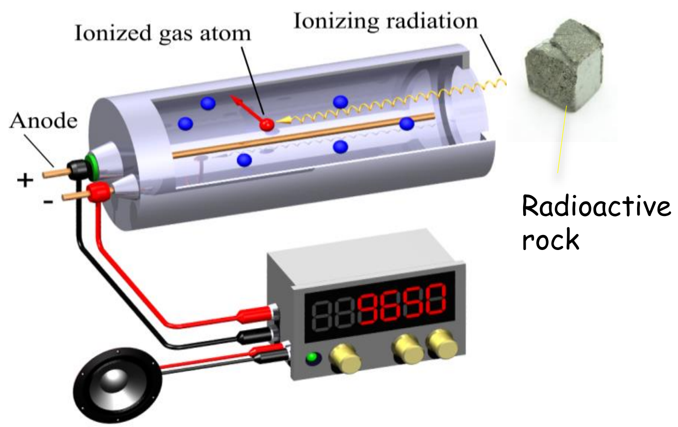
6.23 Describe how the activity of a radioactive source decreases over a period of time



The change is

6.24 Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq

Activity = rate at which a source of unstable nuclei decays, measured in **becquerels (Bq).**

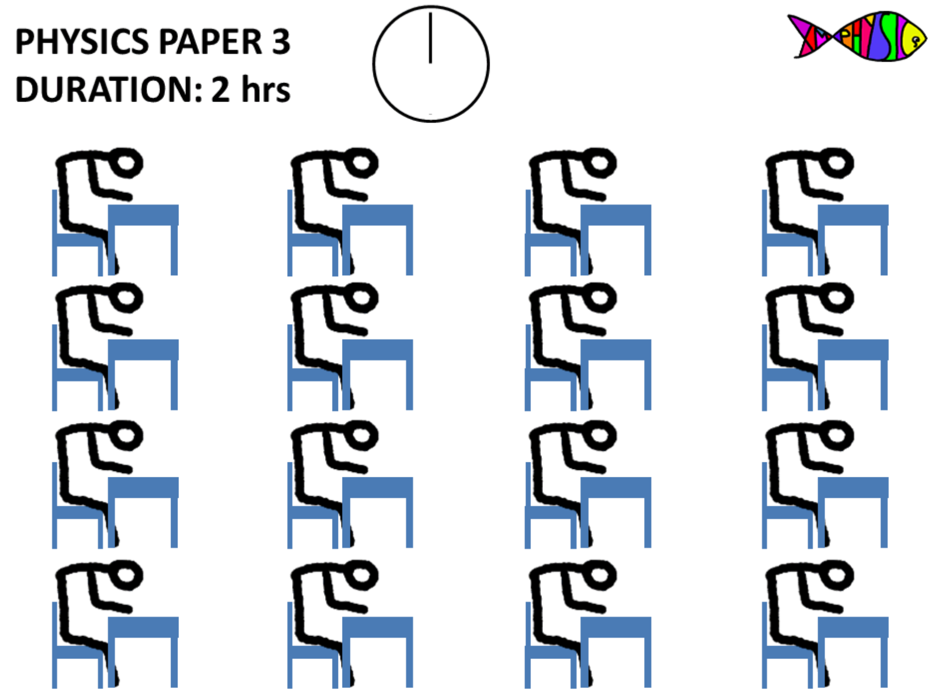


Count-rate = number of decays recorded each second by a detector (e.g. Geiger-Muller tube)

6.25 Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half

Radioactive decay is a random process so the likelihood of a decay taking place is a probability problem. For this reason, the **half-life** of an isotope is given rather than saying how long it will take to fully decay.

The **half-life** of a radioactive isotope is the time it takes for the **number of nuclei** of the isotope in the sample to **halve**, or the time it takes for the **count rate** from a sample containing the isotope to fall to half its initial level.



It turned out to be a killer paper. Half-life was 30 minutes.

6.26 Explain that it cannot be predicted when a particular nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process

If you know the start and finish count rate and the time taken, you can calculate the half life.

Example:
The count rate of an isotope is 1008 Bq. This falls to a count rate of 126 over a period of 21 days.

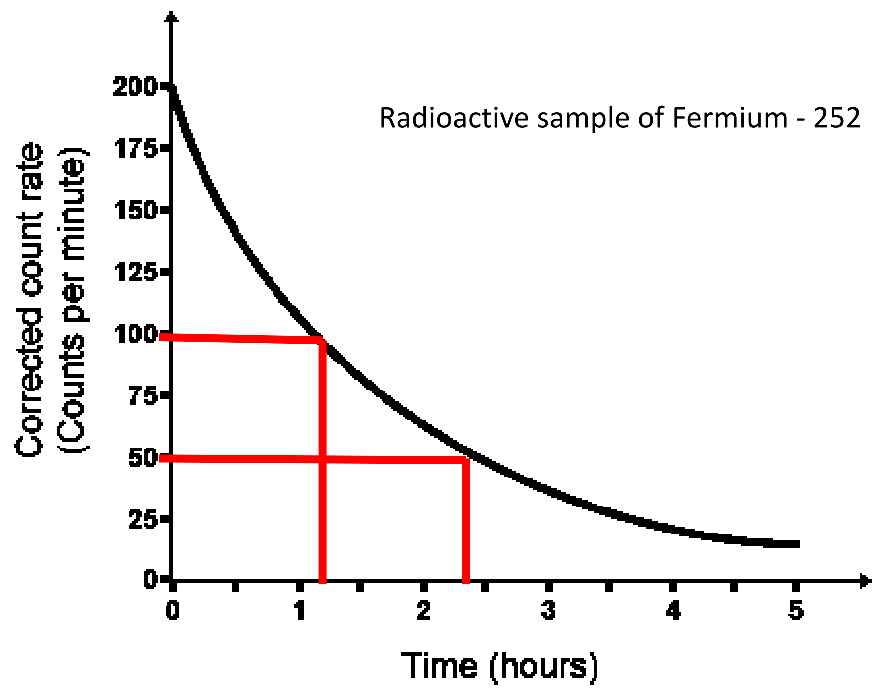
1008 → 504 → 252 → 126

1 2 3

3 half lives for count rate to fall to 126.

These 3 half lives took 21 days so each half life took 7 days.

Half life if this isotope = 7 days



It always takes 1.2 hours for the count rate to halve.

Half life of Fermium - 252 = 1.2 hours.

6.27 Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations

Cosmic rays can cause neutrons to be released in the atmosphere. These neutrons can cause atmospheric nitrogen to decay into radioactive carbon 14.

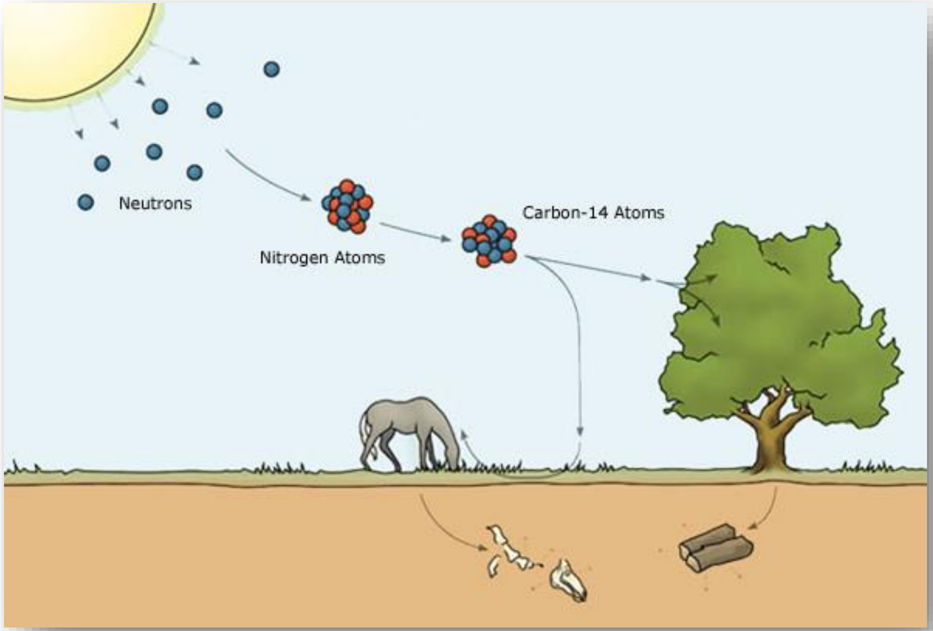
This is, in turn, turned into radioactive CO_2 (about 1 in 1 trillion times)

The CO_2 is absorbed by plants by photosynthesis and then by animals through the food chain.

When organisms die, they no longer take in C-14.

So, we can use the amount of C-14 in a dead organism to figure out it's age IF we know the half life.

For C-14, this is 5700 years!



6.29 Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed

Radioactive materials are **hazardous** to **life**. **Nuclear radiation** can **ionise** (add or remove electrons) substances **within** the human body. This can **change** the way cells behave, **damage** DNA or **destroy** human cells.

Body part	Effect of ionising radiation
Hair	Hair loss
Skin	Can cause burns or lead to skin cancers
Reproductive organs	High doses can cause sterility or mutations in offspring
Thyroid	Exposure to radioactive iodine can destroy the cells in the thyroid or cause cancers
Bone marrow	Can cause leukaemia or other blood cancers

Rapidly dividing cells like cells that produce hair or those in the reproductive organs are most **susceptible** to **ionising radiation**.

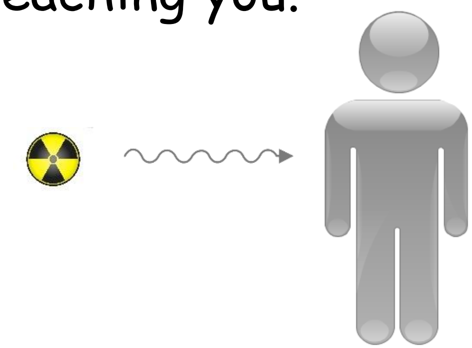
6.31 Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel

Radioactive materials are hazardous, so certain **precautions** can be taken to reduce the risk when using radioactive sources. These include:

- wear **protective clothing** to prevent the body becoming contaminated should radioactive isotopes leak out
- limit the **dose** and monitor **exposure** using detector badges, etc

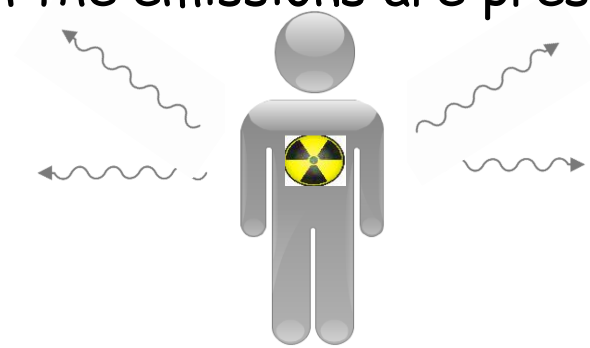
6.32 Describe the differences between contamination and irradiation effects and compare the hazards associated with these two

Irradiation is when an object or person is **exposed** to radiation. Protection from irradiation means stopping the radiation from reaching you.



Medical dressings are often irradiated but present no danger to the user.

Contamination is when a radioactive source is in **contact** with an object or person. The radioactive substance rather than the emissions are present.

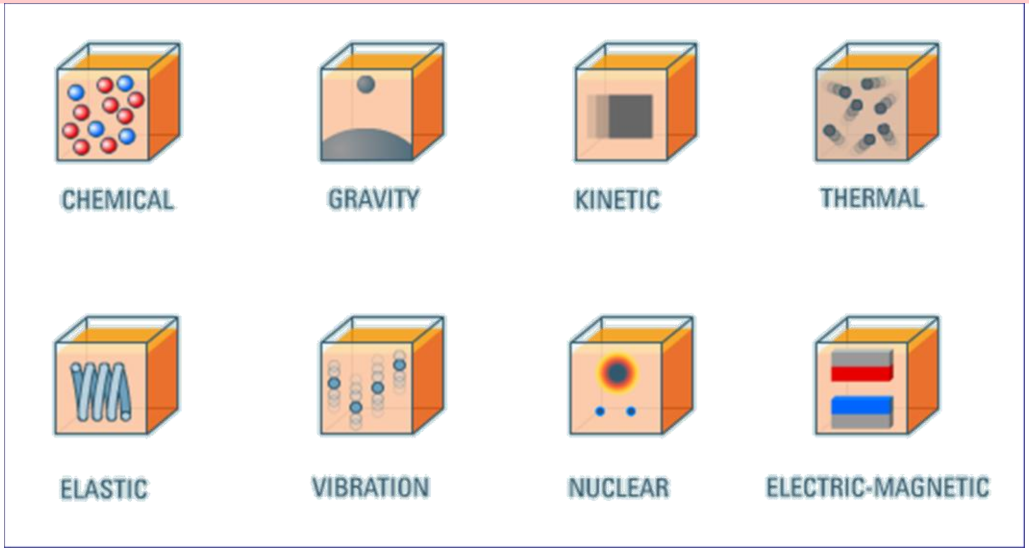


The object remains radioactive until the contamination is removed or decays naturally.

Topic 6 – Radioactivity

1. Describe the structure of the atom fully, including all masses, charges and locations.
2. State the size of the nucleus in standard form.
3. Define the term isotope including the term atomic number and nucleon number.
4. State the relative masses and relative electric charges of protons, neutrons, electrons and positrons
5. Describe the result of the absorption or emission of EM radiation.
6. Define the term emission.
7. Describe how positive ions are formed
8. Describe the location of all nuclear radiation source
9. Describe the term ionisation
10. Define the term background radiation
11. Describe the origins of background radiation.
12. Describe how to use photographic film to detect radiation
13. Describe how to use a Geiger- Müller tube for measuring radioactivity
14. Describe the structure of alpha, beta minus, positron and gamma radiation.
15. Describe alpha, beta and gamma properties including penetration and ionisation capabilities.
16. Describe how and why the atomic model has changed over time: plum pudding, Rutherford and Bohr
17. Describe the process of $\beta-$ decay
18. Describe the process of $\beta+$ decay
19. Describe the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays
20. State the unit of nuclear activity
21. Describe the term half life
22. Describe the dangers of ionising radiation

8.1 Describe the changes involved in the way energy is stored when systems change



There are *processes* or *pathways* through which energy is shifted.

Energy can be shifted / transferred between stores by:

- Mechanical working (a force moves something)
- Electrical working (charge moves through p.d.)
- Heating by particles (conduction, convection)
- Heating by radiation (IR, light, other EM)
- Heating by vibration (air resistance, sound)

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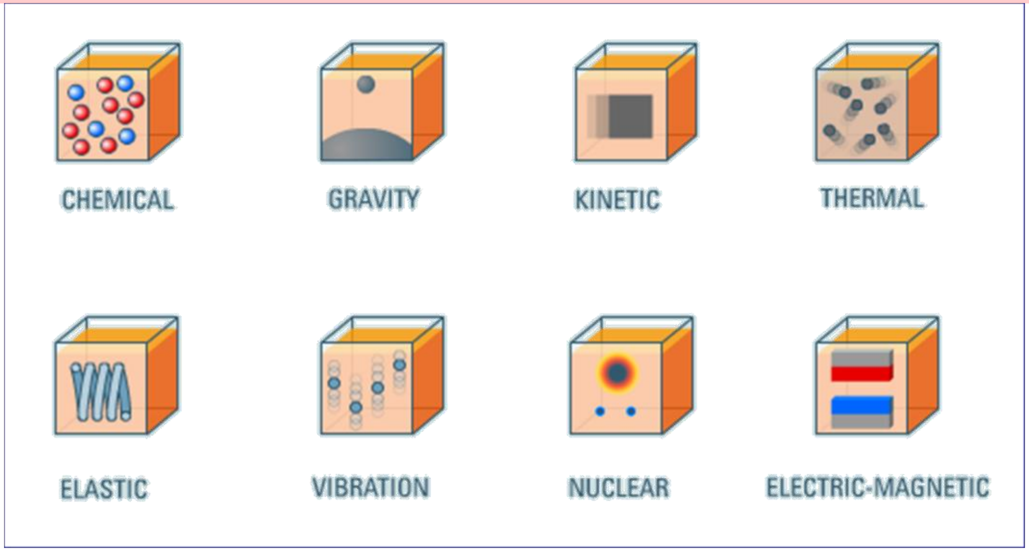

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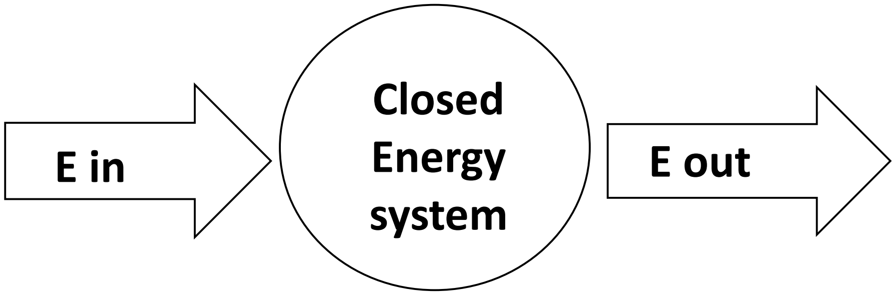
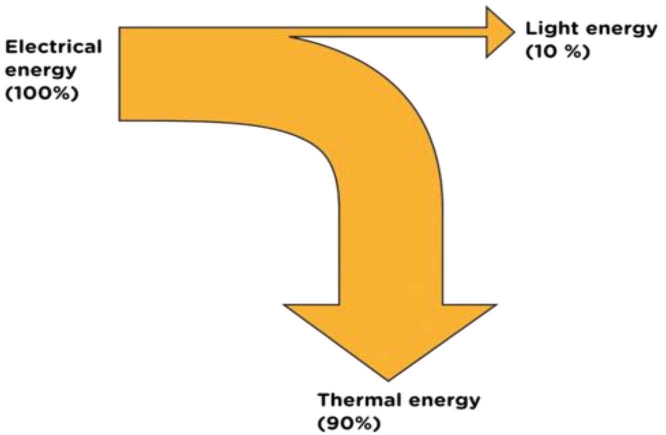
8.2 Draw and interpret diagrams to represent energy transfers

In a closed energy system there can be transfer of energy but not mass. There is no change to the total energy in the system.



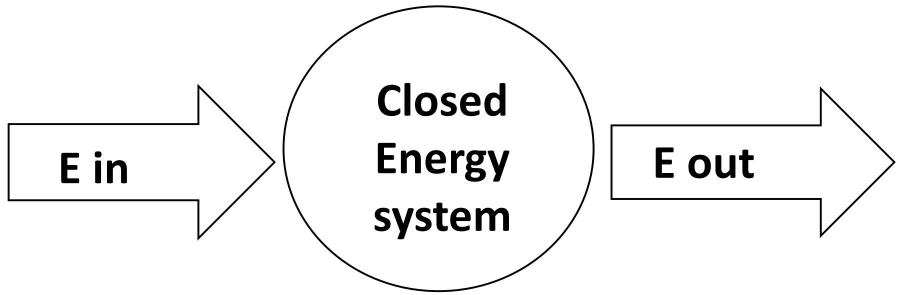
In a **closed energy system** all the energy can be accounted for even when energy stores change.

The diagram shows the energy transfer for a light bulb. All the electrical energy store can be accounted for as light energy and thermal energy.
The thermal energy is not useful in this case and can be considered to be dissipated or "waste" energy.



8.3 Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system

In a closed energy system there can be transfer of energy but not mass. There is no change to the total energy in the system.



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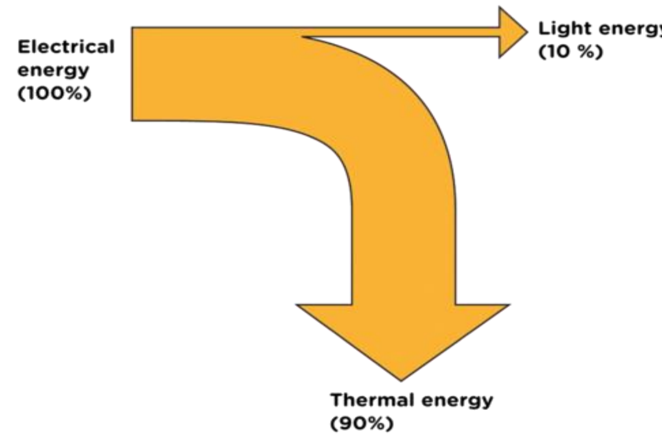
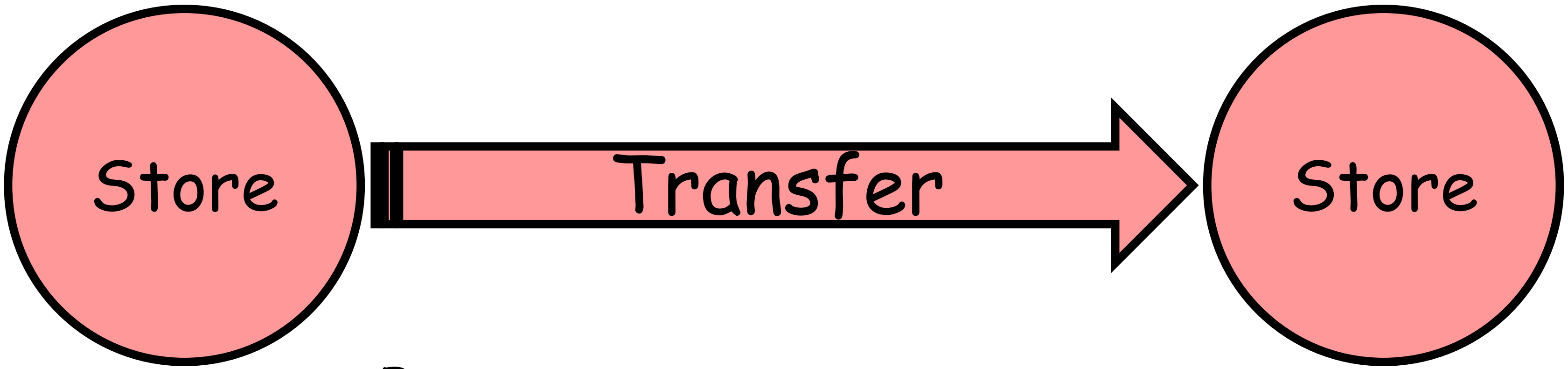


8.4 Identify the different ways that the energy of a system can be changed a through work done by forces b in electrical equipment c in heating



Forces
Friction, Work, Gravity

Electrical Work
Through the wires in a circuit

Heating
Radiation: sun or metal objects
Conduction: oscillation
Dissipation: lost to the surroundings in mechanical work.

8.5 Describe how to measure the work done by a force and understand that energy transferred (joule, J) is equal to work done (joule, J)

When a force causes an object to move through a distance, WORK IS DONE on the object. So a force does work on an object when the force causes a displacement of the object.

Work done can be calculated using the equation:

work done (J) = force (N) x distance moved in the direction of the force (m)

$$E = F \times d$$

8.8 Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground:

When an object is raised above ground level it gains gravitational potential energy (GPE). This stored energy can be released if the object is allowed to fall.

A pile driver is a machine that lifts a heavy weight then drops it on a post to drive it into the ground.

Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground:

change in G.P.E (J) = mass (kg) × gravitational field strength (N/kg) × change in height (m)

$$\Delta GPE = m \times g \times \Delta h$$

The pile driver hammer has a mass of 120 kg and it is raised to a height of 4 m above the ground. How much G.P.E will it have?

$$\Delta GPE = m \times g \times \Delta h$$

$$\Delta GPE = 120 \times 10 \times 4$$

The G.P.E gained is: $\Delta GPE = 4800$ J

8.9 Recall and use the equation to calculate the amounts of energy associated with a moving object:

Moving objects have kinetic energy.

The long-jumper is using her kinetic energy to carry her body as far as possible. The more kinetic energy she has, the longer her jump will be. Her kinetic energy depends on her mass (which she can not change) and her velocity (she can run faster!).

Recall and use the equation to calculate the amounts of energy associated with a moving object:

kinetic energy (J) = $\frac{1}{2}$ × mass (kg) × speed2 (m/s)
KE = $\frac{1}{2}$ m v2

If her mass is 46 kg and she is travelling at 8 m/s, her kinetic energy during her jump will be:
KE = $\frac{1}{2}$ m v2

KE = $\frac{1}{2}$ x 46 x 82

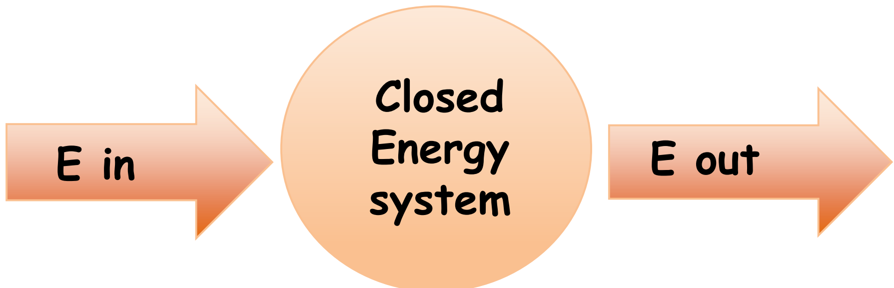
The energy transferred in the jump is: KE = 1472 J

8.10 Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways

Energy can be stored, transferred or dissipated - but can not be created or destroyed.

In a closed energy system there can be transfer of energy but not mass. There is **no change to the total energy in the system.**

No mass change



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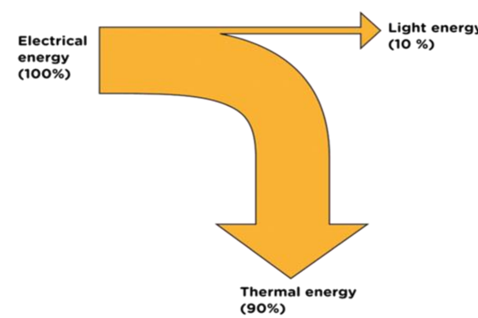


Work Done Against Frictional Forces

When work is done against frictional forces on an object there is a temperature increase of the object.

A bicycle pump gets hot in use as work is done in compressing the gas, causing the pump to get hotter.

8.12 Define power as the rate at which energy is transferred and use examples to explain this definition

Power - the rate at which energy is transferred
the rate at which work is done
(rate means "how quickly")
Power is measured in joules per second

1 J/s = 1 Watt

An object which transfers energy does so at a certain rate. The metal filament in this light bulb transfers the electrical energy store into heat and light.
This bulb transfers 2400 joules of energy in 60 seconds.

8.13 Recall and use the equation: power (watt, W) = work done (joule, J) ÷ time taken (second, s) P E t

An object which transfers energy does so at a certain rate.
The metal filament in this light bulb transfers the electrical energy store into heat and light.
This bulb transfers 2400 joules of energy in 60 seconds.

Power can be calculated using the following equation:

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

$$P = \frac{E}{t}$$

P= 2400 / 60 = 40 J/s

So this is a **40 Watt** light bulb.

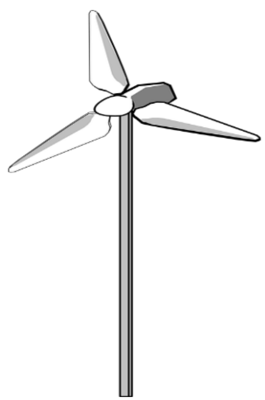
8.15 Recall and use the equation: efficiency = useful energy transferred by the device / total energy sup plied to the device

The amount of useful energy you get from an energy transfer, compared to the energy put in, is called the **EFFICIENCY**

$$\text{Efficiency} = \frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$$

This calculation will result in a decimal value which can be multiplied by 100 to give a percentage efficiency.

A wind turbine energy transfer

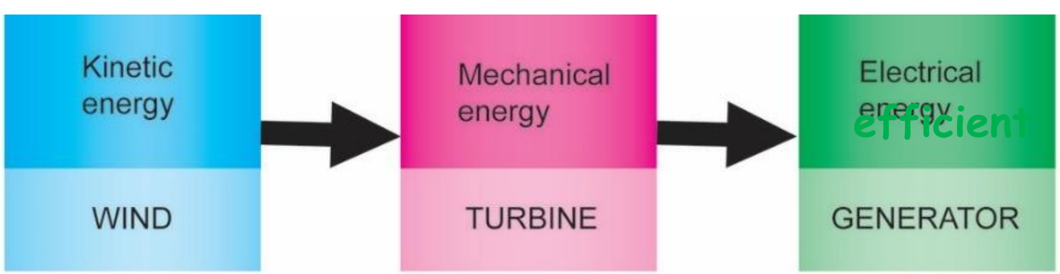


The wind turbine produces 120 MW of electrical energy for every 500 MW of kinetic energy provided by the wind.

$$\text{Efficiency} = \frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$$

$$= \frac{120}{500} \qquad = 0.24 \text{ efficient}$$

or 0.24 x 100 = 24 %



Topic 8 – Energy – forces doing work

1. Describe some changes involved in the way energy is stored when systems change

2. Define the term closed system
3. State the different ways that the energy of a system can be changed
4. Define the term work done
5. State the equation for calculating work done when you have force and distance moved.
6. State the equation to calculate the change in gravitational PE when an object is raised above the ground.
7. State the equation to calculate the amounts of energy associated with a moving object:
8. Define the term dissipation
9. Define the term power
10. State the equation for calculating power when you have the energy transferred and the time taken.
11. Define the term Watt.
12. State the equation for efficiency.

9.1 Describe, with examples, how objects can interact a at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved b by contact, including normal contact force and friction c producing pairs of forces which can be represented as vectors

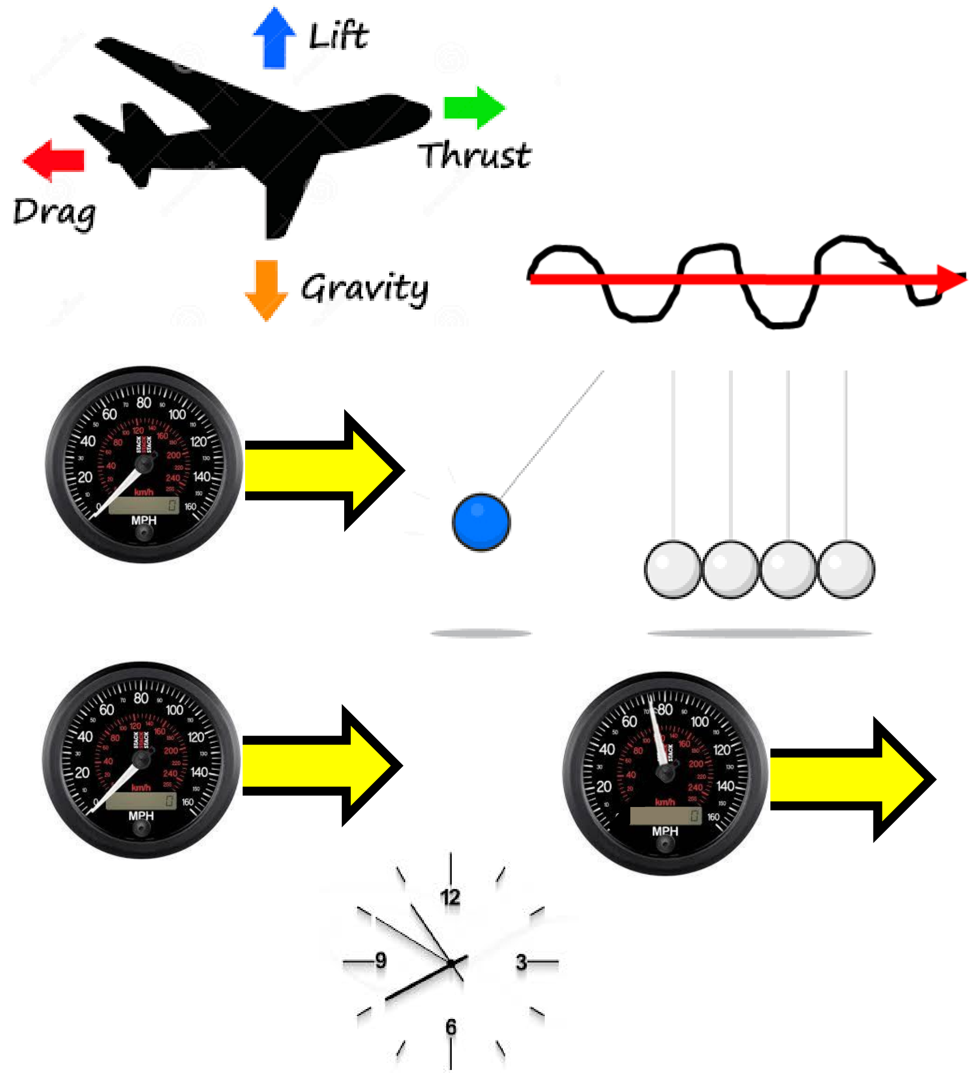
Forces can be placed into two groups. There are forces that act on contact and there are forces that act at a distance.

Contact Forces	Non-Contact Forces
Air Resistance	Gravity
Friction	Magnetism
Tension	Electrical Force
Normal Force	Nuclear Force

9.2 Explain the difference between vector and scalar quantities using examples

Scalars

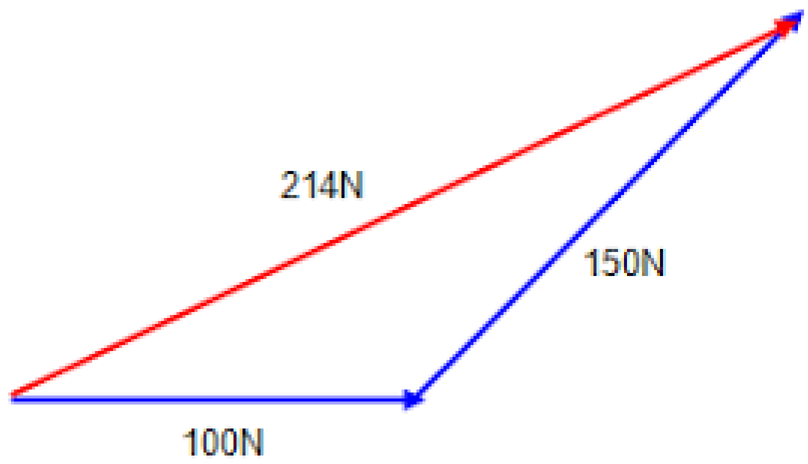
Vectors



9.3 Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)

Vectors can be shown by arrows.

The length of the arrow shows the size, or magnitude, of the force.



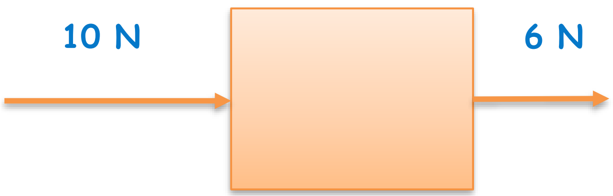
The direction of the arrow shows the direction of the force.

The vector arrows can be added together to show the resultant of two of more vectors.

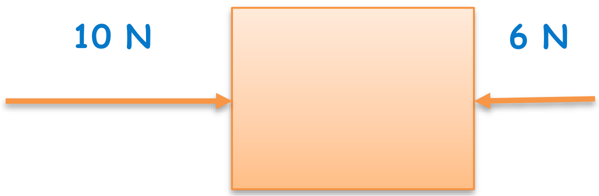
9.3 Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)

A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force.

When two forces act in a line the resultant force is the vector addition of the two vectors. Remember the direction is important.



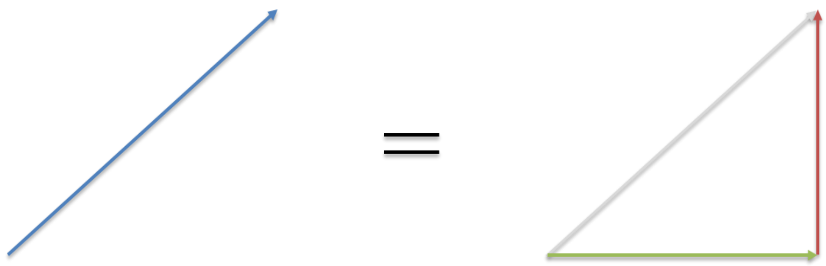
R = 16 N to the right



R = 4 N to the right

9.4 Draw and use free body force diagrams

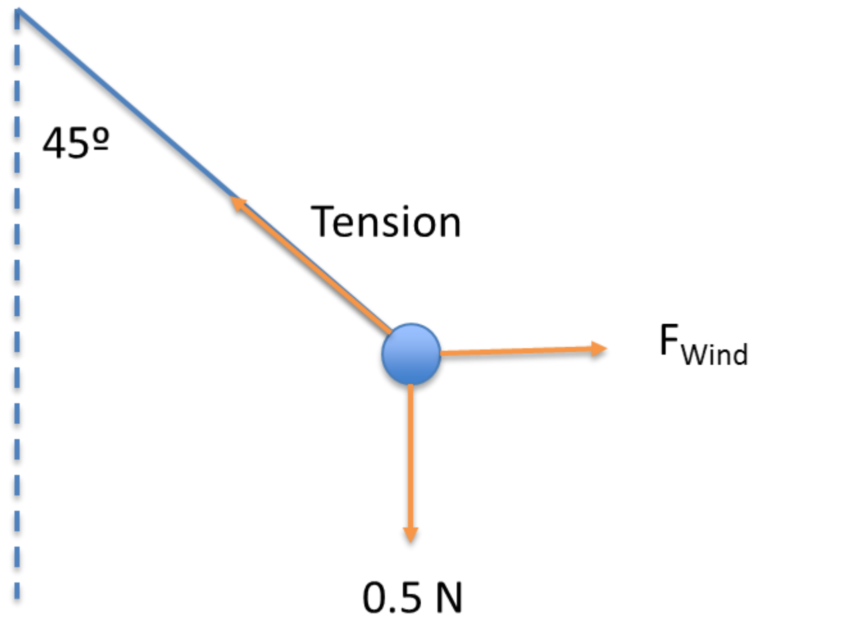
A single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.



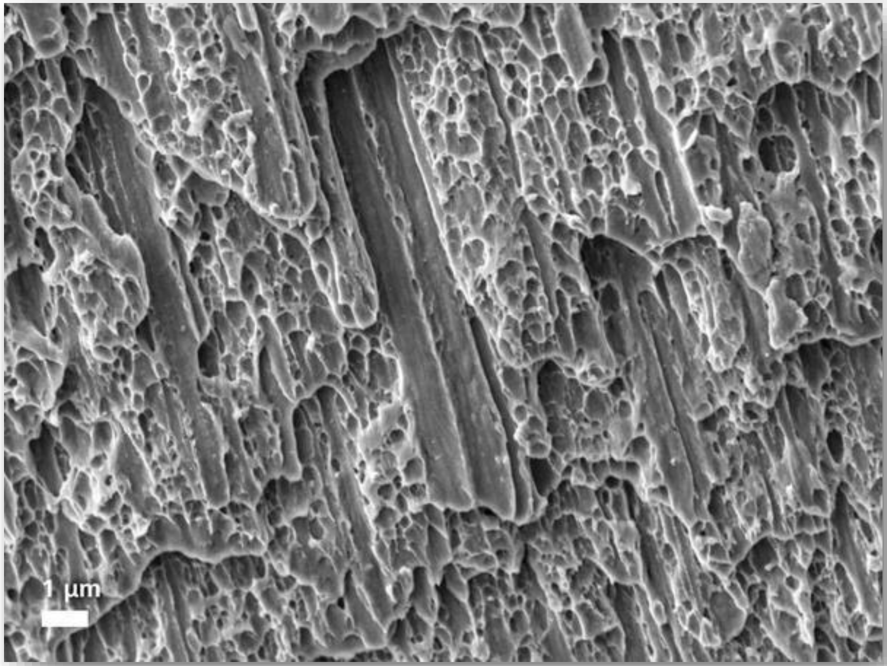
A pendulum has a weight of 0.5 N.

On a windy day the pendulum is hung outside and the pendulum now hangs at an angle of 45°.

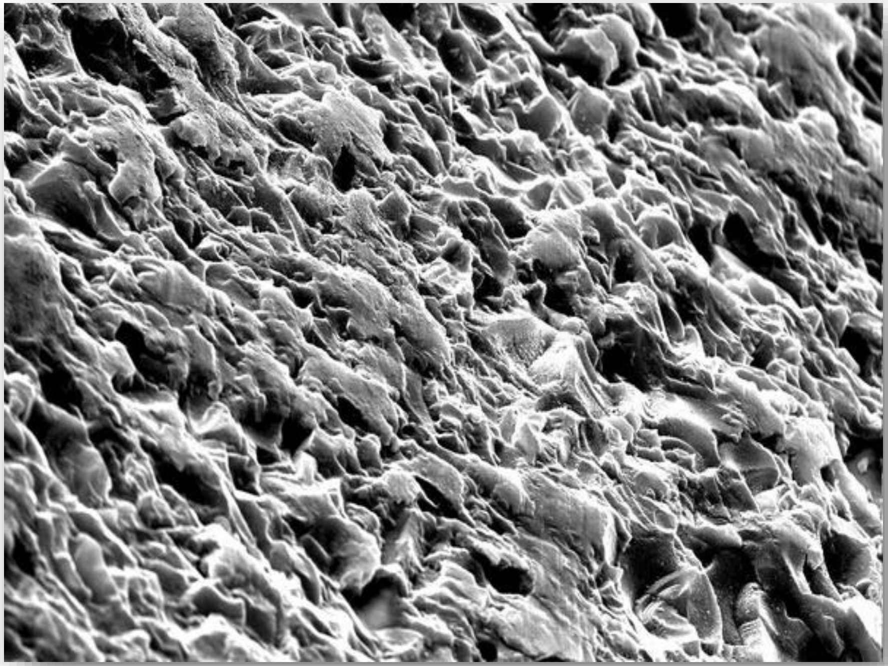
Assuming the wind hits the pendulum moving horizontally, draw a free body diagram to represent the forces acting.



9.10 Explain ways of reducing unwanted energy transfer through lubrication



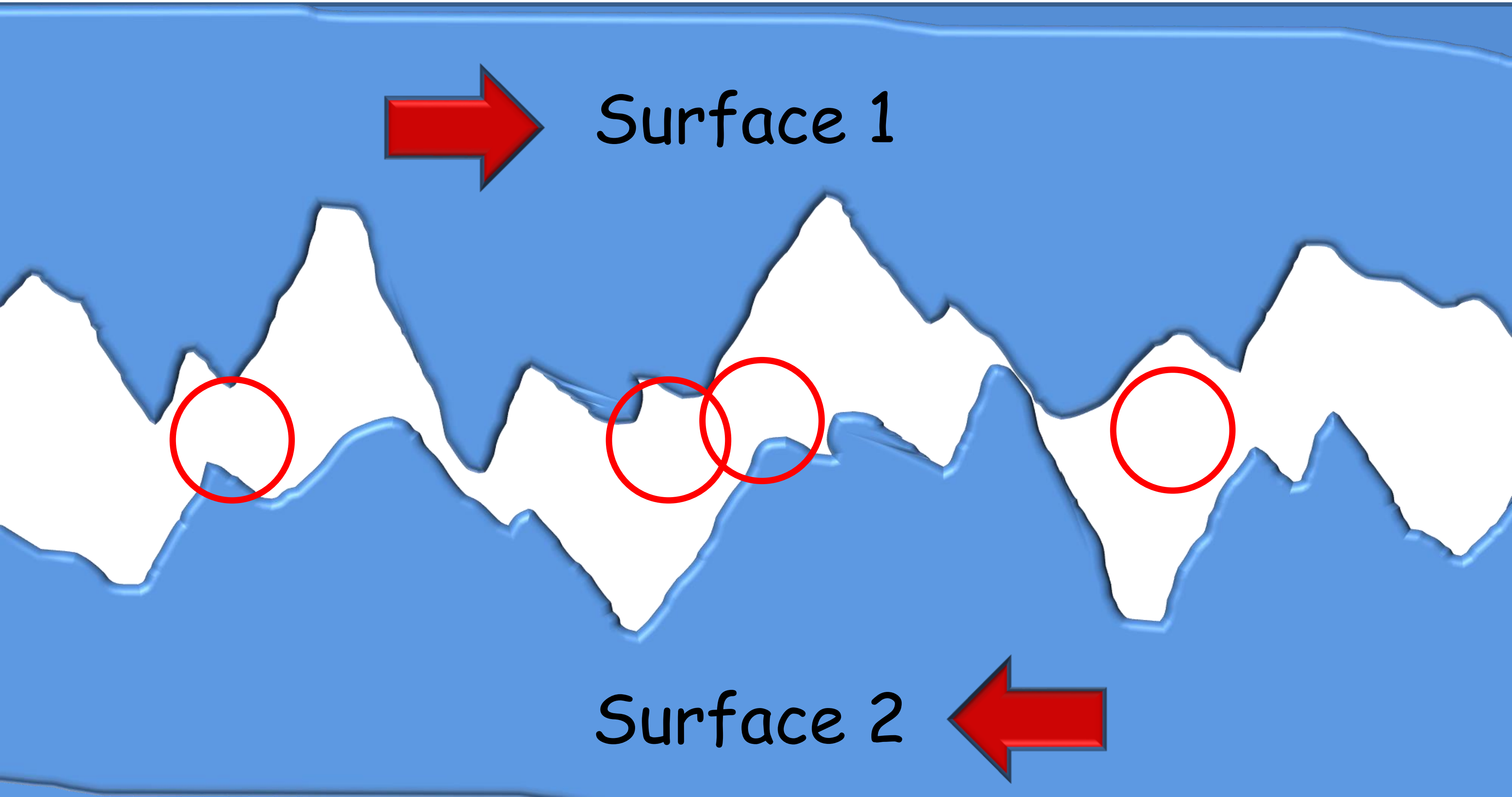
Stainless steel



Glass

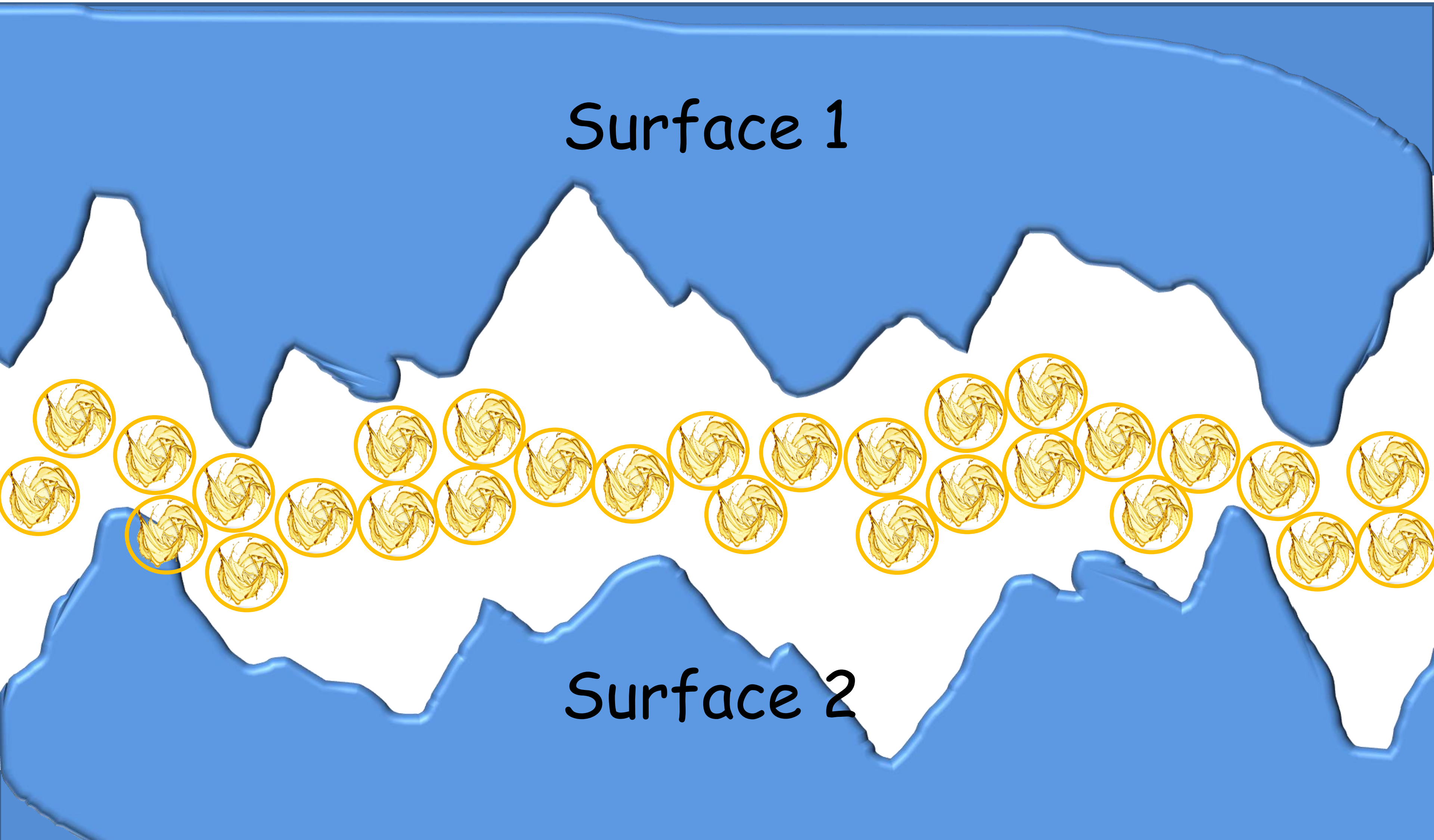
9.10 Explain ways of reducing unwanted energy transfer through lubrication

Surfaces are never perfectly smooth, if we use a microscope we see irregularities, when two surfaces touch these irregularity's "interlock" with each other



9.10 Explain ways of reducing unwanted energy transfer through lubrication

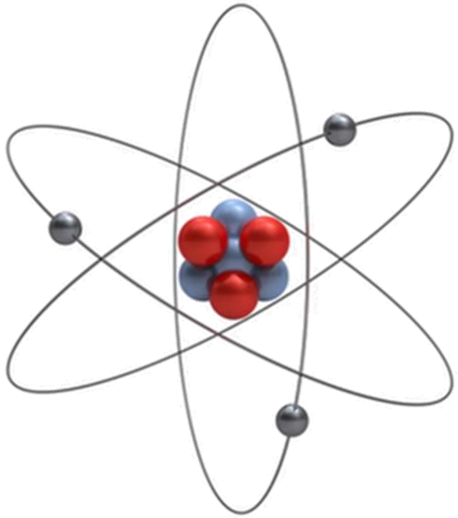
We can reduce friction using lubricants which prevent "interlocking"



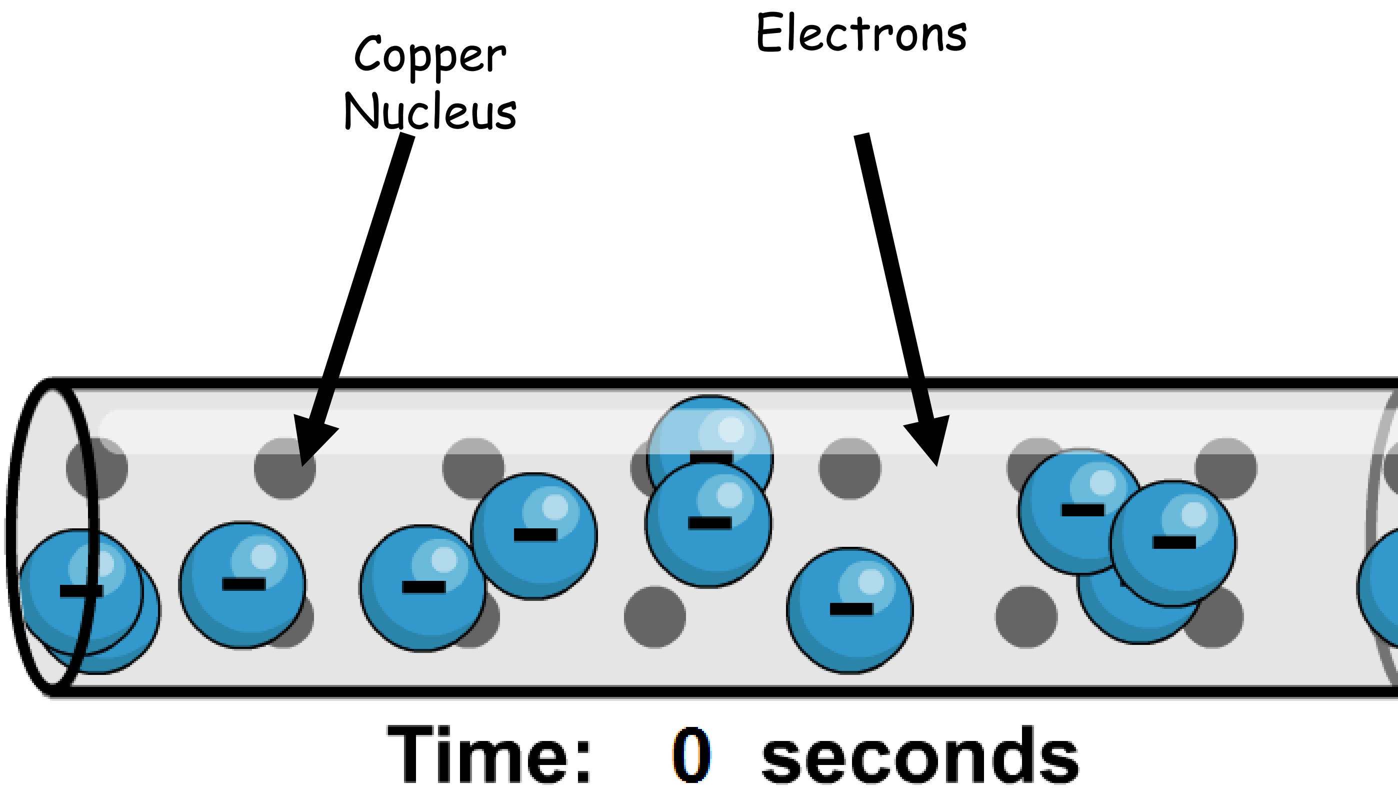
Topic 9 – Forces and their effects

1. Define the term contact force
2. Define the term non-contact force.
3. Describe some contact forces
4. Describe some non-contact force.
5. State Newton’s First Law
6. Describe how to reduce unwanted energy transfers in mechanical systems.
7. Describe how to reduce unwanted energy transfers in heated systems.

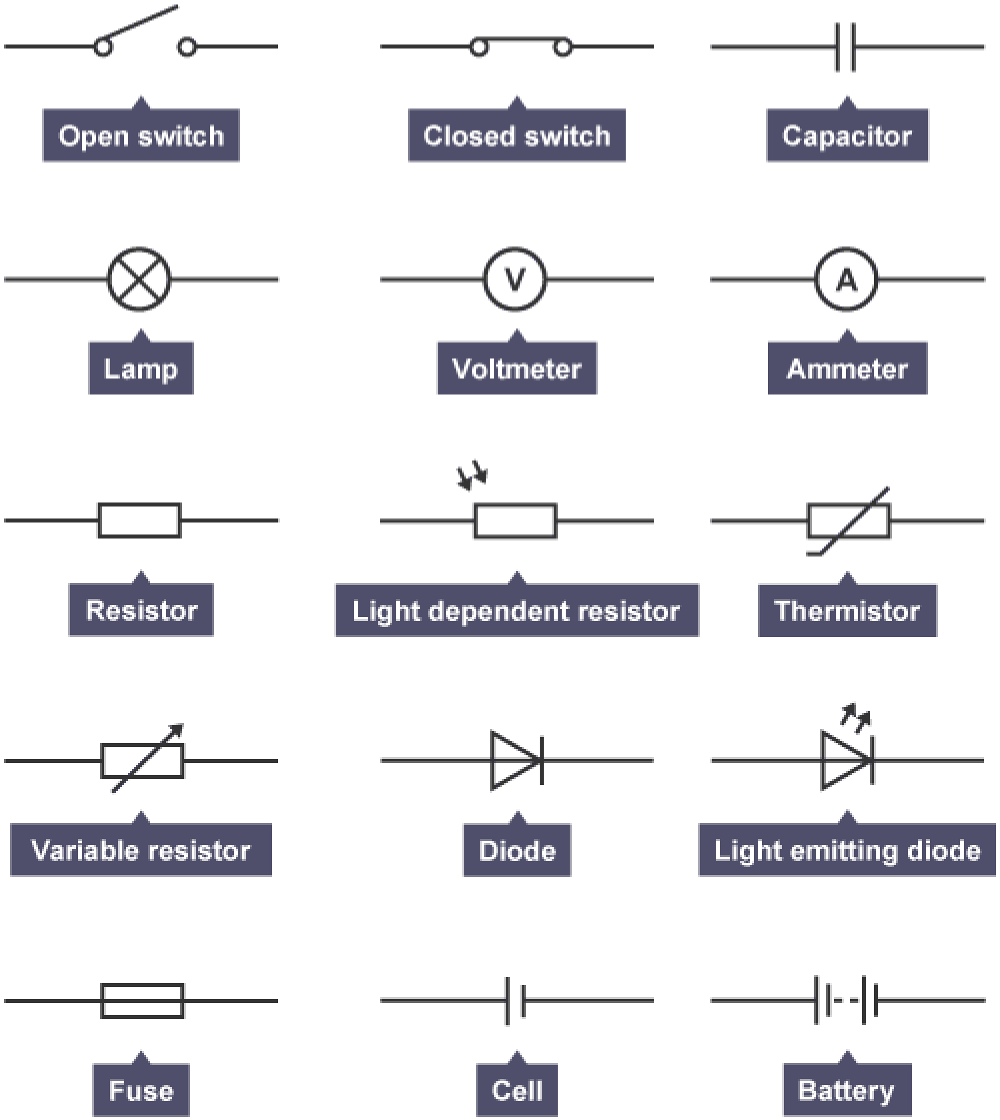
10.1 Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons

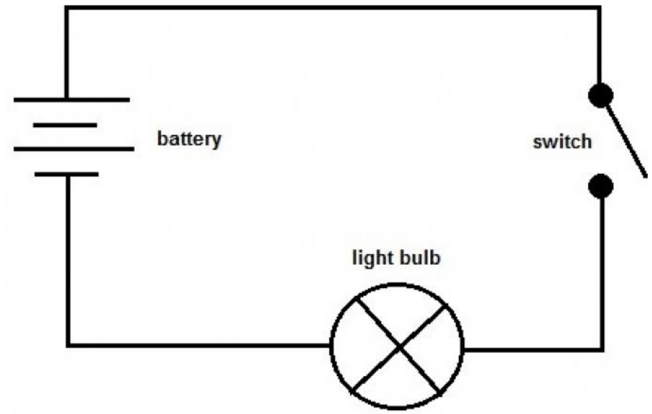


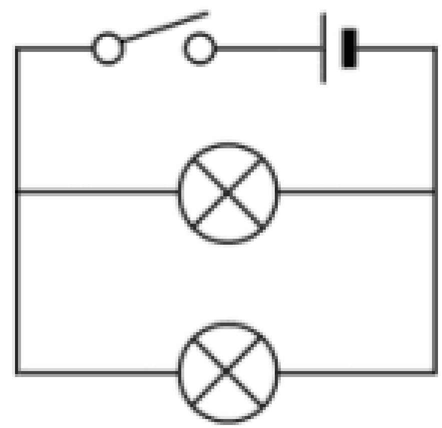
Sub atomic particle	Relative mass	Relative charge
Protons	1	+1
Neutrons	1	0
Electrons	$^{1}/_{1835}$	-1



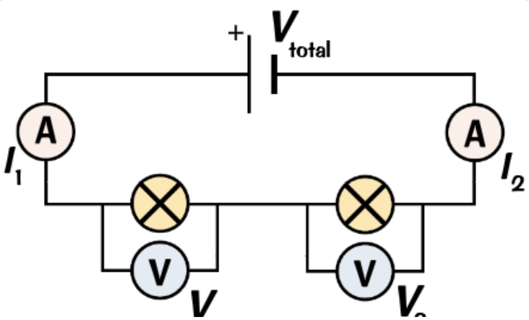
10.2 Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs

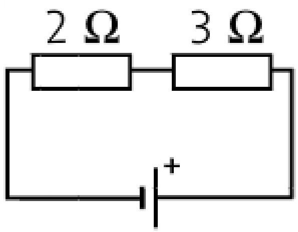






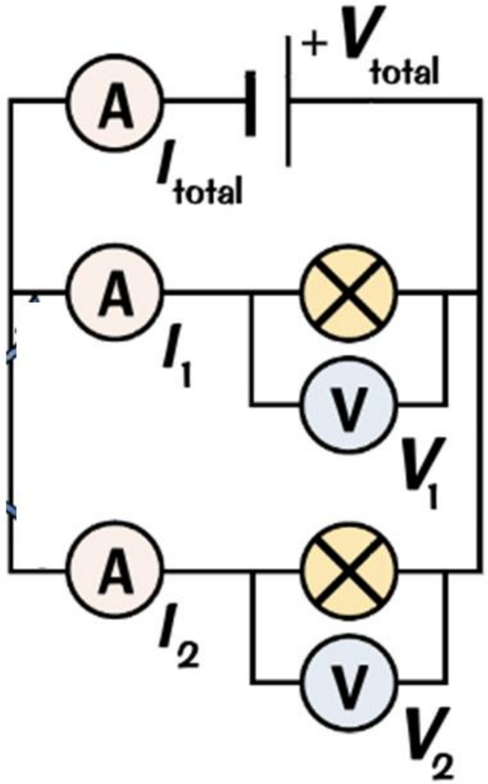
10.3 Describe the differences between series and parallel circuits





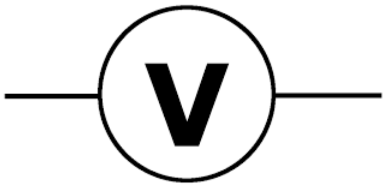
Total resistance = 5 Ω

- The current is the same everywhere ($I_1 = I_2$)
- The p.d. is shared.
- The p.d. depends on the resistance.
- The total resistance increases with added resistors. ($R_T = R_1 + R_2$)



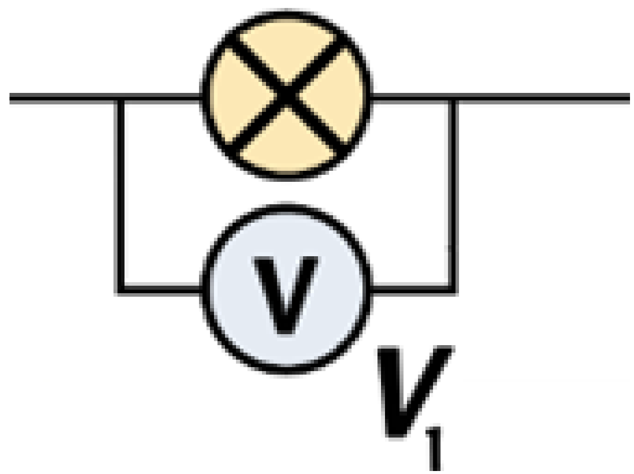
- The p.d is the same across all the components.
  - $V_1 = V_2 = V_3$
- The current is conserved at junction, this means it is shared among the branches.
  - $I_{total} = I_1 + I_2$
- Total resistance DECREASES as you add resistors ($\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2}$)

10.4 Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it



Measures the voltage in a circuit.
(how much energy is transferred)

How much fuel did I use for my drive to Germany in my Voltswagen Golf?

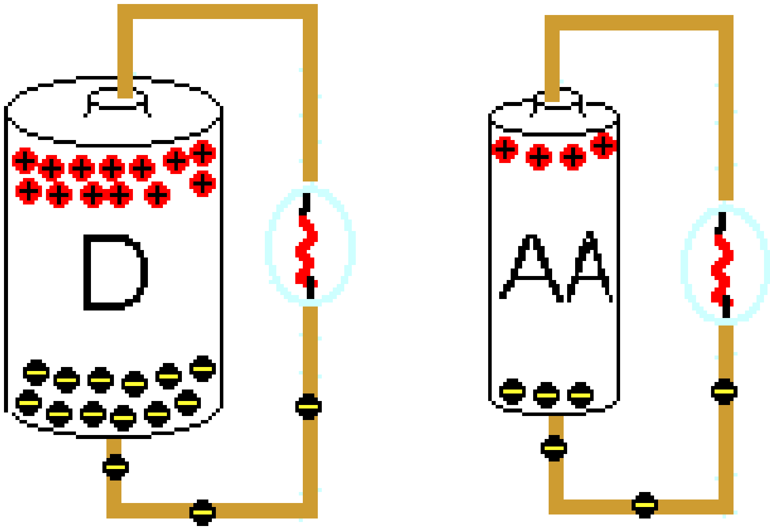


10.5 Explain that potential difference (voltage) is the energy transferred per unit charge passed and hence that the volt is a joule per coulomb

Charge: The number of "packets" of electrons that pass a point.

Joule: the unit of energy

Coulomb: the unit of charge



1.5 v

1.5 v

10.6 Recall and use the equation: energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V) E Q V

Work is done when charge flows in a circuit.

The amount of energy transferred by electrical work can be calculated using the equation:

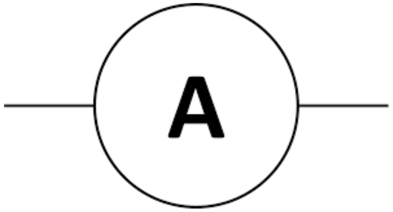
Also:

Energy transferred = Charge flow (C) x Potential difference (V)

$$E = Q\,V$$

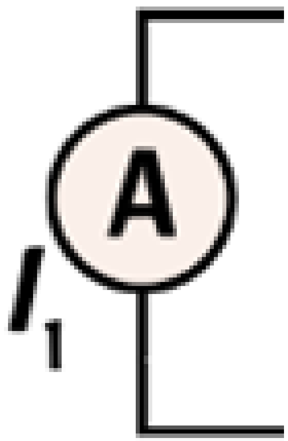
Name	Equation symbol	Unit	Unit Symbol
Energy transferred	E	Joules	J
Power	P	Watts	W
Time	t	Seconds	s
Charge flow	Q	Coulombs	C
Potential difference	V	Volts	V

10.7 Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component



Measures the current in a circuit.
(the rate of flow of charge)

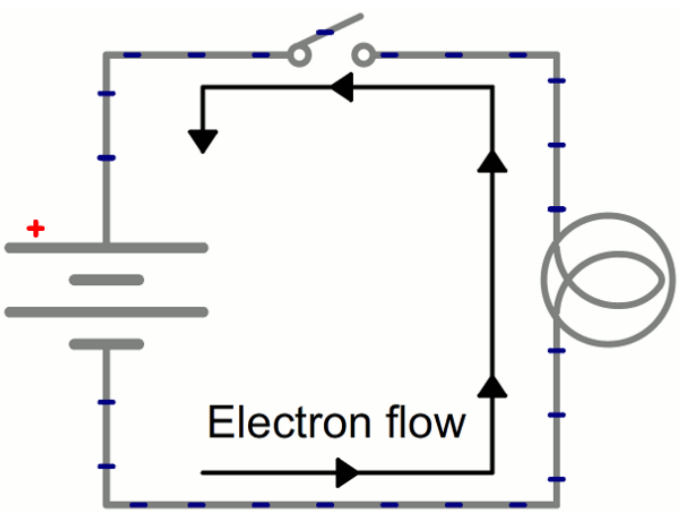
Why do the police stand in the road to see how fast you are driving?

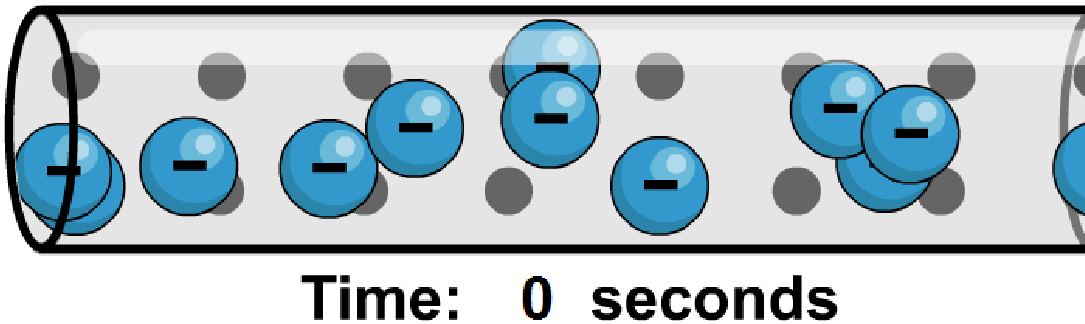


10.8 Explain that an electric current as the rate of flow of charge and the current in metals is a flow of electrons

An electric current is the flow of **electrical charge**, usually **electrons**, around a **circuit**.

The size of the electric current is the rate of flow of electrical charge. In a series circuit (one with a single loop of wire) the current is the same at any point of the loop.





10.9 Recall and use the equation: charge (coulomb, C) = current (ampere, A) × time (second, s) Q = I x t

An electric current is the flow of **electrical charge**, usually **electrons**, around a **circuit**.

The size of the electric current is the rate of flow of electrical charge. In a series circuit (one with a single loop of wire) the current is the same at any point of the loop.

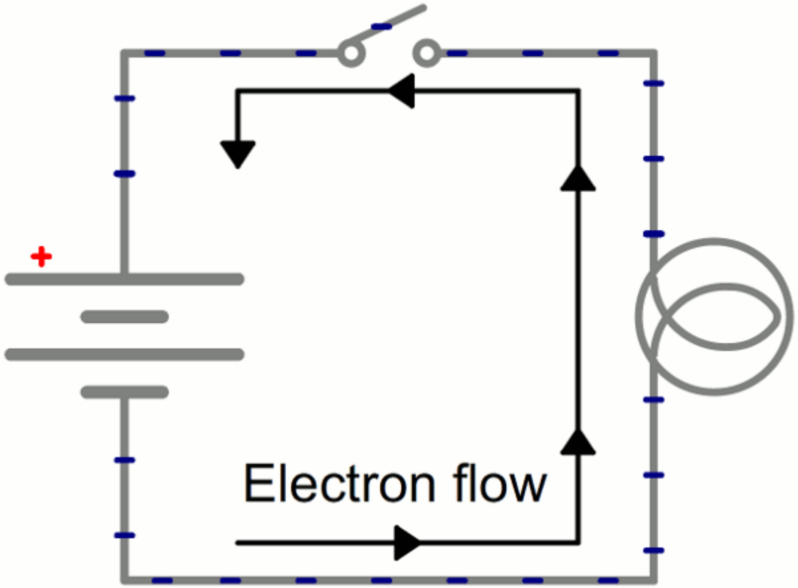
Charge flow, **current** and **time** are linked by the equation:

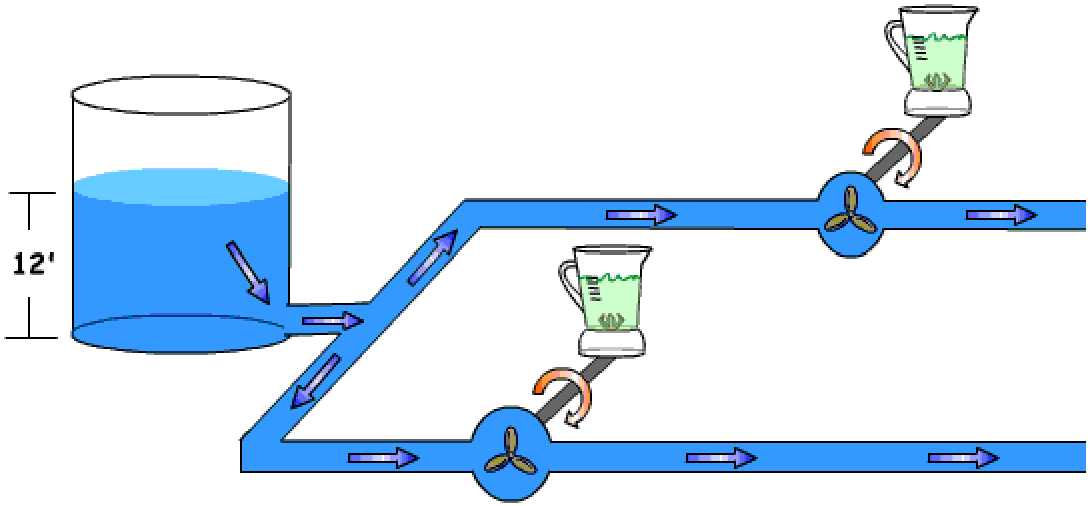
Charge flow (C) = Current (A) × Time (s)

$$Q = I \times t$$

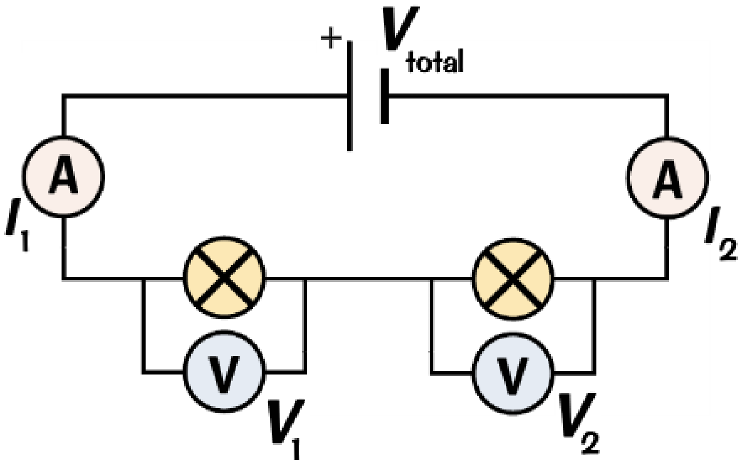
Name	Equation symbol	Unit	Unit Symbol
Charge flow	Q	Coulombs	C
Current	I	Amp	A
Time	t	Seconds	s

10.10 Describe that when a closed circuit includes a source of potential difference there will be a current in the circuit

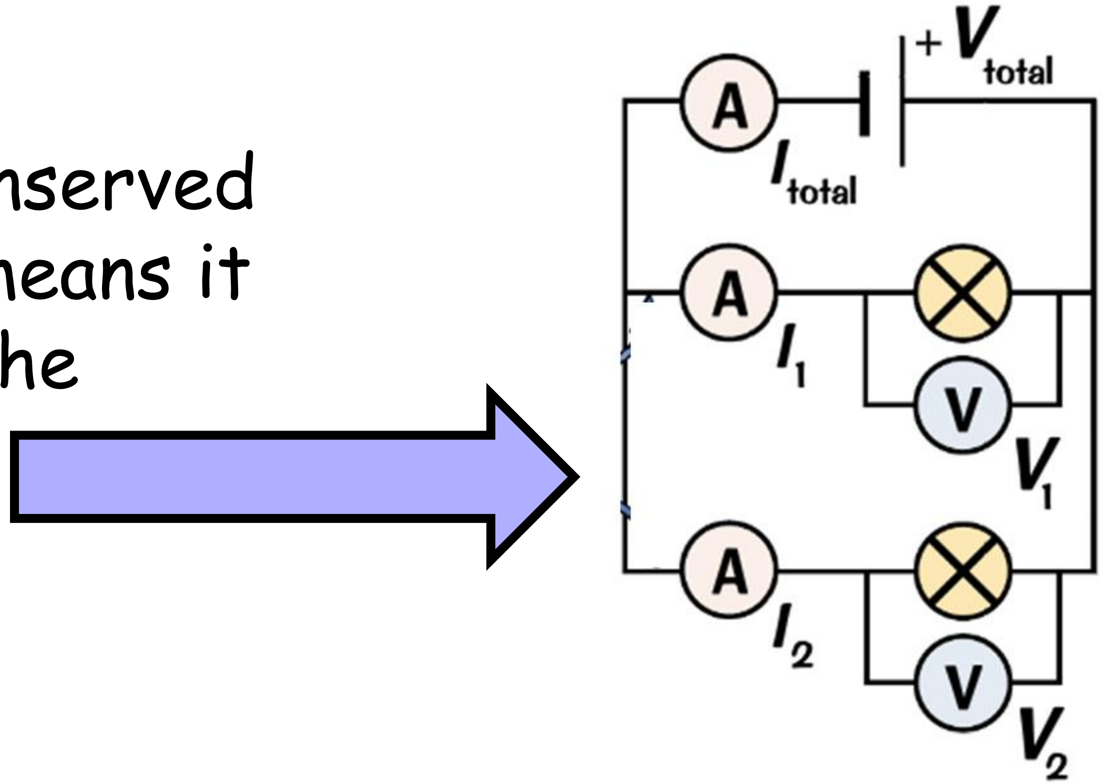




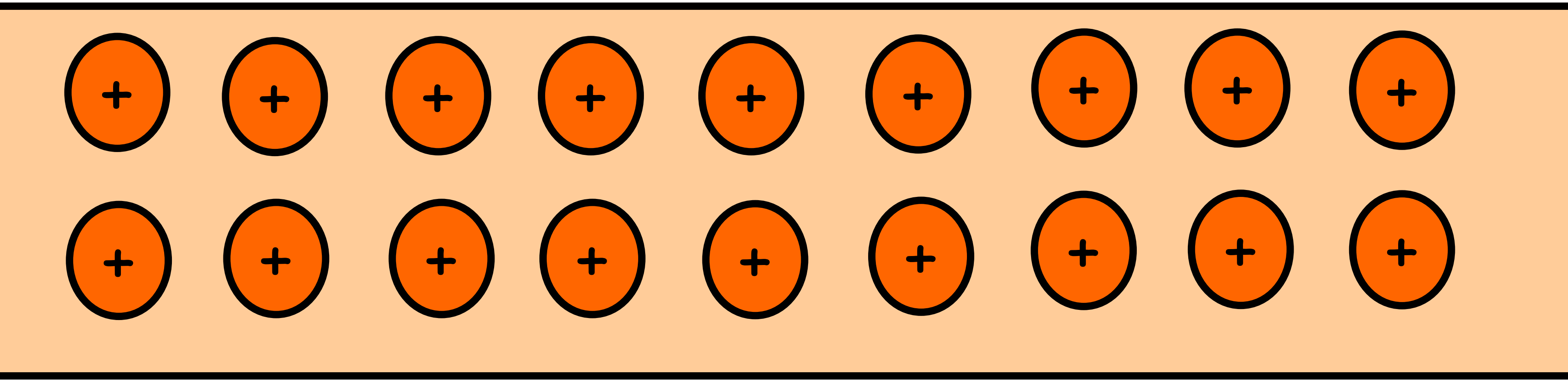
10.11 Recall that current is conserved at a junction in a circuit



- The current is conserved at junction, this means it is shared among the branches.
  - $I_{total} = I_1 + I_2$



10.12 Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor



The resistance is caused by the negative electrons colliding with the positive ions in the wire.

The electrons collide with the positive ions and transfer some energy to them, causing them to oscillate more, thereby increasing the resistance,

A.C = Alternating Current (Mains in UK)
D.C = Direct Current (Battery Powered)

10.13 Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) V = I x R

- The current (*I*) through a component depends on both the resistance (*R*) of the component and the potential difference (*V*) across the component.
- The greater the resistance of the component, the smaller the current for a given potential difference (*V*) across the component.

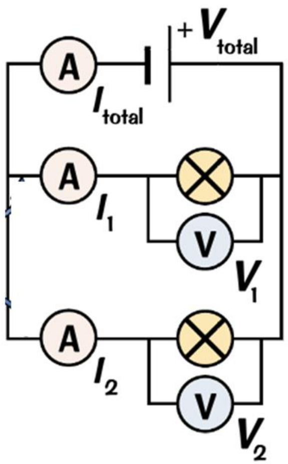
Potential Difference (V) = Current (A) x Resistance (Ω)

$$V = I \times R$$

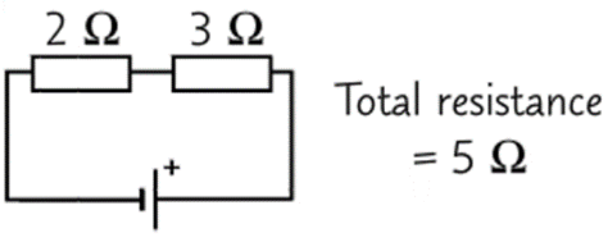
The resistance in a circuit will depend on the components used in the circuit as well as the length of wire used in the circuit. The longer the wire, the greater the resistance.

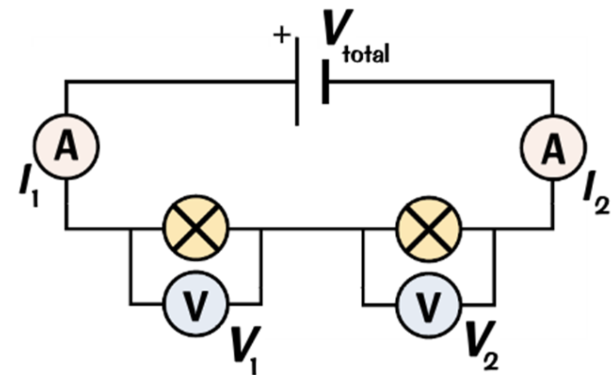
Name	Equation symbol	Unit	Unit Symbol
Potential difference	V	Volts	V
Current	I	Amp	A
Resisitance	R	Ohms	Ω

10.14 Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased



- Total resistance DECREASES as you add resistors ($\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2}$)
- Because the potential difference is the same across the resistors….
- … but in parallel the current has more than one route…
- …this increases the total current around the loop…
- …which decreases the resistance using V=IR





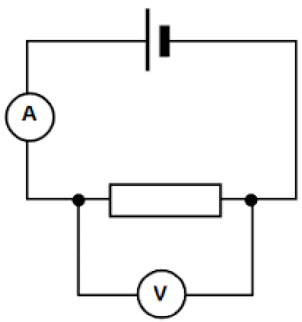
- The current is the same everywhere ($I_1 = I_2$)
- The p.d. is shared.
- The p.d. depends on the resistance.
- The total resistance increases with added resistors. ($R_T = R_1 + R_2$)

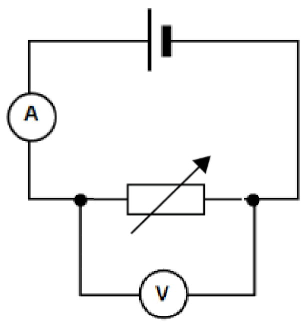
10.15 Calculate the currents, potential differences and resistances in series circuits

Measuring Resisitance:

To measure the resistance of an electrical component the following circuit needs to be set up…

$$V = I \times R$$





By measuring the **current**, using the **ammeter**, and the **potential difference**, using a **voltmeter**, the <u>resistance</u> can be found from…

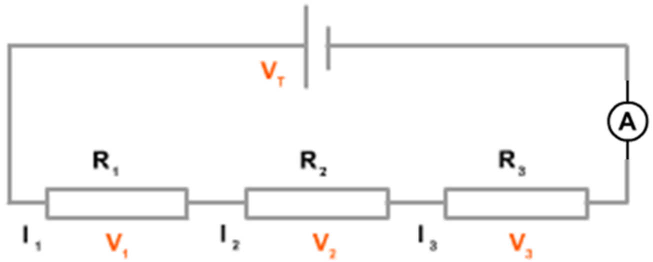
$$R = \frac{V}{I}$$

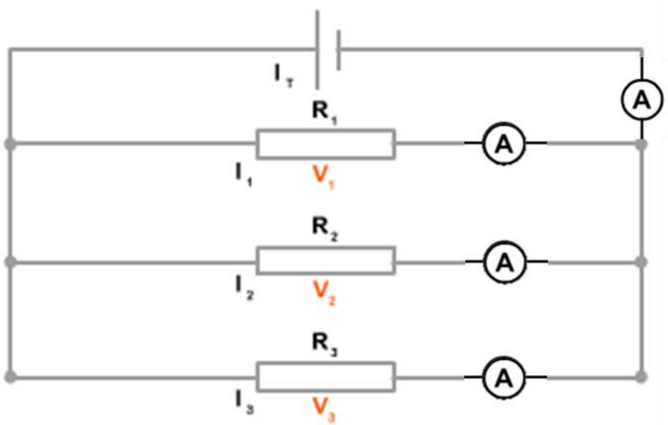
The electrical component tested can be changed from the resistor shown to any other electrical component.

To get a **range** of **potential differences** and currents a **variable resistor** can be added into the circuit **or** the input **potential difference** changed.

Name	Equation symbol	Unit	Unit Symbol
Potential difference	V	Volts	V
Current	I	Amp	A
Resisitance	R	Ohms	Ω

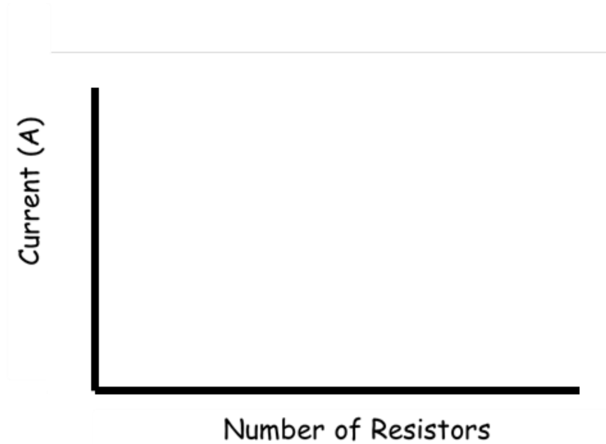
10.16 Explain the design and construction of series circuits for testing and measuring





1. Build the circuit, use only 6V!
2. Start with one resistor then move up to three for series and parallel.
3. Calculate the resistance every time.
4. Plot a graph to show the trend.
5. Compare resistance in series and parallel circuits.

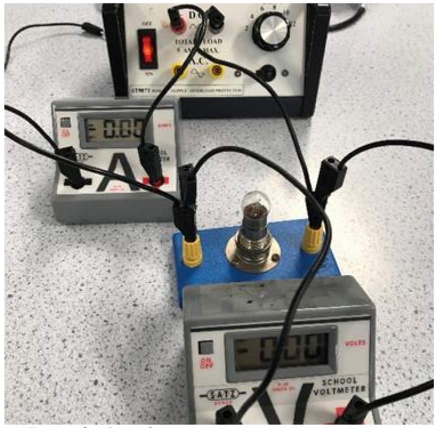
	Resistors	Current	Resistance
Series	1		
	2		
	3		
Parallel	Resistors		
	1		
	2		
	3		



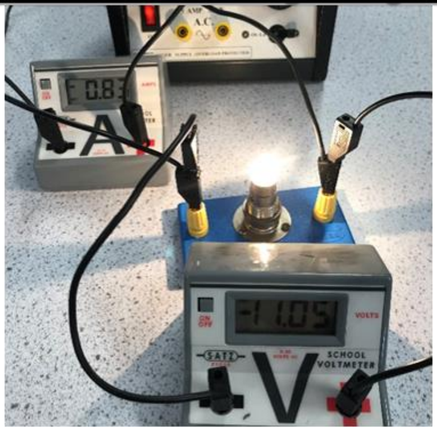
Parallel Series

10.17 Core Practical: Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps

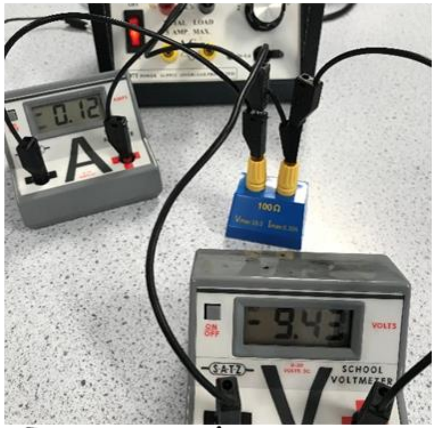
Core practical 5: Investigating resistance



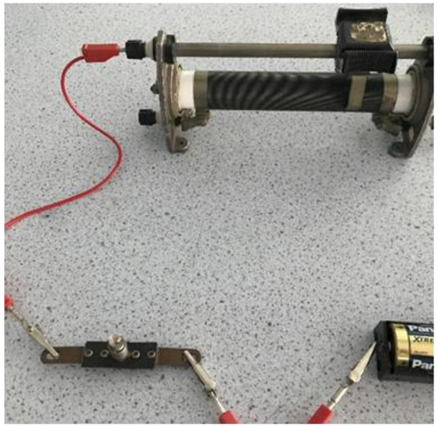
Build the circuit as shown in the diagram. Start at 0V on the power pack.



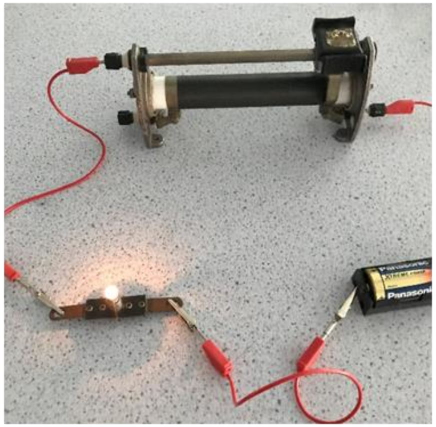
Increase the voltage from the power pack, recording the voltage and current across the bulb /resistor using ammeter and voltmeter.



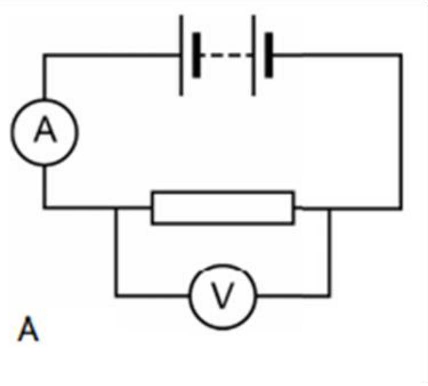
Repeat the experiment using an Ohmic resistor.



If you don't have access to a power pack, you can use a variable resistor (rheostat).



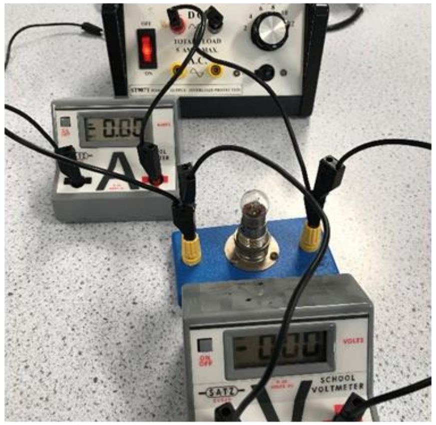
By changing the resistance of the current and voltage across the component.



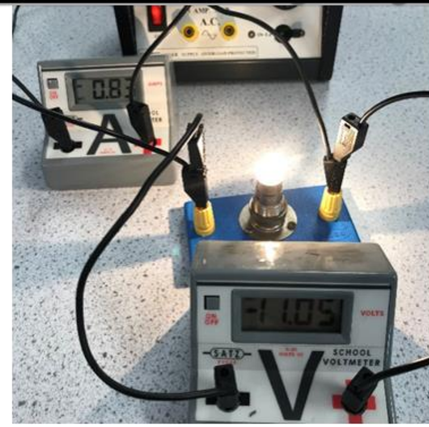
Be sure to include the ammeter and voltmeter in your circuit diagram.

10.17 Core Practical: Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps

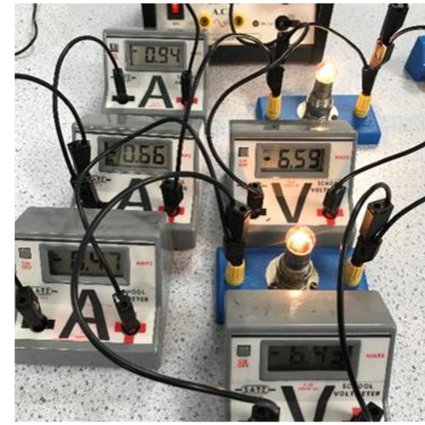
Core practical 5: Investigating resistance



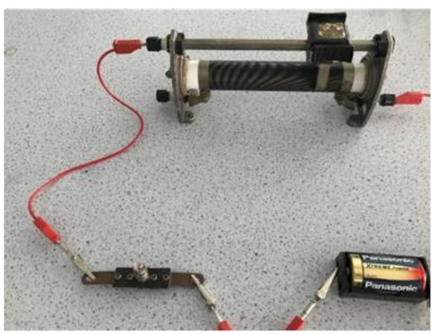
Build the circuits as shown in the diagram. Ensure you start at 0V (power pack off)



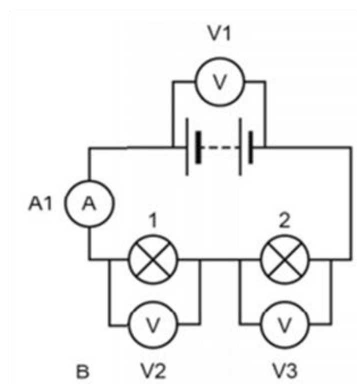
Increase the voltage reading from the power pack, recording the readings from the ammeters and voltmeters as you do so.



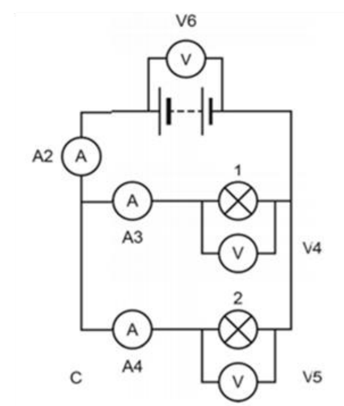
The parallel circuit can be confusing, make sure you label the ammeters, voltmeters and bulbs according to the circuit diagram.



You can use a rheostat instead of a power pack to change the voltage and current across the component.



Make sure you include the ammeters and voltmeters in your circuit diagram.



Series	Parallel
$I_{TOT} = I_1 = I_2$	$V_{TOT} = V_1 = V_2$
$V_{TOT} = V_1 + V_2$	$I_{TOT} = I_1 + I_2$
$R_T = R_1 + R_2$	$\frac{1}{R_{TOT}} = \frac{1}{R1} + \frac{1}{R2}$

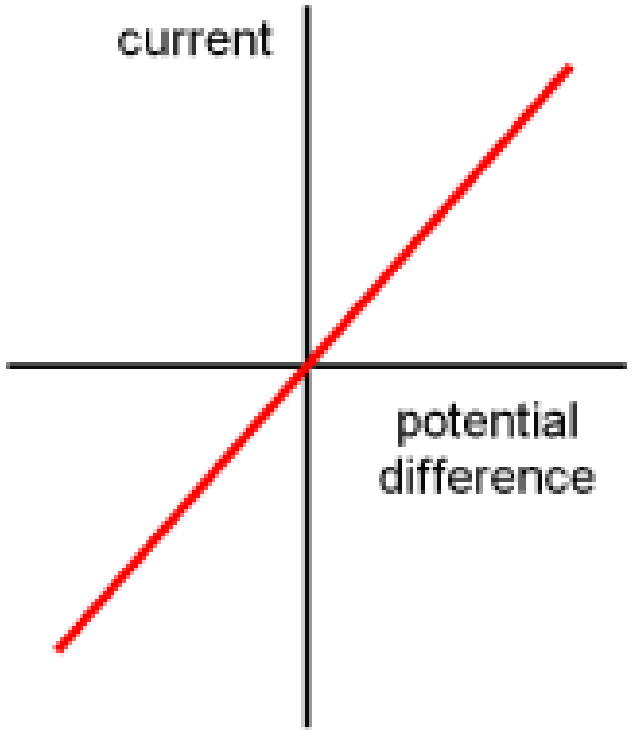
10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps b diodes c fixed resistors

Ohmic Conductors

Some resistors have a fixed value that does not depend on the current flowing through the circuit. **These are ohmic conductors.**

Ohm's Law states "the current through an ohmic conductor (at a constant temperature) is **directly proportional** to the potential difference across the resistor".

Ohmic conductors will produce a **straight line** V – I graph that goes through the origin.

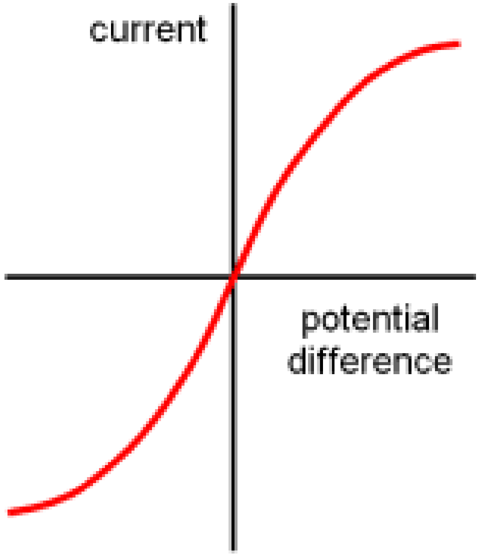


10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps b diodes c fixed resistors

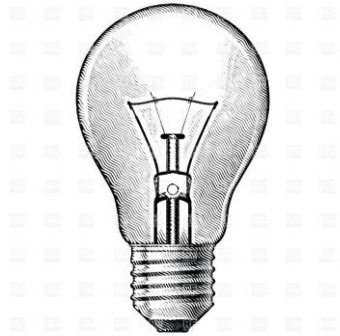
Non-Ohmic Conductors:

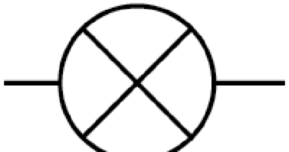
The resistance of components such as lamps, diodes, thermistors and LDRs is not constant. It changes with the current through the component.

A filament lamp is often called a lamp or a lightbulb.



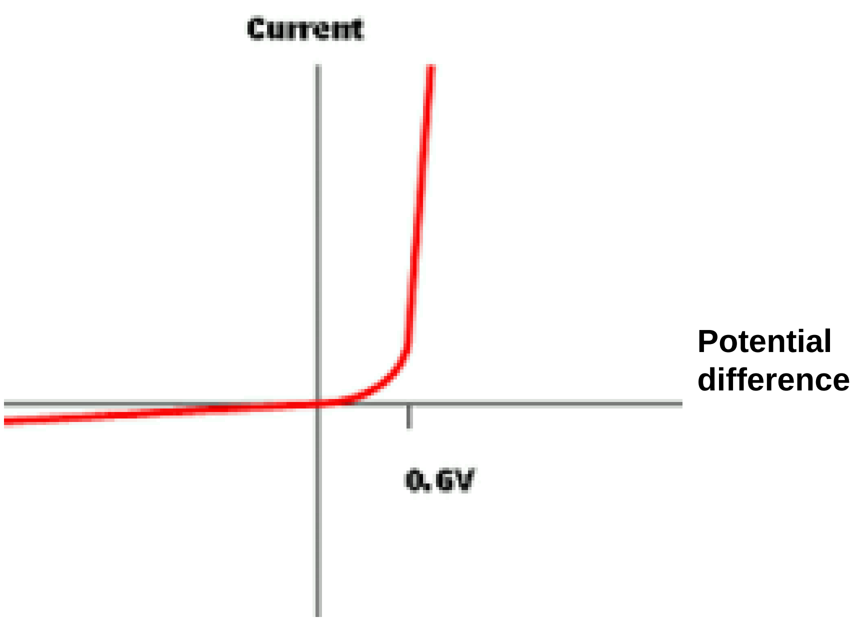
As the current increases, the temperature of filament increases therefore the resistance of the filament lamp increases.

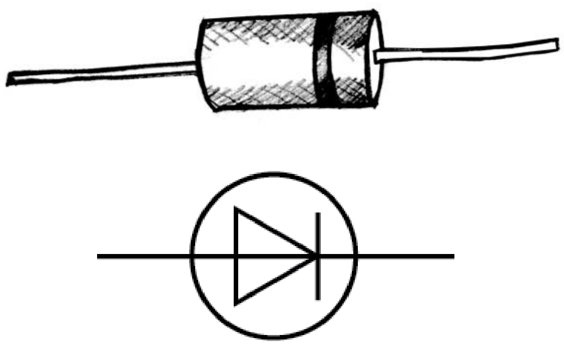




Non-Ohmic Conductors: Diodes

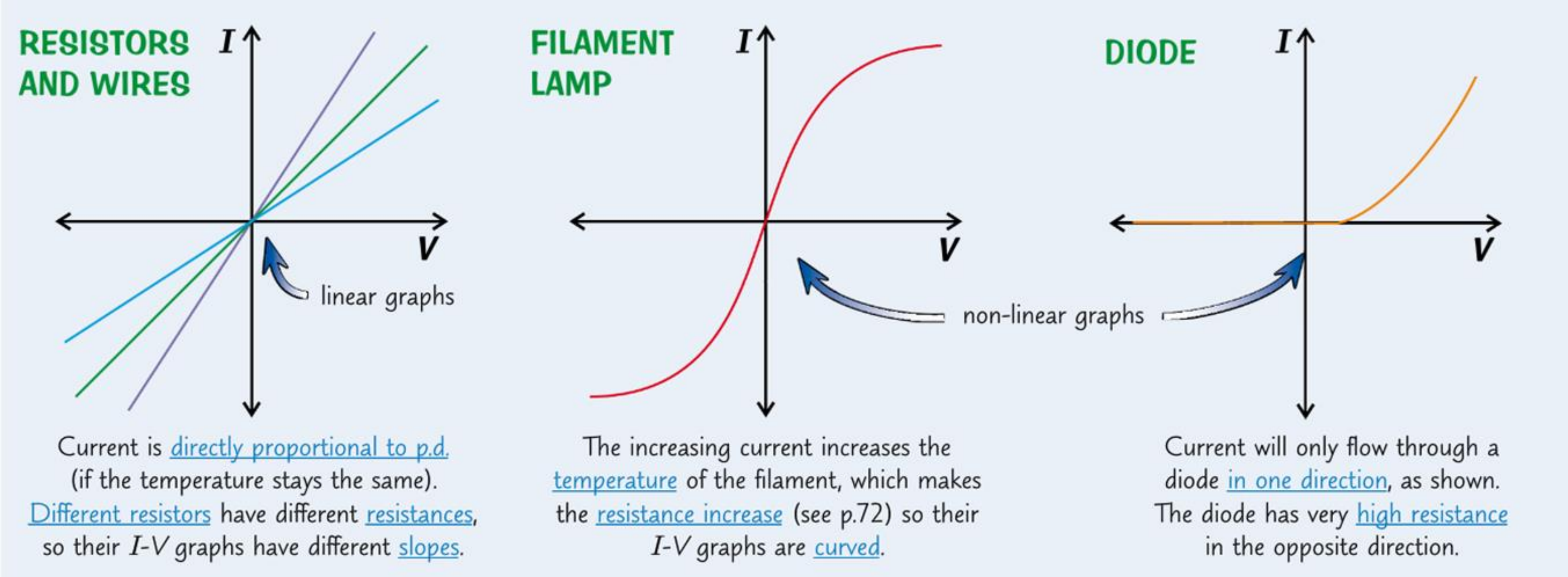
Diodes are electrical components that only allow a current to flow in one direction only.





Diodes have a low resistance in the forward direction but a high resistance in the reverse direction.

10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps b diodes c fixed resistors



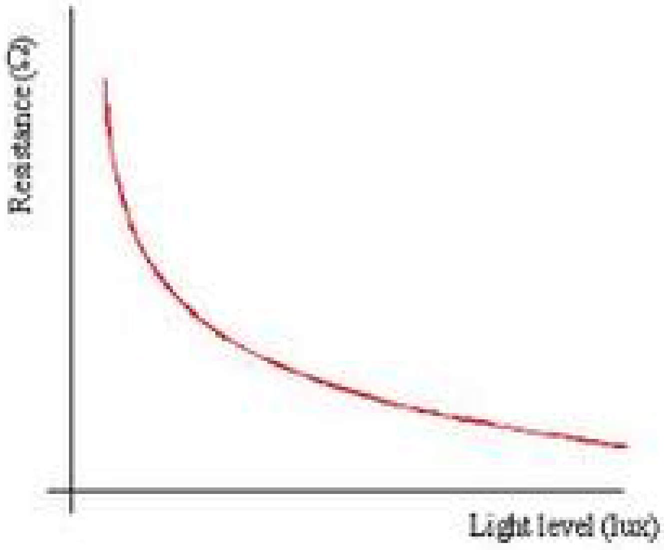
Current can be directly proportional, can be curved and can be exponential in growth

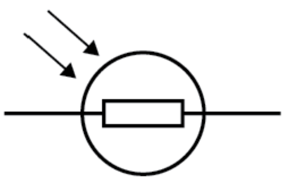
Diodes are exponential as the only allow current through in one direction.

Filament lamps are curved because the resistance increases with temperature

10.19 Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity

Light Dependent Resistors - LDRs are types of resistors where the resistance varies with light intensity.



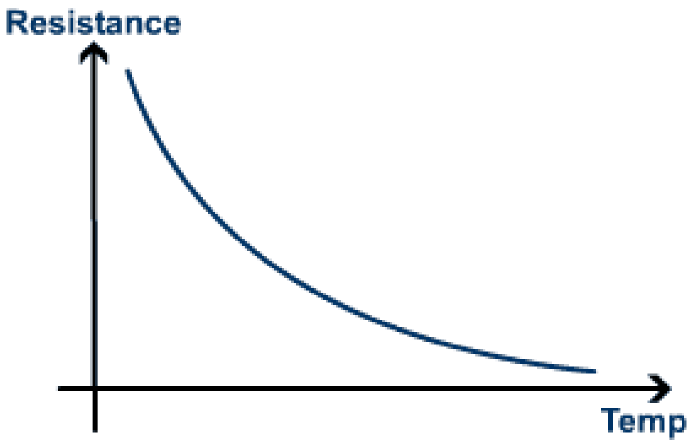


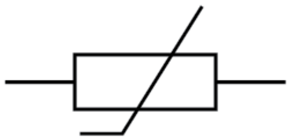
The resistance of a LDR decreases as light intensity increases.

LDRs are used as switches to turn on street lights when it gets dark.

10.20 Describe how the resistance of a thermistor varies with change of temperature (negative temperature coefficient thermistors only)

Thermistors are types of resistors where the resistance varies with temperature.





The resistance of a thermistor decreases as temperature increases.

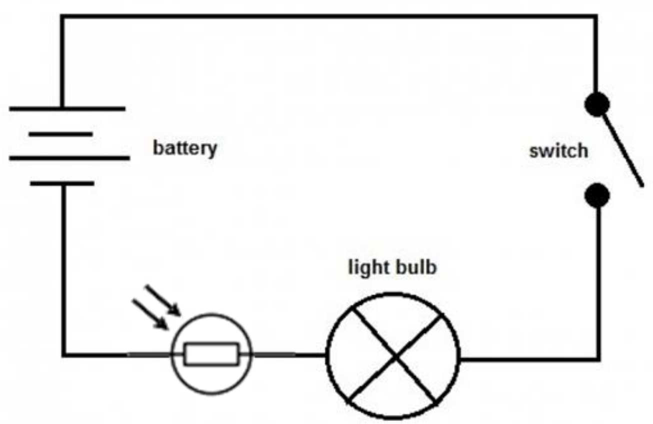
Thermistors are used in thermostats to control temperature in the home.

10.21 Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices a filament lamps b diodes c thermistors d LDRs

LDRs (light-dependent resistors) are used to detect light levels, for example, in automatic security lights. Their resistance decreases as the light intensity increases:

In the dark and at low light levels, the resistance of an LDR is high, and little current can flow through it.

In bright light, the resistance of an LDR is low, and more current can flow through it.

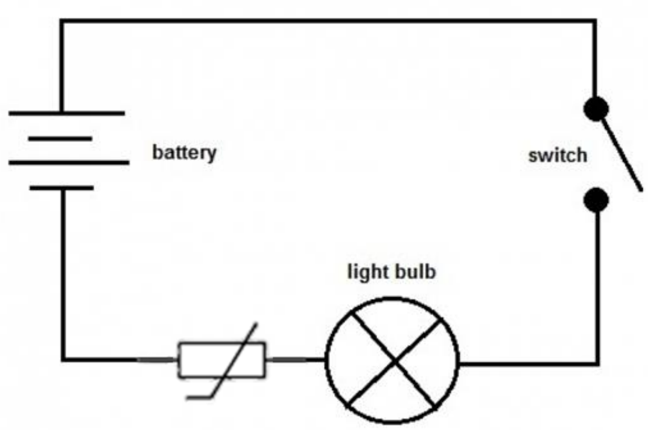


10.21 Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices a filament lamps b diodes c thermistors d LDRs

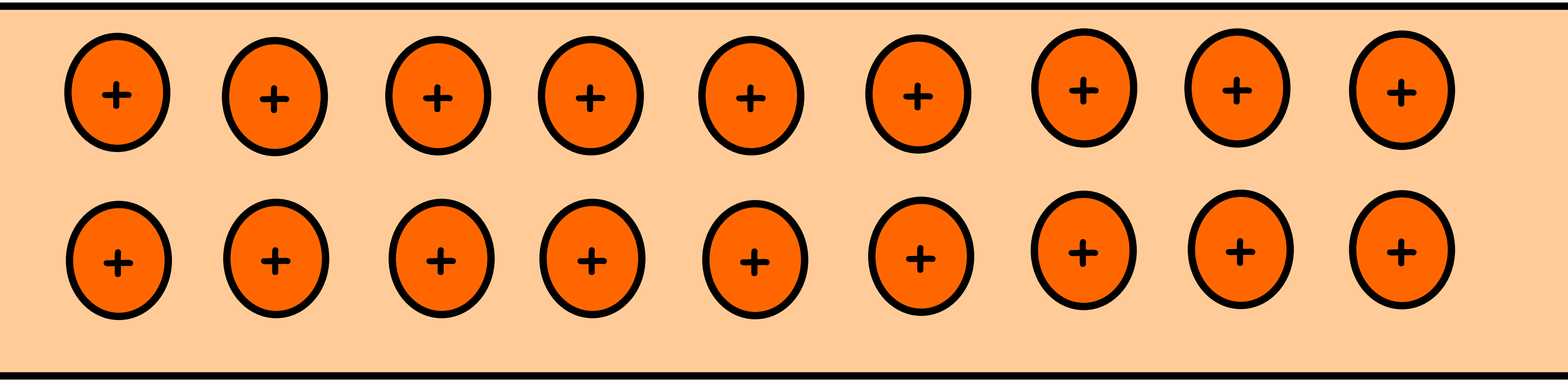
Thermistors are used as temperature sensors, for example, in fire alarms. Their resistance decreases as the temperature increases:

At low temperatures, the resistance of a thermistor is high, and little current can flow through them.

At high temperatures, the resistance of a thermistor is low, and more current can flow through them.



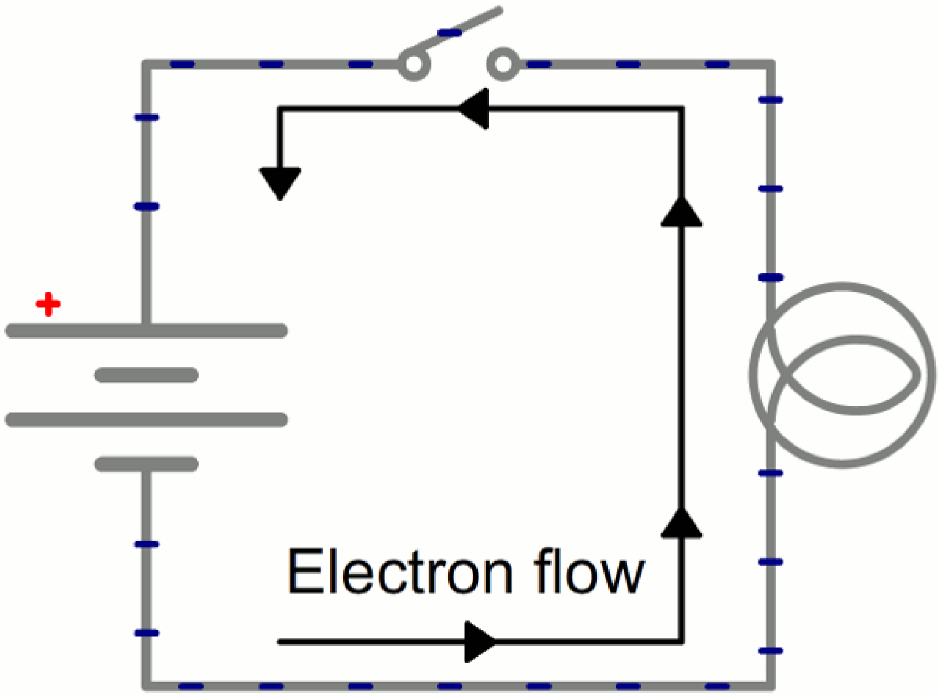
10.22 Recall that, when there is an electric current in a resistor, there is an energy transfer which heats the resistor

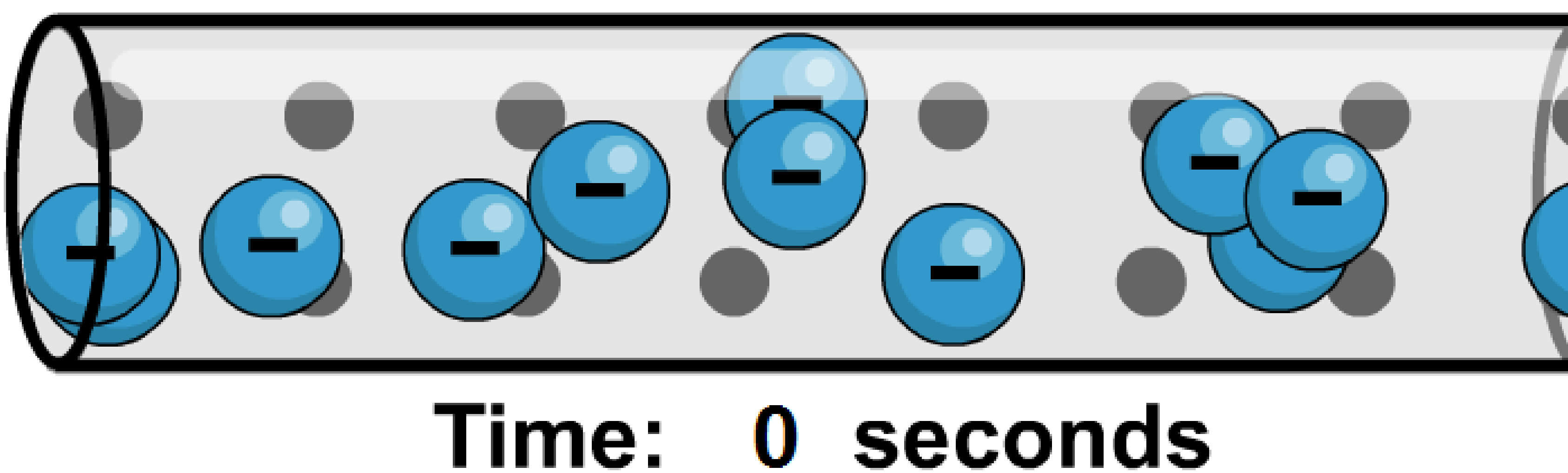


As the vibration increases the heat increases too.

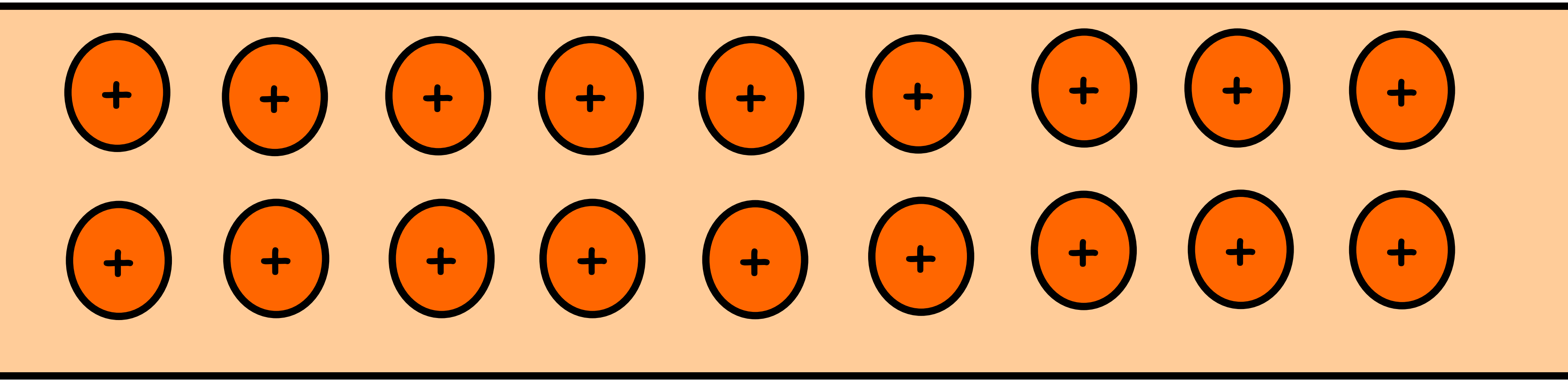
The greater the current the greater the heat released.

10.23 Explain that electrical energy is dissipated as thermal energy in the surroundings when an electrical current does work against electrical resistance





10.24 Explain the energy transfer (in 10.22 above) as the result of collisions between electrons and the ions in the lattice

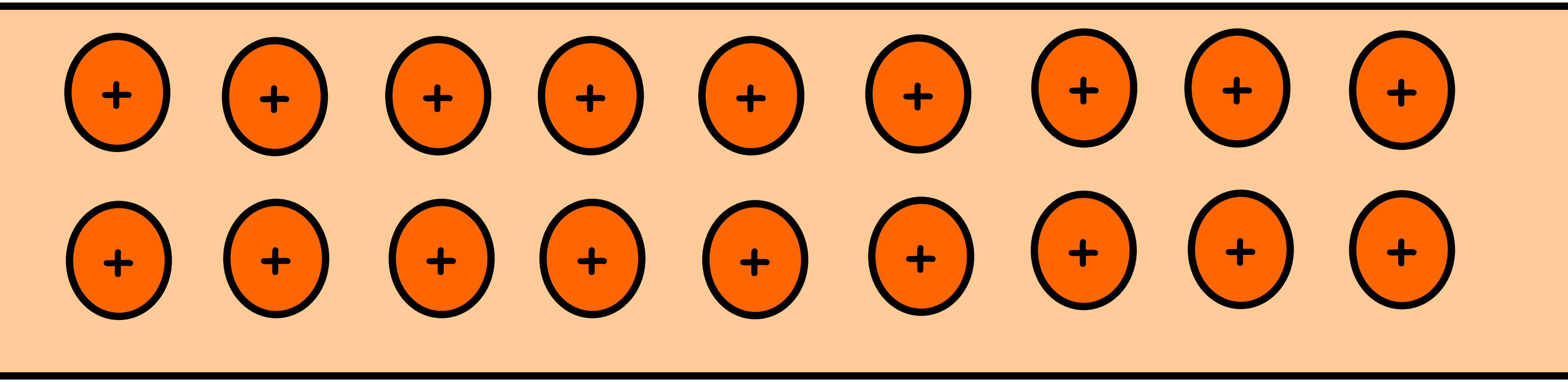


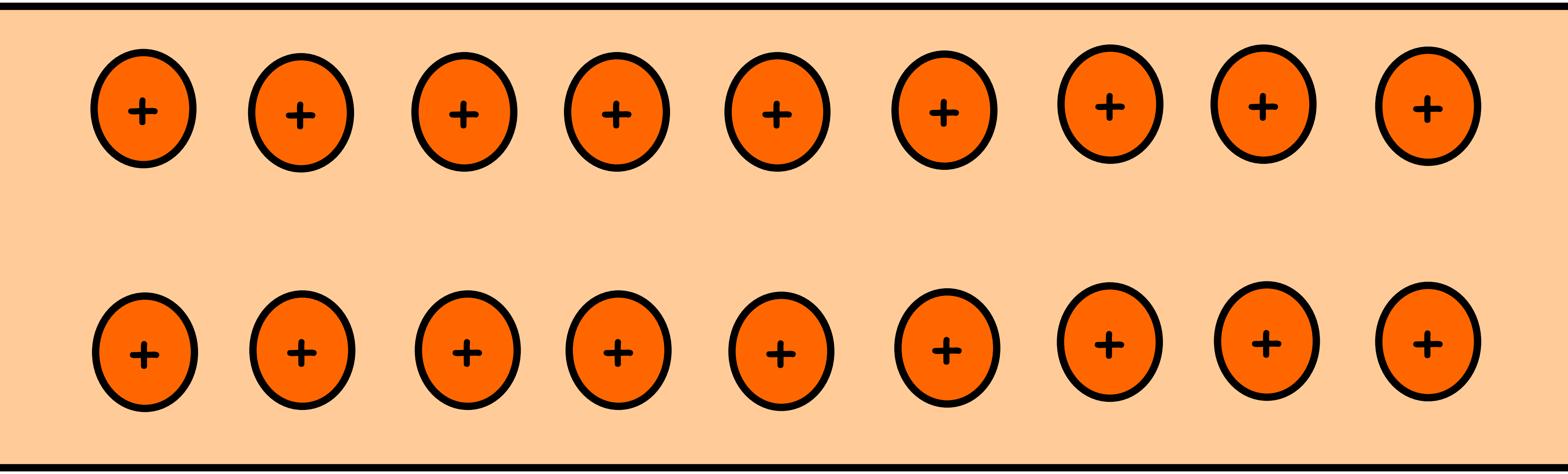
As the vibration increases the heat increases too.

The greater the current the greater the heat released.

The vibrations increase as the electrons collide with the lattice of positive ions.

10.25 Explain ways of reducing unwanted energy transfer through low resistance wires





10.26 Describe the advantages and disadvantages of the heating effect of an electric current

We can use the heating effect in coils for any machine that we need to produce heat.

Electric heaters and toasters are an example of this.

A regulated amount of power and special coils of metals called elements are used

Appliances and sockets that are not wired correctly can pull too much current through them.

If this happens the wires can over heat. If there is no fuse attached then this can cause the appliance or the wire to go on fire.

There is also a loss of efficiency in overhead wires when a lot of current goes through it.

10.27 Use the equation: energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s) E I V t

We have two equations here for energy. But they are actually the same.

$E = I \times t \times V$ $E = Q \times V$

But to do this, we need to remember a third equation

$Q = I \times t$

We now substitute the QIT equation into the EQV equation

$E = Q \times V$ $E = I \times t \times V$

This gives us the EVIT equation

$E = I \times t \times V$

10.28 Describe power as the energy transferred per second and recall that it is measured in watt

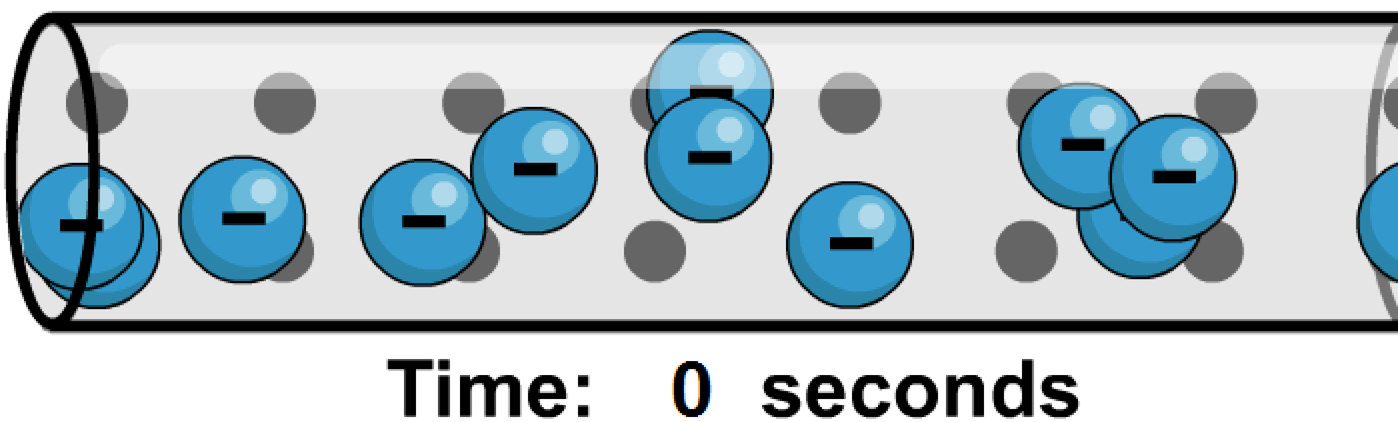
Power is the amount of energy transferred in a second.

Electrons are the "carriers" of energy.

Power is therefore the amount of electrons passing energy to the component every second.

Current is the amount of electrons passing a point in a given amount of time.

The current in a circuit depends on the amount of resistance in the circuit and the push from the cell.



10.29 Recall and use the equation: power (watt, W) = energy transferred (joule, J) ÷ time taken (second, s) E P t

Work is done when charge flows in a circuit.

The amount of energy transferred by electrical work can be calculated using the equation:

Power (W) = energy transferred (J) ÷ time (s)

$$P = E / t$$

Name	Equation symbol	Unit	Unit Symbol
Energy transferred	E	Joules	J
Power	P	Watts	W
Time	t	Seconds	s

10.30 Explain how the power transfer in any circuit device is related to the potential difference across it and the current in it

Power: When electrical appliances are connected into a circuit energy is transferred to the appliance. The rate at which energy is transferred to the appliance is the power rating of the appliance.

To calculate the power of an electrical component:

Power (W)= Current (A) x Potential Difference (V)

$$P = I\ V$$

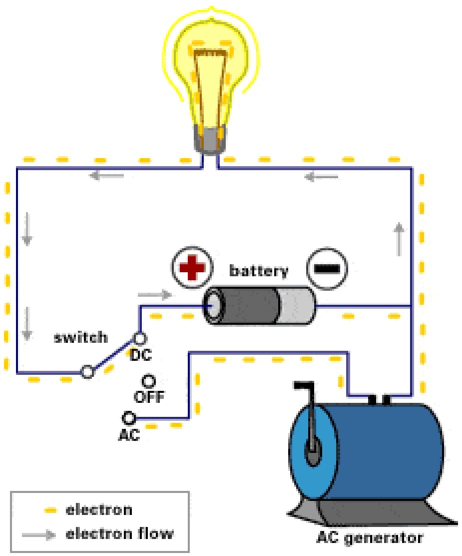
An alternative equation for calculating power is:

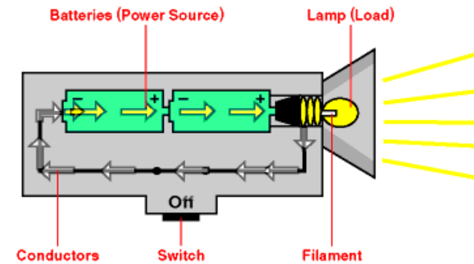
Power = (current)^2 x Resistance

$$P = I^2\ R$$

Name	Equation symbol	Unit	Unit Symbol
Power	P	Watts	W
Potential difference	V	Volts	V
Current	I	Amp	A
Resisitance	R	Ohms	Ω

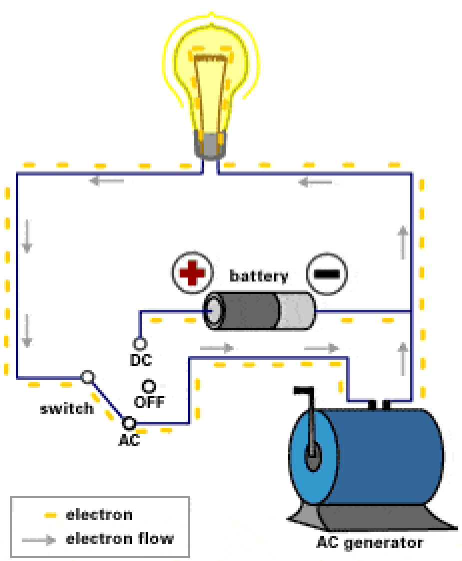
10.32 Describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors and heating devices





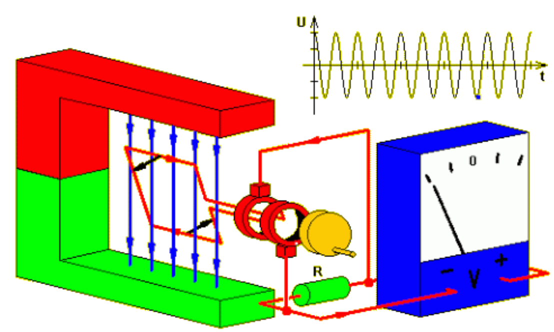
<u>A.C = Alternating Current (Mains in UK)</u>

Caused by a rotating copper wire in a magnetic field. Electric currents are only formed in wires when there is this alternation. Because it is rotating, the current in the system also changes direction. The change is 50 times a second (or 50Hz) and in the mains it is 230V.



<u>D.C = Direct Current (Battery Powered)</u>

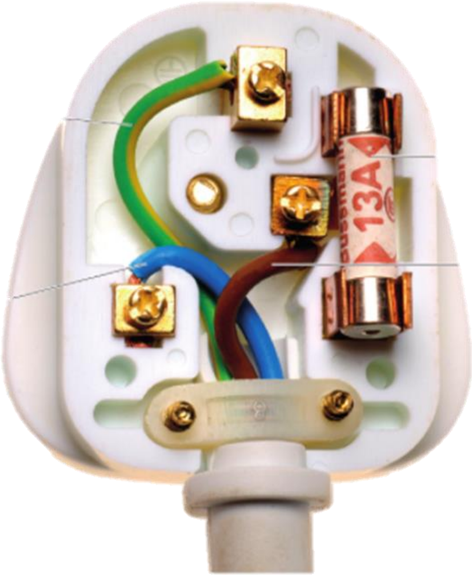
Electrons are simply pushed by the cell so there is only one direction.



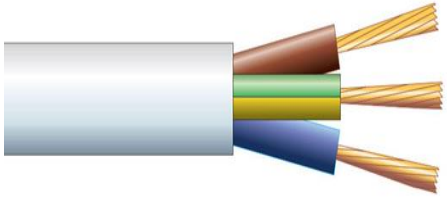
10.37 Explain the difference in function between the live and the neutral mains input wires

Neutral **(Blue)**
Completes the circuit.
The return path to the power station. This is where the circuit it closed.

If the circuit is connected properly the voltage is 0V.



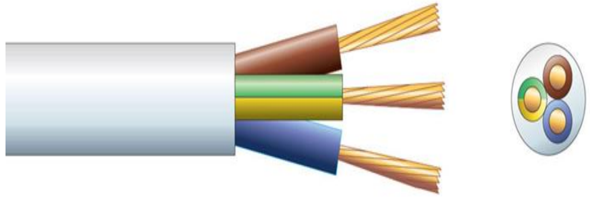
Live **(Brown)**
Carries alternating potential difference from the supply.
The live wire connects to the component or appliance to the generator.
The voltage on this wire is 230V.

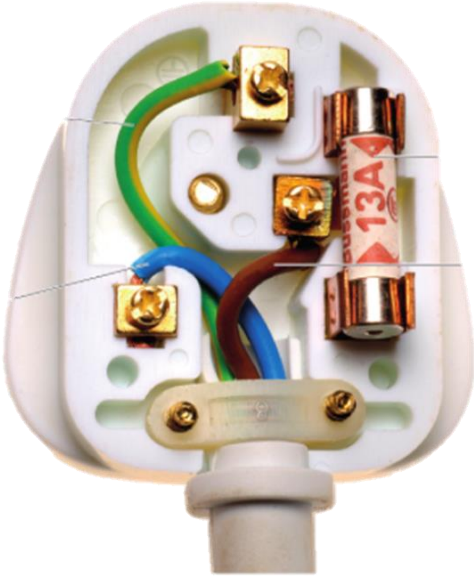


10.38 Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety

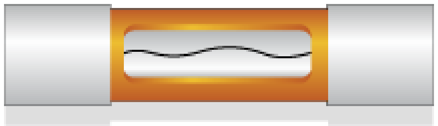
- The potential difference between the live wire and earth (0 V) is about 230 V.
- The neutral wire is at, or close to, earth potential (0 V).
- The earth wire is at 0 V,
- The earth wire only carries a current if there is a fault.

The live wire may be dangerous when a switch in the mains circuit is open as a person could complete the circuit to ground (0 V) themselves and therefore get electrocuted as the current will flow through them.



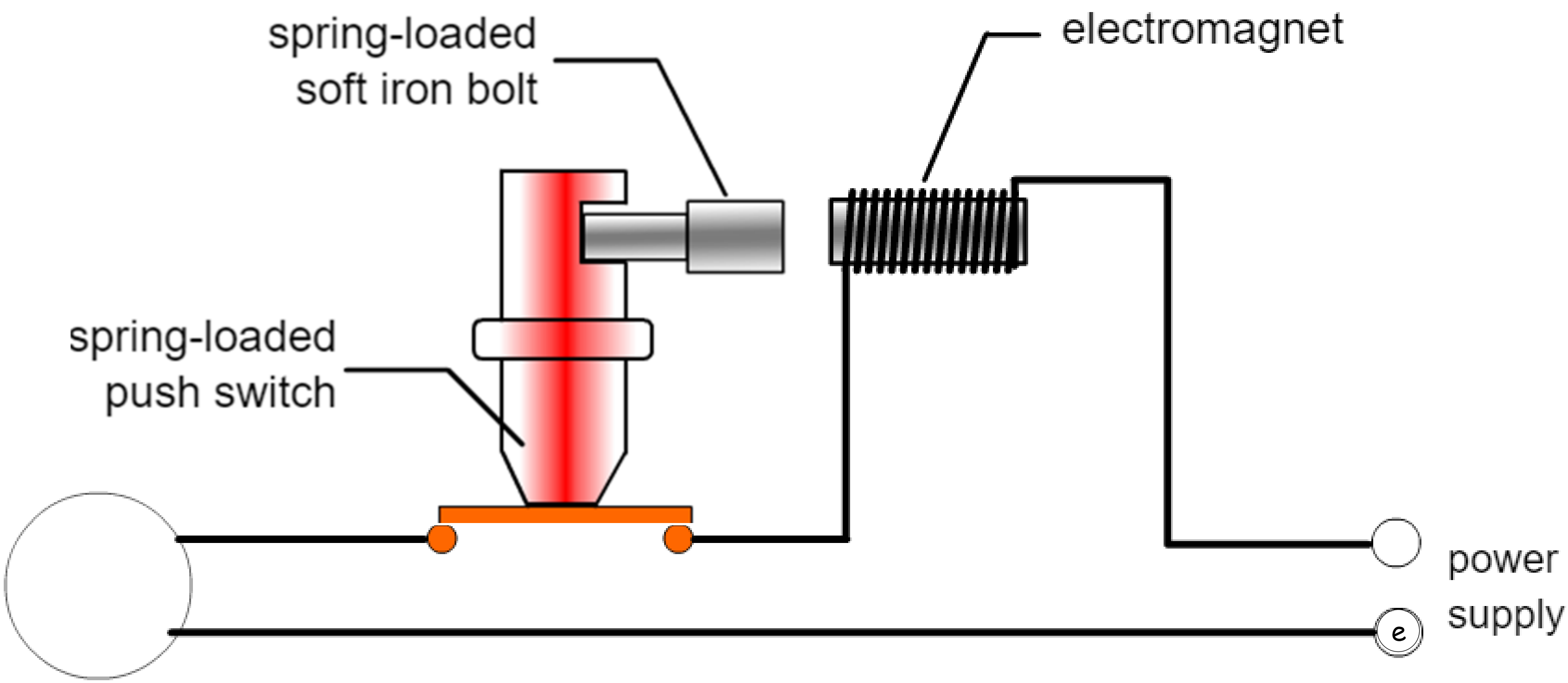


10.38 Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety



Fuses have small thin wires in them – they are designed to stop an overflow of current from reaching the appliance.

Circuit Breakers are soft iron plugs that are attracted to an electromagnet. As the current increases the electromagnet becomes more powerful. If the current reaches an unsafe level, the plug is removed and the circuit stops

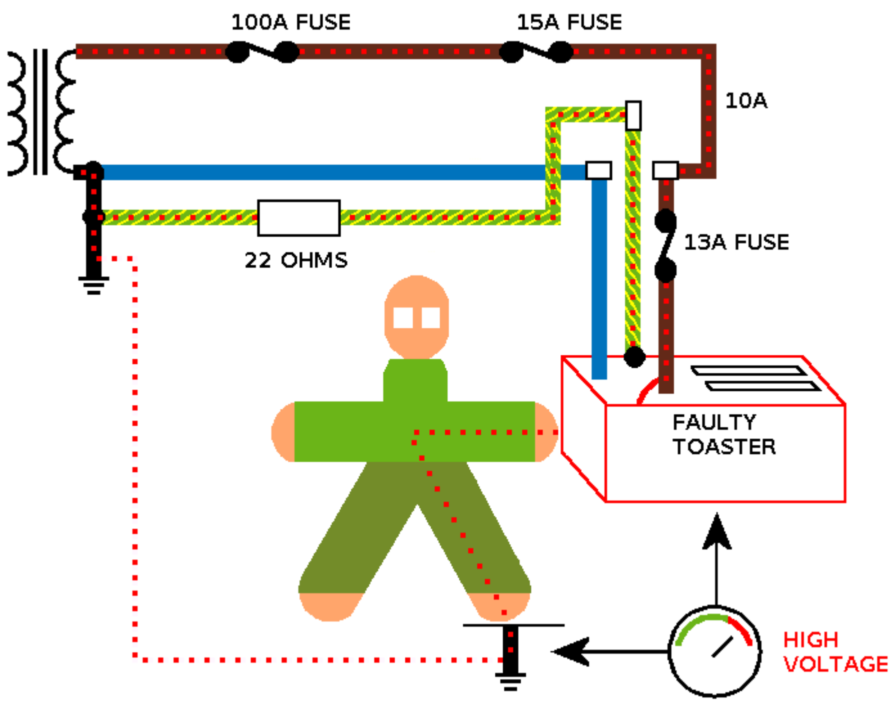


10.39 Explain why switches and fuses should be connected in the live wire of a domestic circuit

Unfortunately, Kevin bought a toaster from a car boot sale and plugged it in.
The mains cable was damaged just as it entered the metal body of the toaster and the live wire had made contact with the case making the metal body of the toaster live.

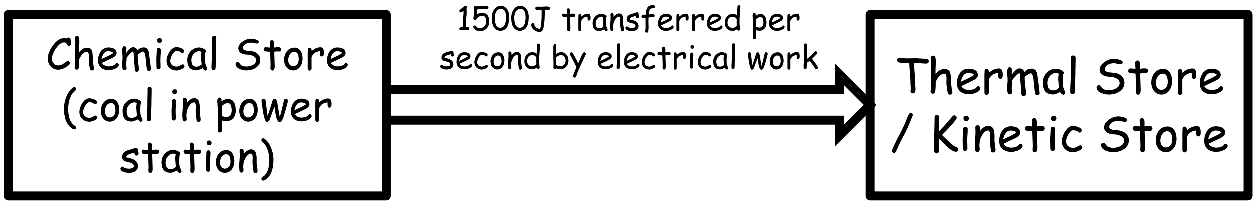
The 13A plug top fuse would normally blow, removing the danger but in this case the maximum fault current is 10 Amps and the fuse does not blow.

When Kevin touches the toaster, he received an electric shock.



10.42 Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use

1500W



Appliances have power ratings. A watt is one joule per second of energy.

These appliances mainly get their energy from the mains.

Mains energy is produced in power stations, using fossil fuels usually. This is a chemical store.

This is transferred through electrical work.

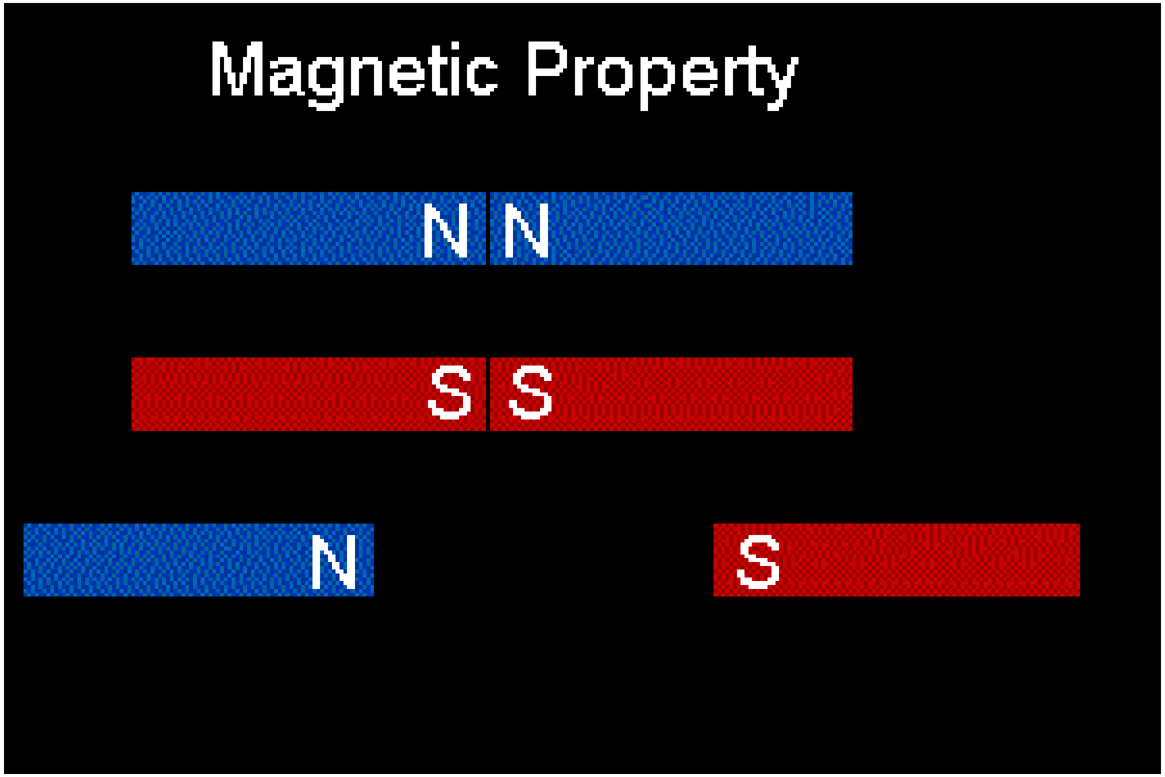
This is then transferred into a new store, depending on the appliance.

Topic 10 – Electricity and circuits

1. Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons
2. Draw the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs
3. Describe the differences between series and parallel circuits
4. Describe how to connect a voltmeter over a filament lamp.
5. Define the term potential difference, include the units, the unit symbol and the equation symbol.
6. Define the term charge, include the units, the unit symbol and the equation symbol.
7. State the equation to find the energy transferred when you have the charge and the voltage.
8. Describe how to connect and ammeter to a circuit.
9. Define the term current include the units, the unit symbol and the equation symbol.
10. State the equation for charge when you have current and time.
11. Describe what conservation of current in a parallel circuit means.
12. Describe the use of a variable resistor for increasing or decreasing current.
13. State the equation for voltage when you have current and resistance.
14. Describe how connecting resistors in series affect resistance
15. Describe how connecting resistors in parallel affects resistance
16. Describe the effect of increasing resistance on current in circuits.
17. Describe the effect of increasing the current in an ohmic resistor
18. Describe the effect of increasing the current in a filament lamp
19. Describe the effect of increasing current in a diode.
20. Describe the effect of changing temperature on a thermistor
21. Describe the effect of changing light levels on a light dependent resistor.
22. Define and describe the term resistance, including reference to subatomic particles.
23. Describe the energy transfers in a resistor when there is an electric current.
24. Describe the term dissipation
25. Describe the cause of dissipation in electrical circuits
26. Describe the effect of using low resistance wires on energy transfers
27. Describe advantages and disadvantages of the heating effect of electric current.
28. State the equation to calculate energy when you have voltage, current and time.
29. Define the term power include the units, the unit symbol and the equation symbol.
30. Describe the link between voltage, current and power.
31. State the equation to calculate power when you have voltage and current
32. State the equation to calculate power when you have resistance and current.
33. Describe the difference between direct and alternating voltage, include directionality and sources
34. Describe fully the UK electrical domestic supply.
35. Describe the function, and properties of the wires in UK domestic plugs.

Describe the function of an earth wire and of fuses or circuit breakers in ensuring safety

12.1 Recall that unlike magnetic poles attract and like magnetic poles repel



12.2 Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel

Cobalt makes magnets that can operate at really high temperature.

Steel magnets can keep their magnetism for a long, long time. They can make permanent magnets.

Iron loses it's magnetism very quickly, this could be used for electromagnets that have to be switchable.

Nickel is inexpensive and quite hard. It can be used to cover more expensive magnets for protection.

12.3 Explain the difference between permanent and induced magnets

1. Bring the iron nail close to the paper clips
2. Run the magnet over the iron nail in the same direction repeatedly (try yourself to find the best number)
3. Bring the iron nail close to the paper clips

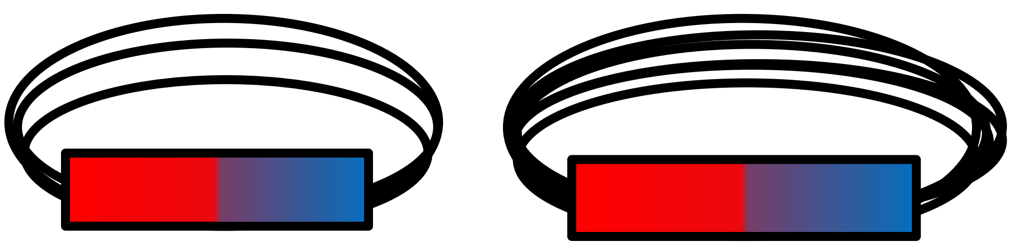
1. Bring the iron nail close to the paper clips
2. Hold the magnet onto the iron nail.
3. Bring the iron nail close to the paper clips

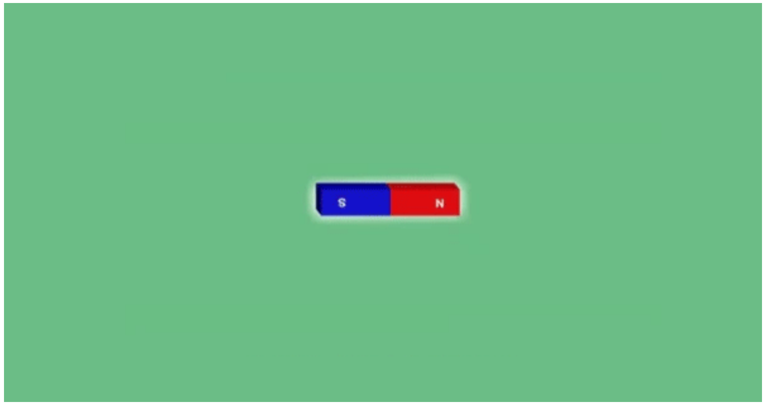
1. Bring the iron nail close to the paper clips
2. Wrap the insulated wire around the nail (carefully – it will get warm)
3. Hang the iron nail off the bench, turn on the current.
4. Bring the paper clips close to the iron nail (because it is hot)

Magnets have fields of magnetism. Any magnetic material in the field is effected by it.

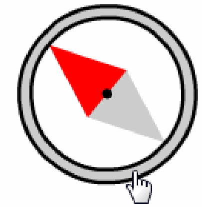
The more field lines the greater the strength of the magnet.

Which magnet would be stronger. The one on the left or the one on the right?



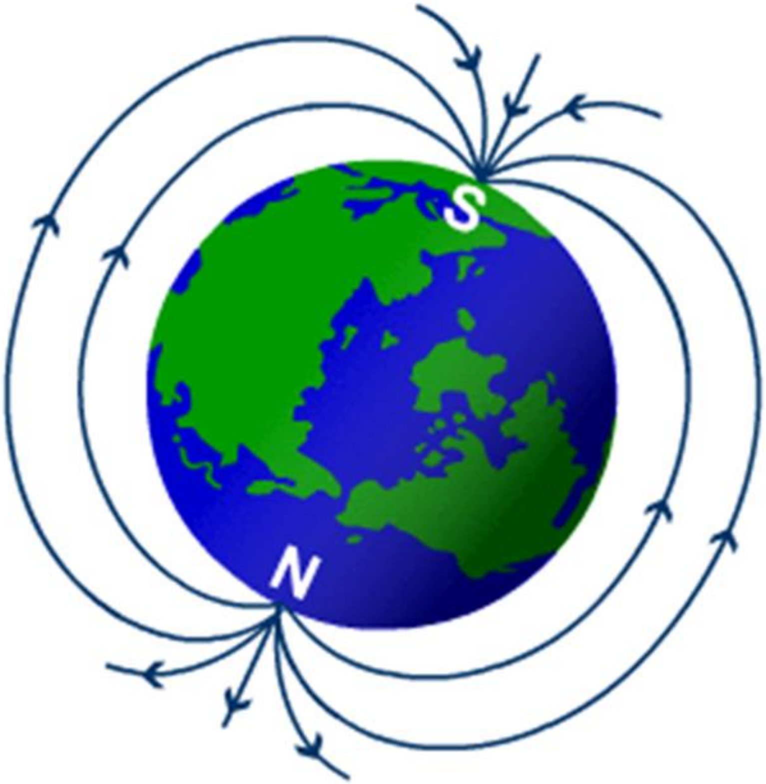


12.5 Describe the use of plotting compasses to show the shape and direction of the field of a magnet and the Earth’s magnetic field



How could you use this for finding the shape of a magnetic field?

12.6 Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic



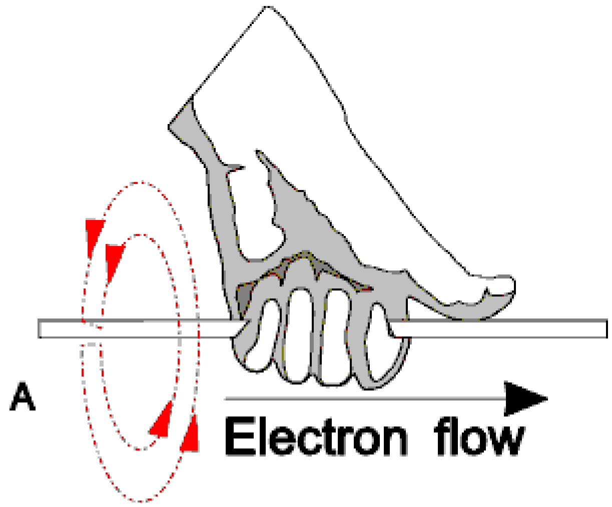
12.7 Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the magnetic field produced and relating the direction of the magnetic field to the direction of the current

When current flows through a long thin conductor – a magnetic field is formed.

The field is circular perpendicular to the wire.

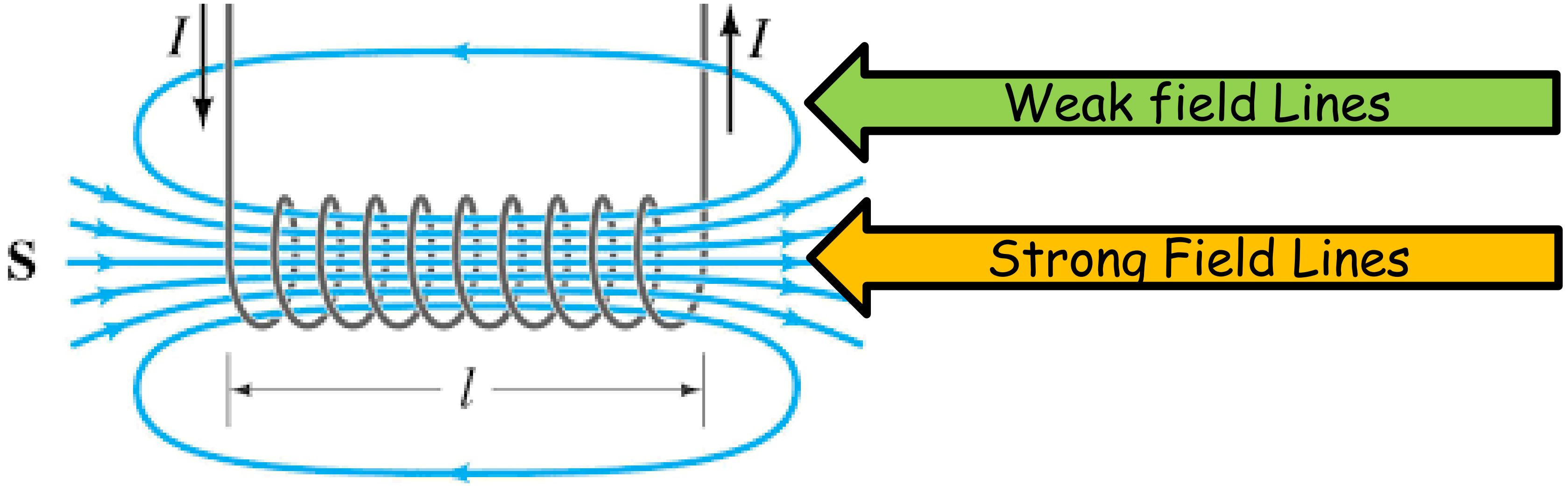
Changing the direction of the current changes the direction of the magnetic field.

The larger the current or the closer to the wire – the stronger the magnetic field is.

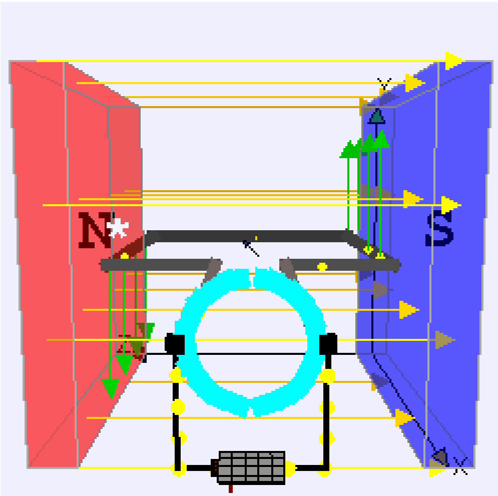


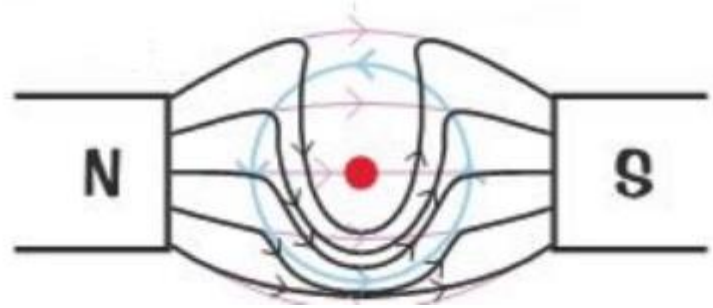
Solenoids are coils of wire, with a current running through them.

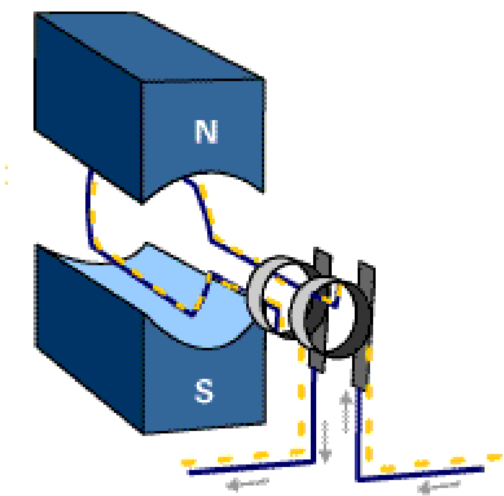
Inside a solenoid (an example of an **electromagnet**) the fields from individual coils add together to form a very **strong** almost **uniform** field along the centre of the solenoid and cancel to give a **weaker** field outside the solenoid

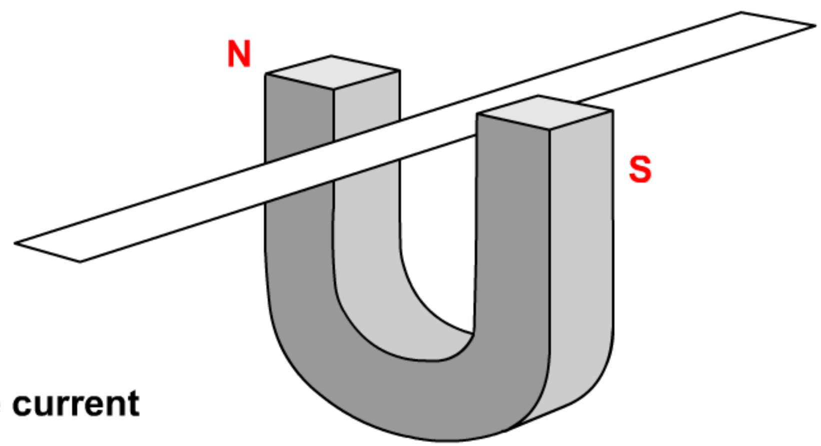


12.10 Recall that a current carrying conductor placed near a magnet experiences a force and that an equal and opposite force acts on the magnet







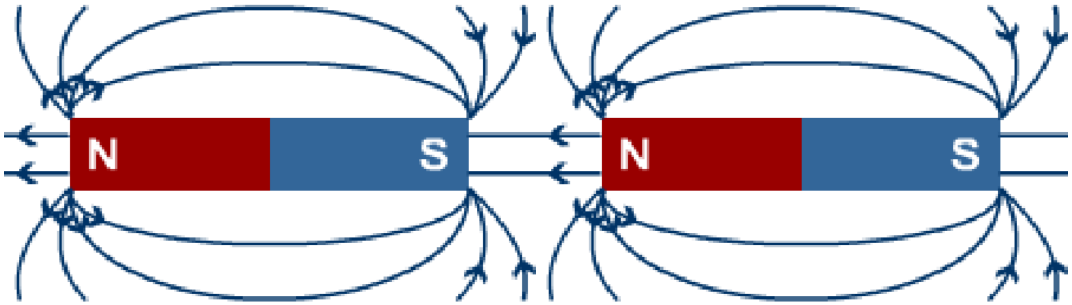


Apply/change current

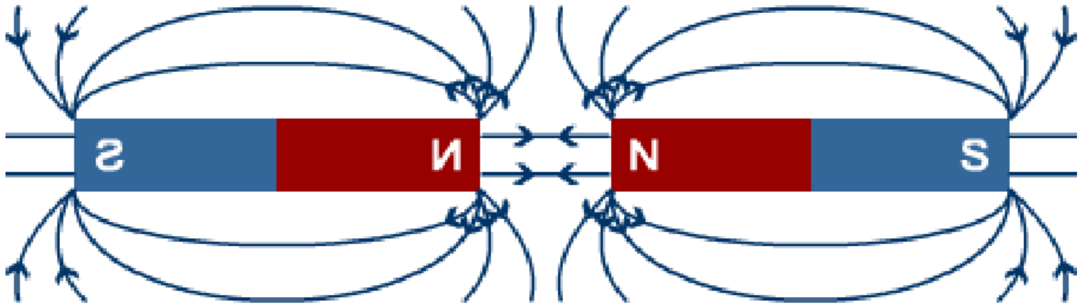
Switch off current

12.11 Explain that magnetic forces are due to interactions between magnetic fields

Attraction is due to the force fields lining up in the same direction.



Attraction is due to the force fields lining up in different directions.



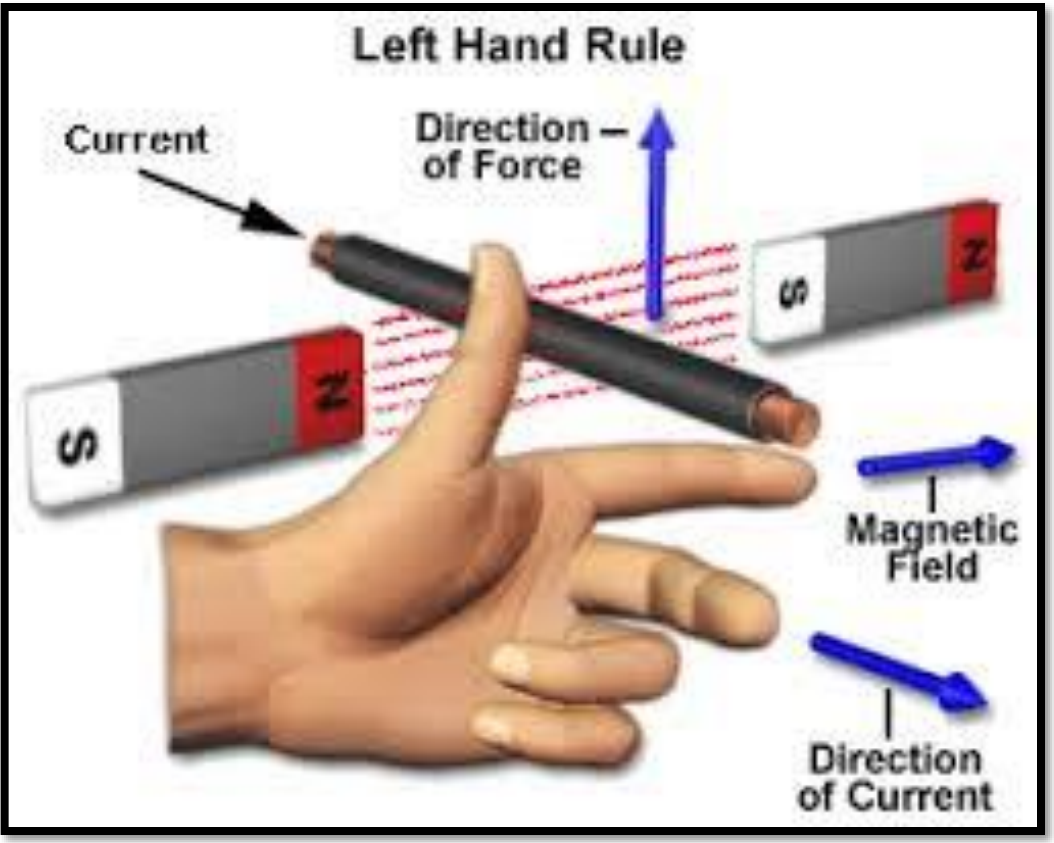
12.12 Recall and use Fleming's left-hand rule to represent the relative directions of the force, the current and the magnetic field for cases where they are mutually perpendicular

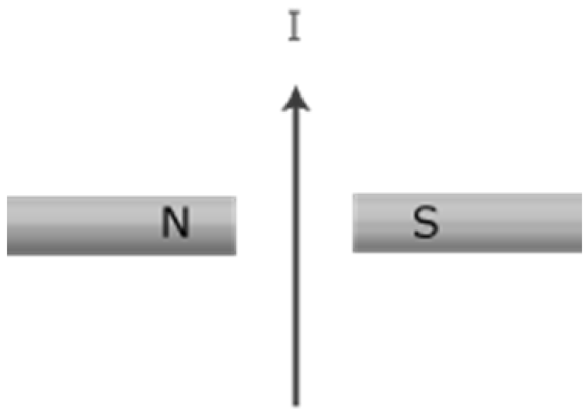
Use the left hand

First finger – Magnetic Field

Second finger – current

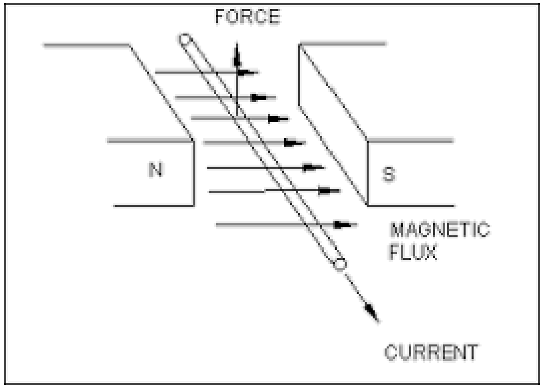
Thumb – force motion





12.13 Use the equation: force on a conductor at right angles to a magnetic field carrying a current (newton, N) = magnetic flux density (tesla, T or newton per ampere metre, N/A m) × current (ampere, A) × length (metre, m) F B I l

The factors that affect the force on a conductor are:



Name	Symbol	Unit	Symbol
Force	F	Newton	N
Magnetic Flux Density	B	Tesla	T
Current	I	Amps	A
Length	L	Meters	m

These quantities are linked by the equation:

force on a conductor (N) = magnetic flux density (T) x current (A) x length (m)

$$F = BIl$$

Topic 12 – Magnetism and the motor effect

1. ___________ magnetic poles ___________ and ___________ magnetic poles repel.

2. Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel
3. Describe the difference between permanent and induced magnets
4. Describe the shape and direction of the magnetic field around bar magnets.
5. Describe the use of plotting compasses to show the shape and direction of the field of a magnet
6. Describe evidence that the core of the earth must be magnetic
7. Describe the effect of a current flowing through a long straight conductor.
8. Describe how to change the strength of this field.
9. Describe the magnetic field of a solenoid, including reference to field lines.

13.2 Recall the factors that affect the size and direction of an induced potential difference, and describe how the magnetic field produced opposes the original change

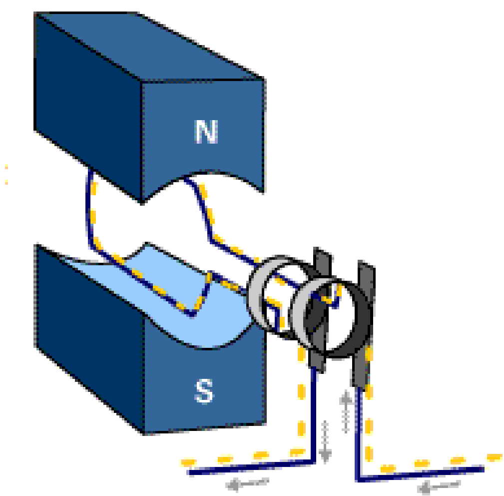
When the magnetic field in a conductor changes, you get an **induced** potential difference and current.

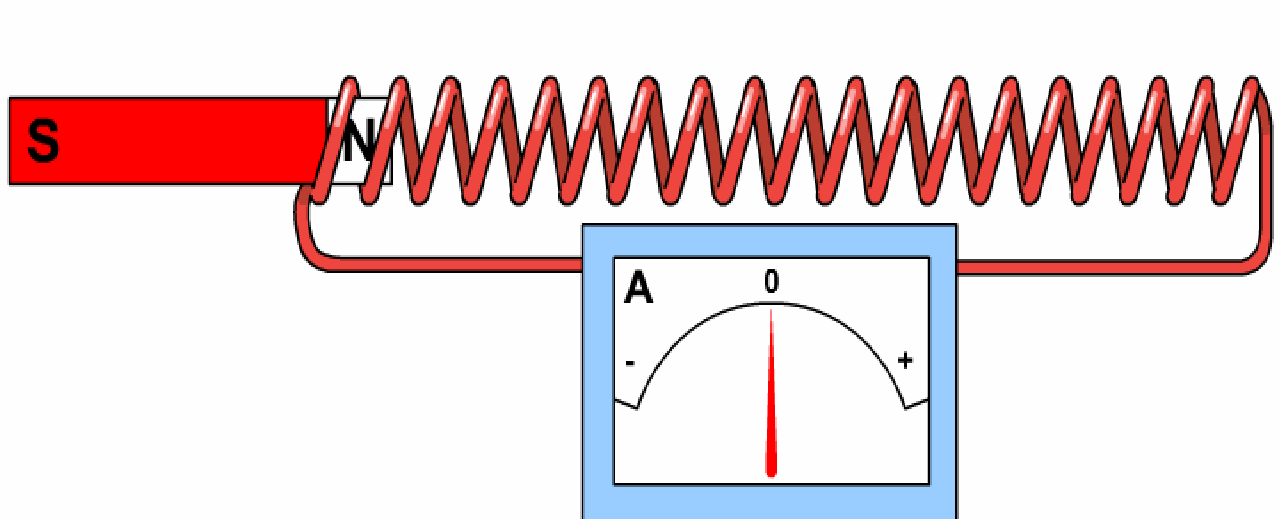
This is because the magnetic field and the electrical field lines interact..

If you keep the magnet moving forwards and backwards, you get an alternating current.

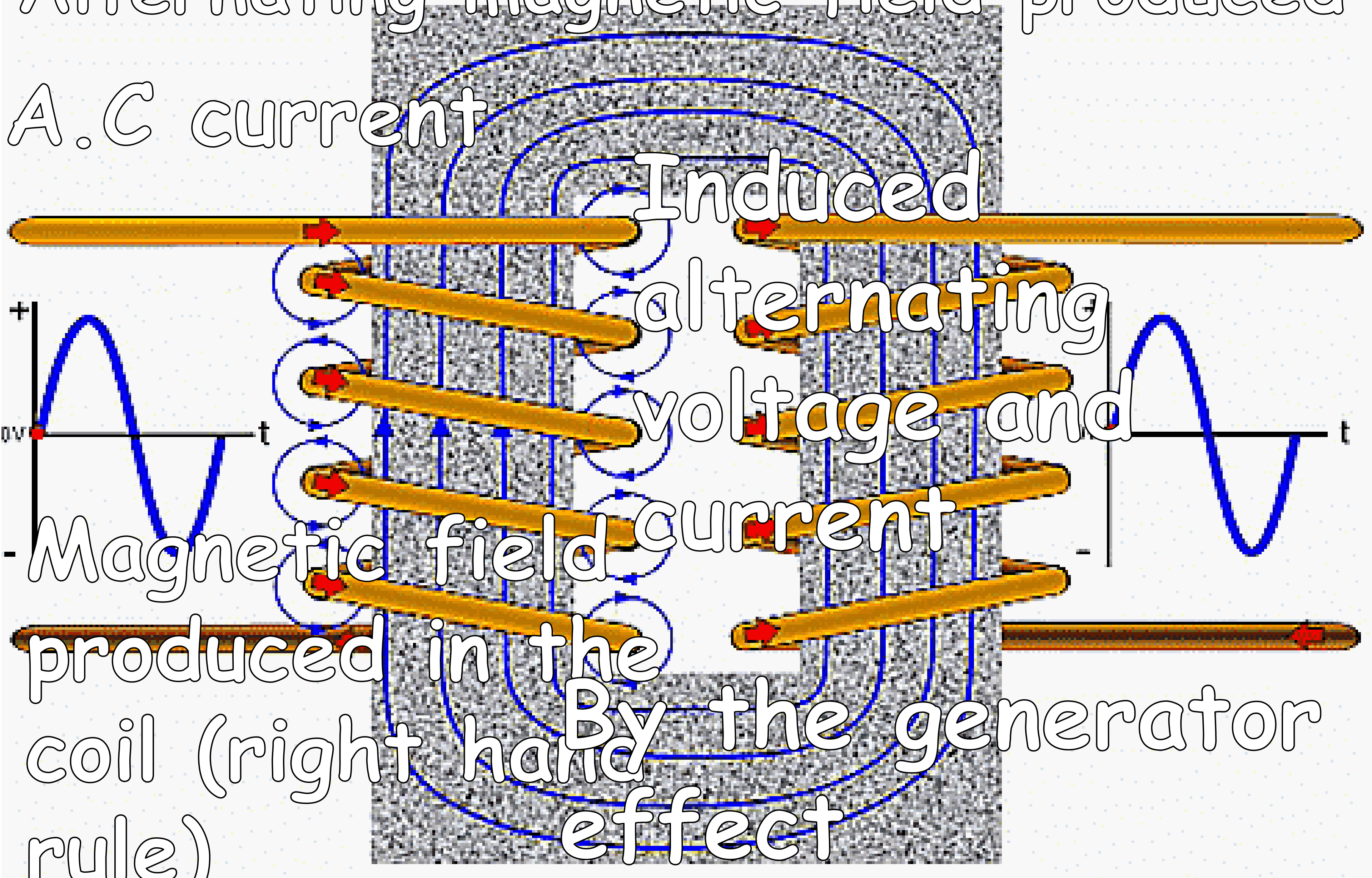
You can increase the p.d. by increasing the strength of the magnetic field, the speed of the movement and more turns in the coil.

The current that is induced acts against the change, trying to return things to the way it was.





13.5 Explain how an alternating current in one circuit can induce a current in another circuit in a transformer



Alternating magnetic field produced

A.C current

Induced alternating voltage and current

Magnetic field produced in the coil (right hand rule)

By the generator effect

13.6 Recall that a transformer can change the size of an alternating voltage

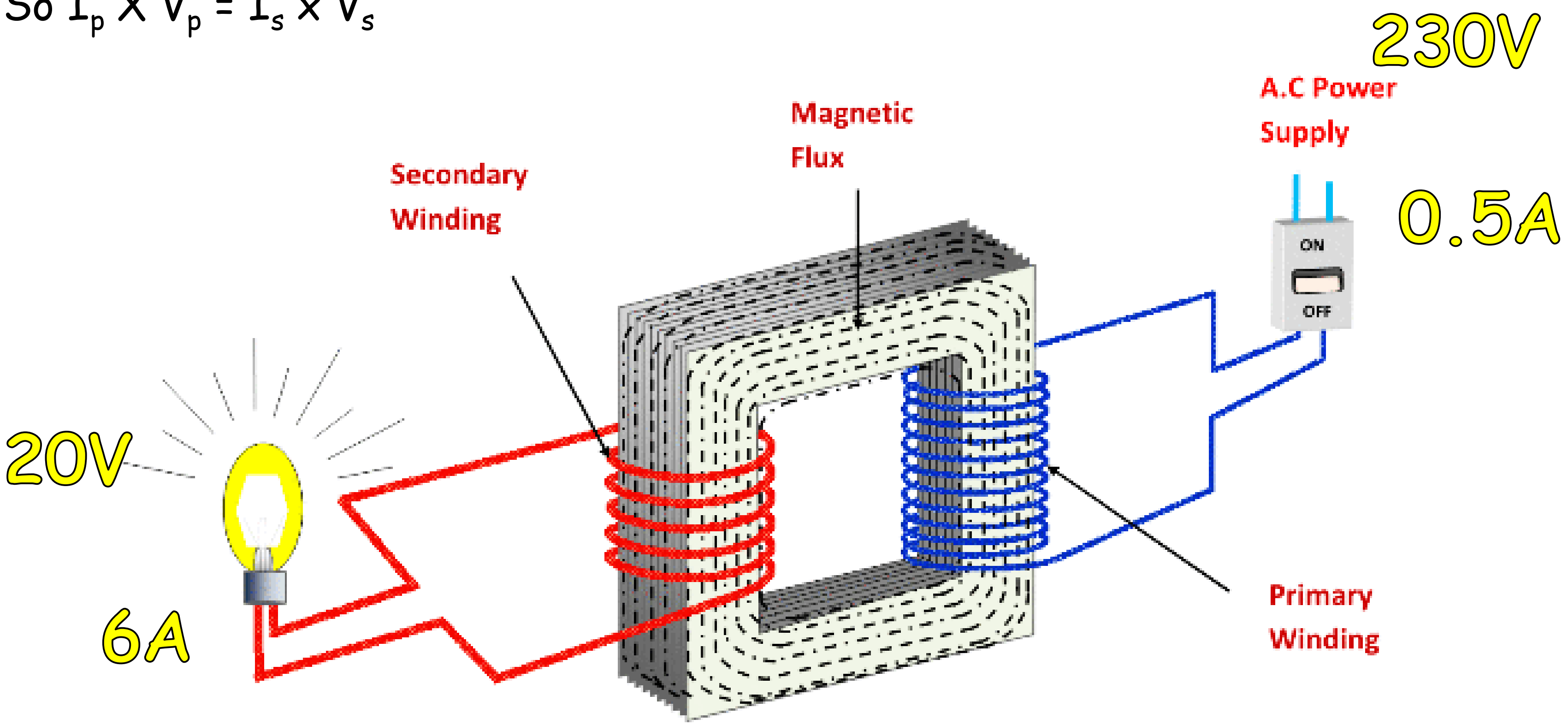
The current and voltage in the step-up and step-down transformers are proportional.

The **power** on the primary coil is the same as the power on the secondary coil.

Using the equation $P = I \times V$

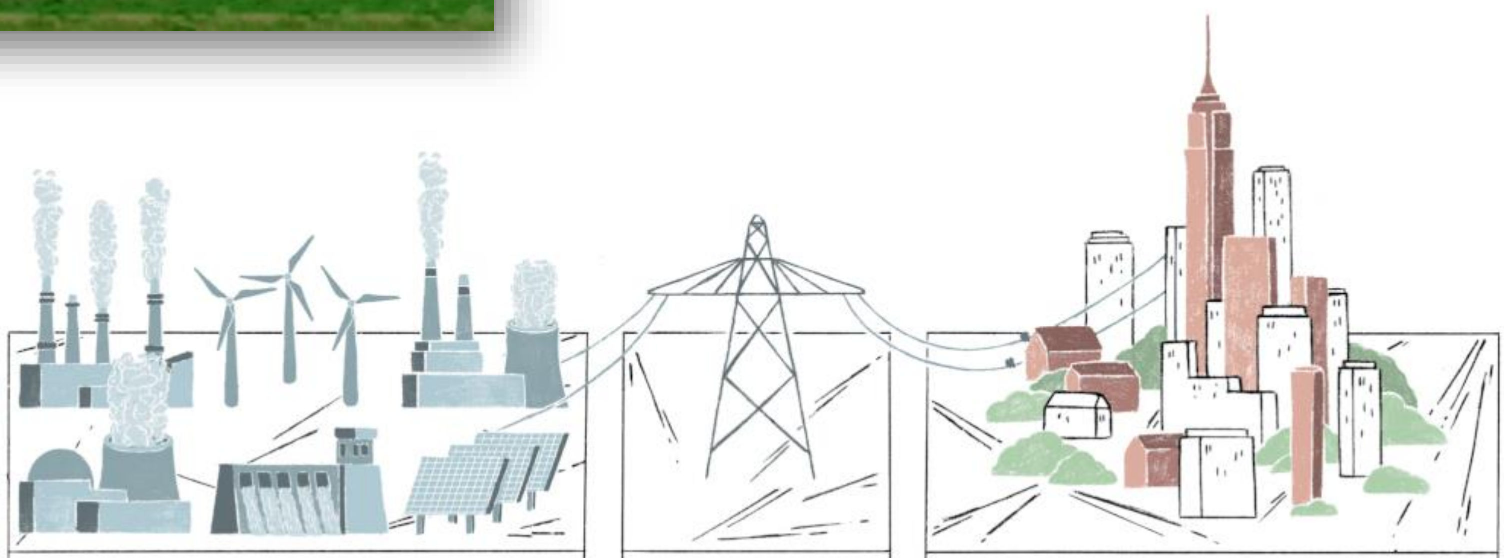
Power in the Primary Coil = Power in Secondary Coil [$P_1 = P_2$]

So $I_p \times V_p = I_s \times V_s$



13.8 Explain why, in the national grid, electrical energy is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic uses as it improves the efficiency by reducing heat loss in transmission lines

- High current means high resistance
- Because the negative electrons collide with the positive ions in the wire.
- The high resistance causes heat loss
- The reduces the amount of energy transferred
- Some power is lost as heat because $P = I^2 \times R$
- To stop this, low current is used.



13.9 Explain where and why step-up and step-down transformers are used in the transmission of electricity in the national grid

25,000V 400,000V 230V

- Increasing the potential difference through the powerlines decreases the current
- As the total power stays the same.
- The greater the current the more the wires heat up
- So a lower current means that the wires heat up less
- Making transmission more efficient.

13.10 Use the power equation (for transformers with100% efficiency): potential difference across primary coil (volt, V) × current in primary coil (ampere, A) = potential difference across secondary coil (volt, V) × current in secondary coil (ampere, A) VP IP VS IS

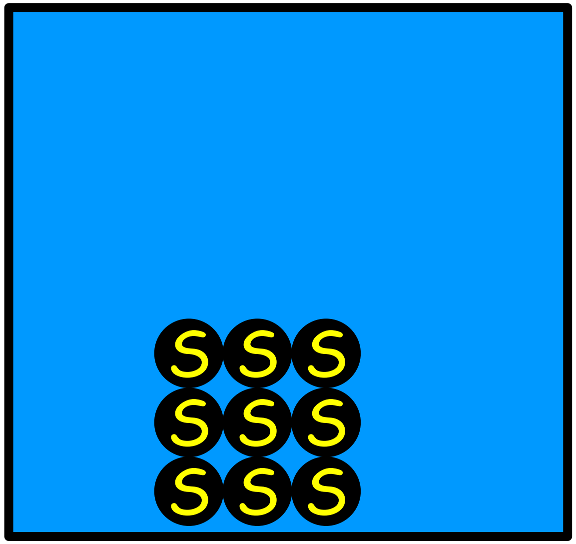
Name	Symbol	Units	Symbol
Primary voltage	Vp	Volts	V
Secondary voltage	Vs	Volts	V
Primary current	Ip	Amps	A
Secondary current	Is	Amps	A

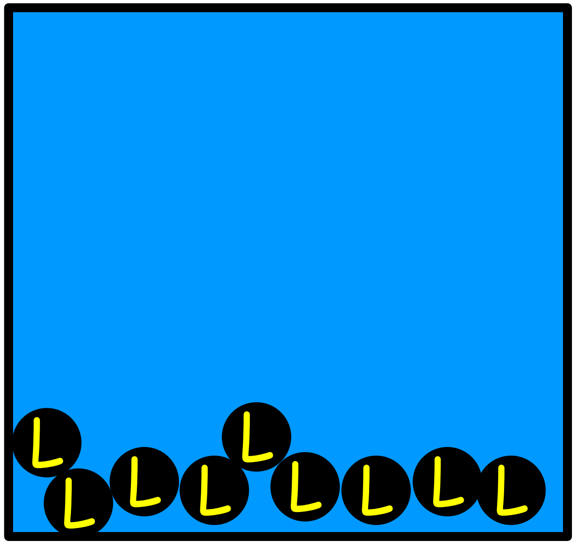
A step-down transformer can be used to charge laptop computers. A 230 V laptop computer charger has 600 turns of wire on the primary coil and 50 turns of wire on the secondary coil. Work out the output potential difference on the laptop charger. c. The current in the secondary coil of the laptop charger is 5A. Work out the current in the primary coil of the laptop charger.

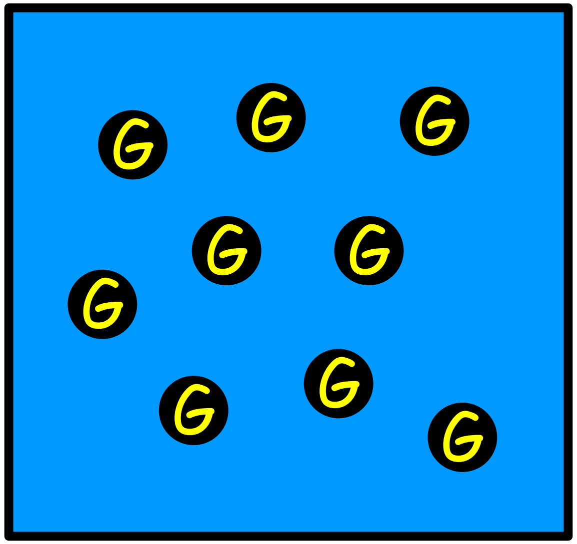
Topic 13 – Electromagnetic induction

1. Describe the factors that affect the size and direction of an induced potential difference.
2. Describe the effect of an alternating current in one circuit on another in a transformer.
3. Describe the uses of transformers
4. Describe the need for step up transformers
5. Describe the advantages of using high voltage power lines
6. Describe the need for step down transformers
7. Describe the assumptions made when using the power equation for transformers.

14.1 Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles







Solid

-Particles vibrate but do not have the kinetic energy to break intermolecular bonds.
-The shape does not change unless enough thermal energy is provided.

Liquid

-Particles vibrate with enough kinetic energy to change shape but without enough kinetic energy to vibrate enough to change their volume.

Gas

-Particles have enough kinetic energy to change their volume to fill in the container.
-Gas pressure is caused by the particles hitting the walls of the container..

14.2 Recall and use the equation: density (kilogram per cubic metre, kg/m3) = mass (kilogram, kg) ÷ volume (cubic metre, m3) ρ= m/V

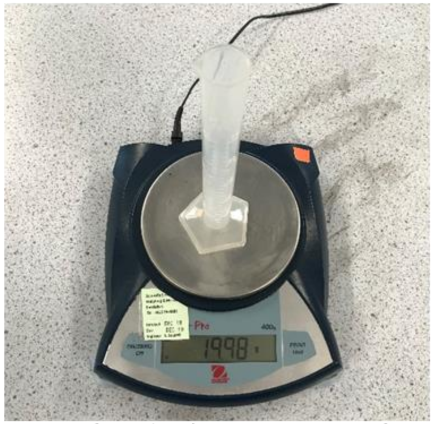
density (kg/m^3) = mass (kg) ÷ volume (m^3)

$$\rho = \frac{m}{V}$$

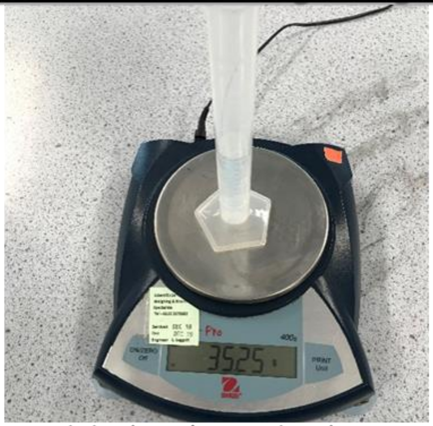
Variable	Symbol	Unit	Symbol
Density	ρ	Kilogram meter cubed	kg/m^3
Mass	m	Kilogram	kg
Volume	V	Meter cubed	m^3

14.3 Core Practical: Investigate the densities of solid and liquids

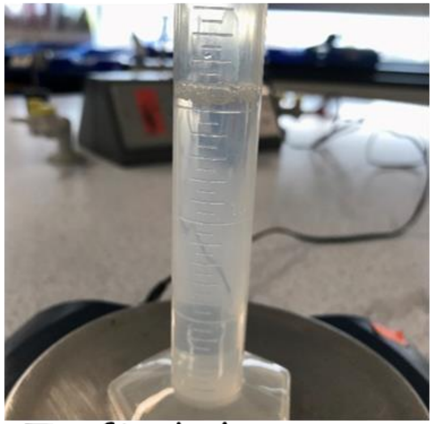
Core practical 6: Investigating densities



To find the mass of a liquid, find the mass of the graduated cylinder



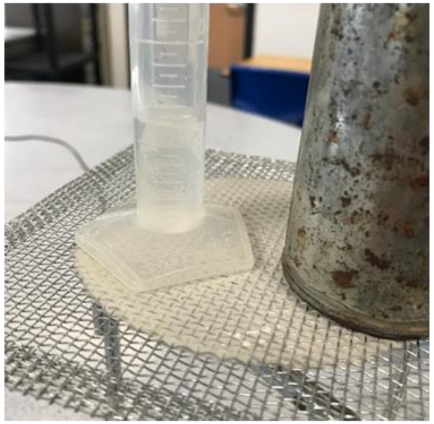
Add the liquid, then find the new mass. Find the difference. Convert to kilograms



To find the volume, read from the bottom of the meniscus.

For an irregular solid or a regular solid. Use a balance, convert to kilograms.

For a regular solid, find the volume by measuring with a calipers. For an irregular solid, use an overflow can.

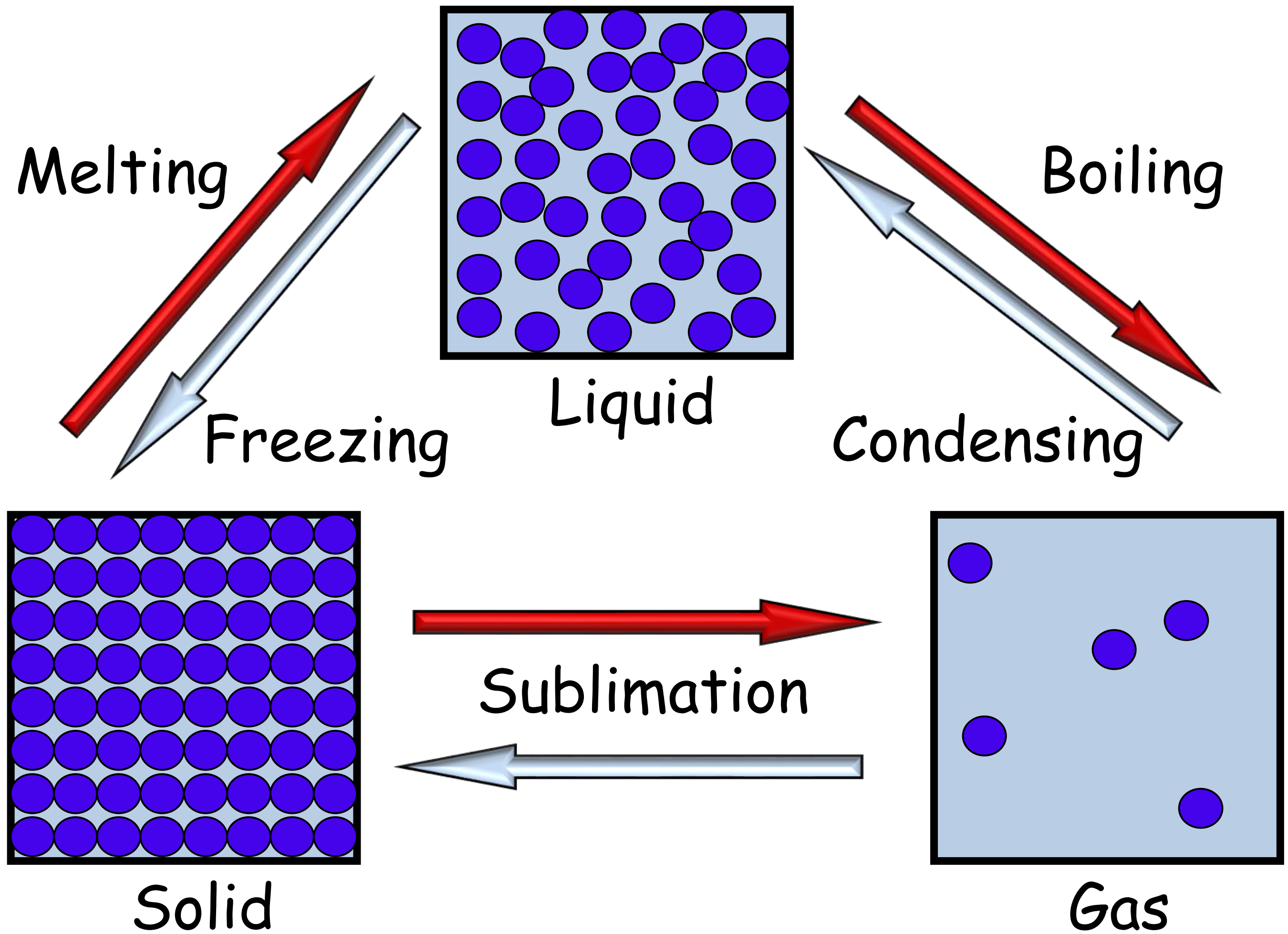


The volume of displaced water is the same as the volume of an irregular solid. If it floats, push it below the waterline with a pin.

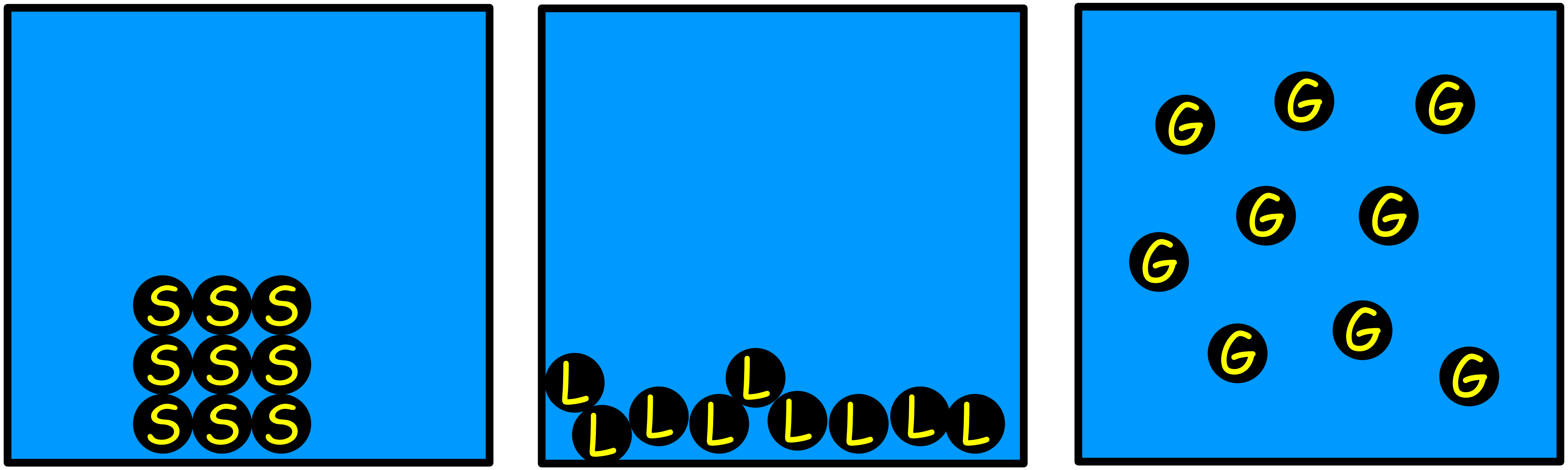
14.4 Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules

The change in state changes the volume of a substance.

By increasing the space between the molecules, the density decreases because P=mxV



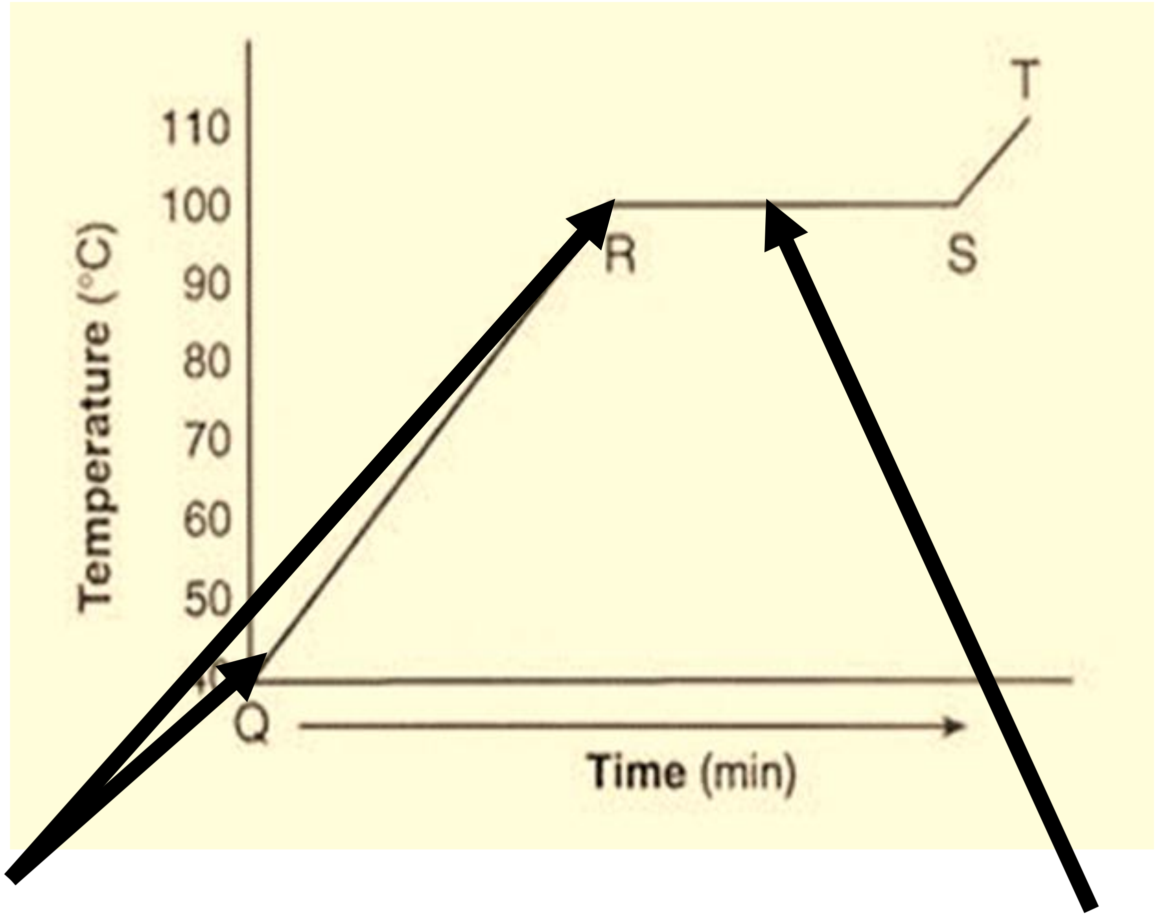
14.5 Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed



When a substance changes state, the particles are not altered.

This means when a change of state happens, the particles change revert back to their original properties.

14.6 Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

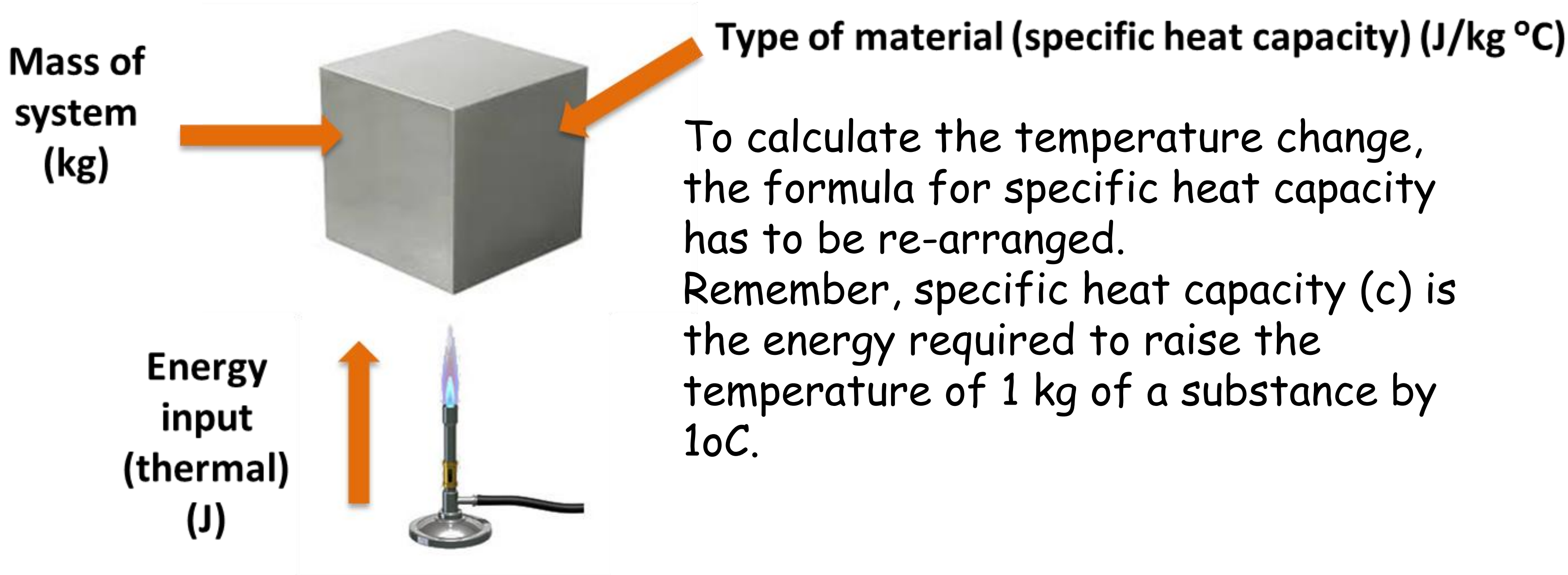


Heating a substance will increase the energy store and raise its temperature.

This will happen until the substance changes state

In a pure substance the change of state will happen at one temperature until the change occurs.

14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them



To calculate the temperature change, the formula for specific heat capacity has to be re-arranged.
Remember, specific heat capacity (c) is the energy required to raise the temperature of 1 kg of a substance by 1oC.

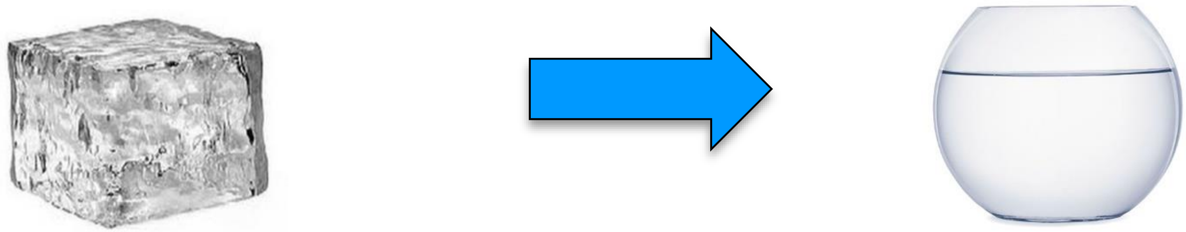
$$\text{Temperature change } (\boldsymbol{\Delta\theta}) = \frac{\text{change in thermal energy } (\boldsymbol{\Delta E})}{\text{mass } (\mathbf{m}) \times \text{specific heat capacity } (\boldsymbol{C})}$$

14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them

Latent heat is the energy needed to change the state of a substance without a change in temperature.
The energy supplied is used to change the internal energy store of the substance.

1kg of ice at 0°C

1kg water at 0°C



Specific latent heat of fusion for water = 336 000 J/kg
This means 336 000 J of energy are needed to turn 1 kg of ice into 1 kg of water with no temperature change.

Energy to change state (J) = mass (kg) x specific latent heat (J/kg)

14.8 Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C)
ΔQ □ m□ c □ $\Delta\theta$

$$\boldsymbol{E = m \times c \times \Delta\theta}$$

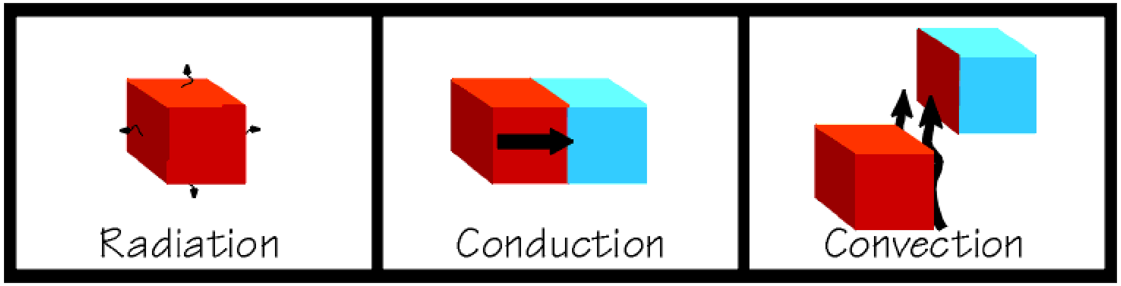
Name	**Symbol**	**Unit**	**Symbol**
Temperature	θ	Degree Celsius	°C
Energy	E	Joule	J
Mass	m	Kilogram	kg
Specific Heat Capacity	c	Joule per kilogram degree Celsius.	J/kg°C

14.9 Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) Q m L

$$E = m \times L$$

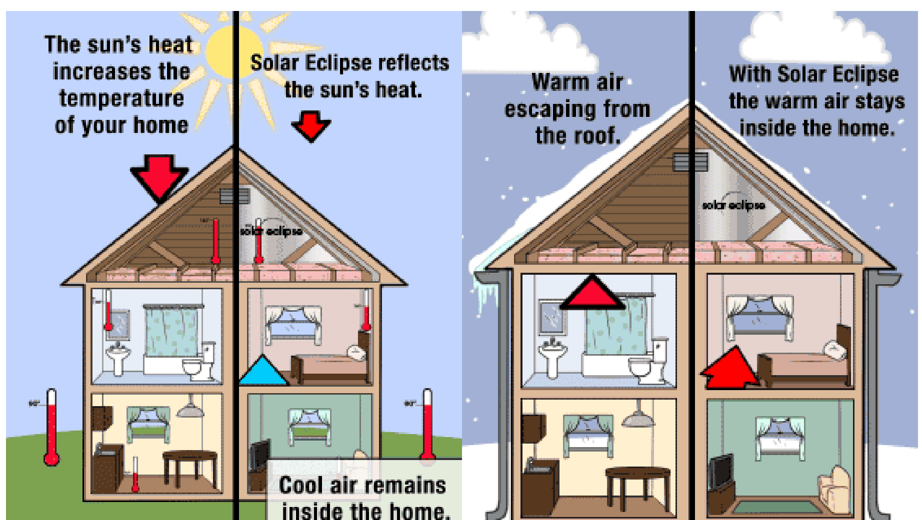
Name	Symbol	Unit	Symbol
Energy Transferred	E	Joule	J
Mass	m	Kilogram	kg
Specific Latent Heat	L	Joule per kilogram	J/kg

14.10 Explain ways of reducing unwanted energy transfer through thermal insulation



The higher the thermal conductivity, the quicker heat is transferred through a material.

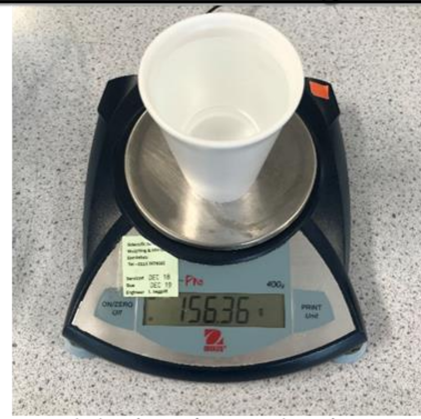
Insulation uses materials with low thermal conductivity, such as fibreglass, foam and trapped gases.



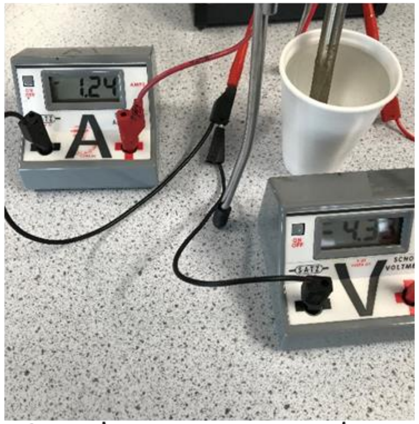
14.11 Core Practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice

Core practical 7: Investigating water

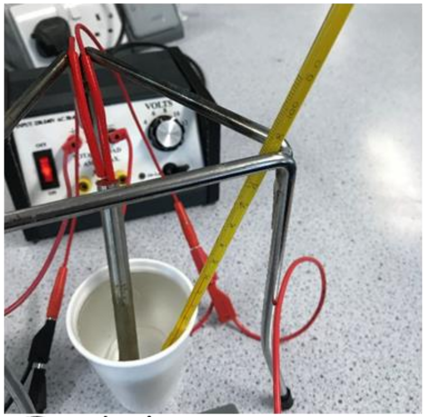
To find the mass of a liquid, find the mass of the polystyrene cup



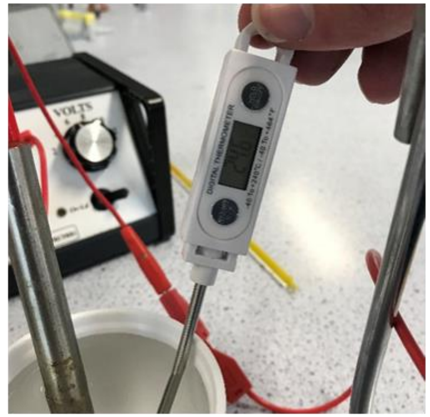
Add the liquid, then find the new mass. Find the difference. Convert to kilograms



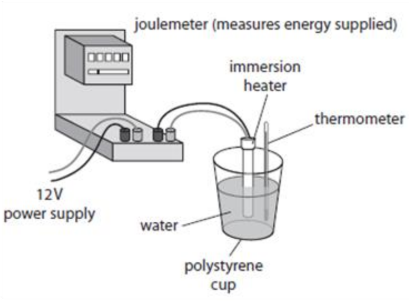
Attach an ammeter and voltmeter to the immersion heater. Use a stopwatch and E=VIt to calculate energy transferred.



Find the start temperature and final temperature after heating.



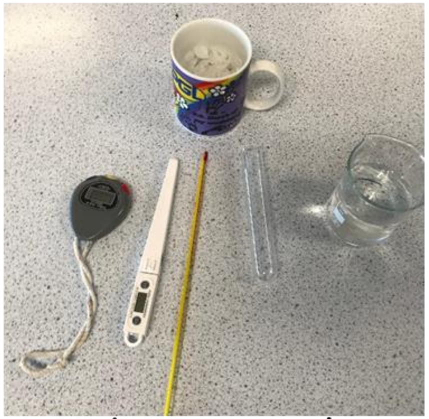
Use a digital thermometer for greater accuracy.



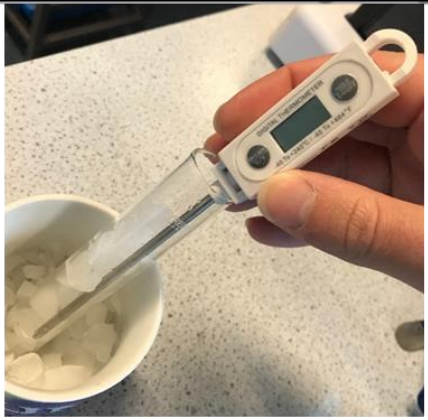
You can use a joulemeter instead of ammeters and voltmeters.

14.11 Core Practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice

Core practical 7: Investigating water

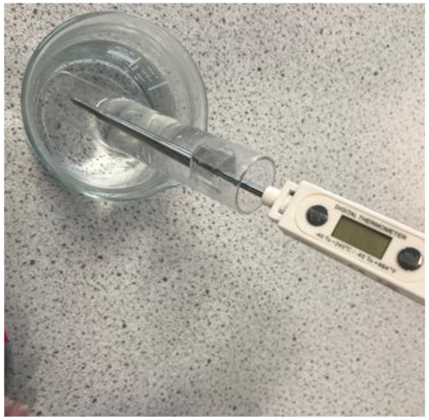


To draw a cooling – heating curve, you need water in a sloid state.

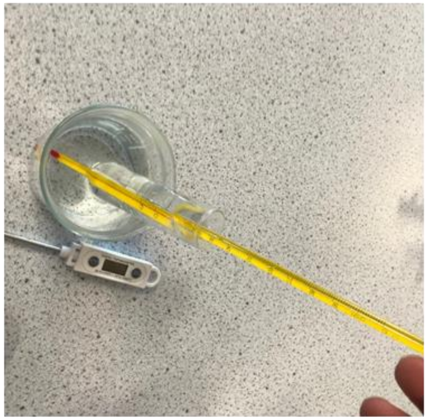


Find the initial temperature of the ice.

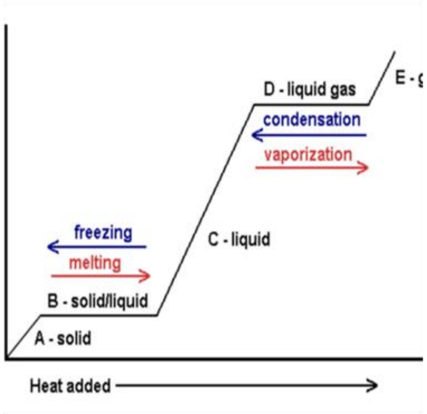
Use a stopwatch to measure the time.



Put the ice in a water bath and record the temperature every 30 seconds.



Digital thermometers are more accurate than traditional thermometers.



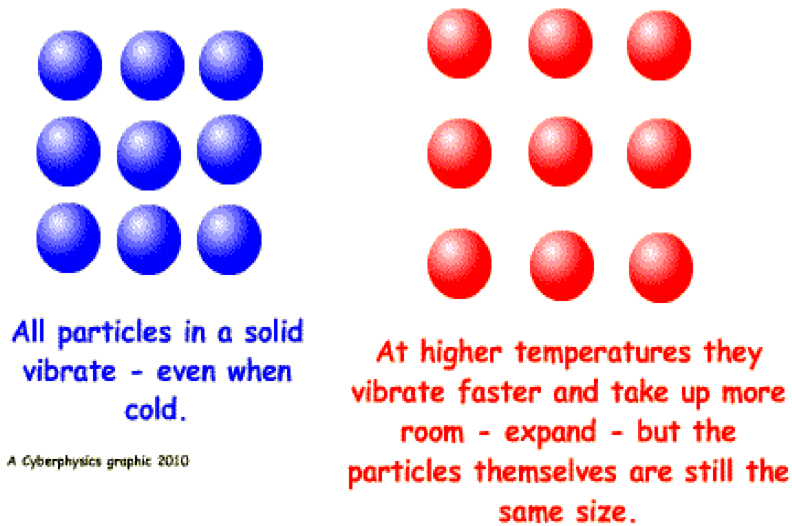
Plot a graph of time (x-axis) and temperature (y-axis)

14.12 Explain the pressure of a gas in terms of the motion of its particles

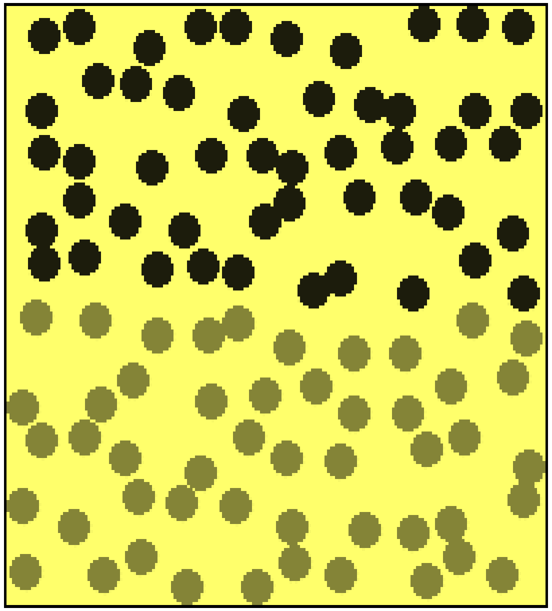
If a sealed can of air (gas) is heated, the molecules of air move faster and faster.
The collisions of these molecules on the inside walls of the container create a pressure. The hotter the molecules, the faster they move and the more pressure they exert on the wall of the can.

If the can continues to be heated, the pressure will keep rising steadily.

The graph opposite shows that gas pressure is directly related to its temperature, if the volume remains constant.



14.13 Explain the effect of changing the temperature of a gas on the velocity of its particles and hence on the pressure produced by a fixed mass of gas at constant volume (qualitative only)



Particles of a gas inside a container have kinetic energy

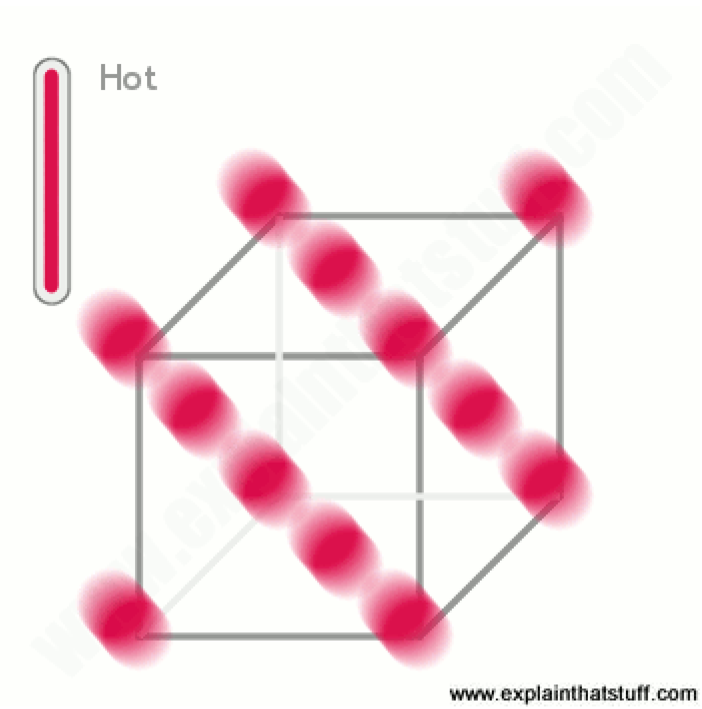
- The **temperature** of this gas is related to the average **kinetic energy** of all the particles.
- If the temperature of the gas is increased, the particles will **move faster**.
- Faster moving particles exert a **greater force** on the walls of the container.
- This will either cause the container to **expand** (balloon) or **increase the pressure** of the gas (gas cylinder).

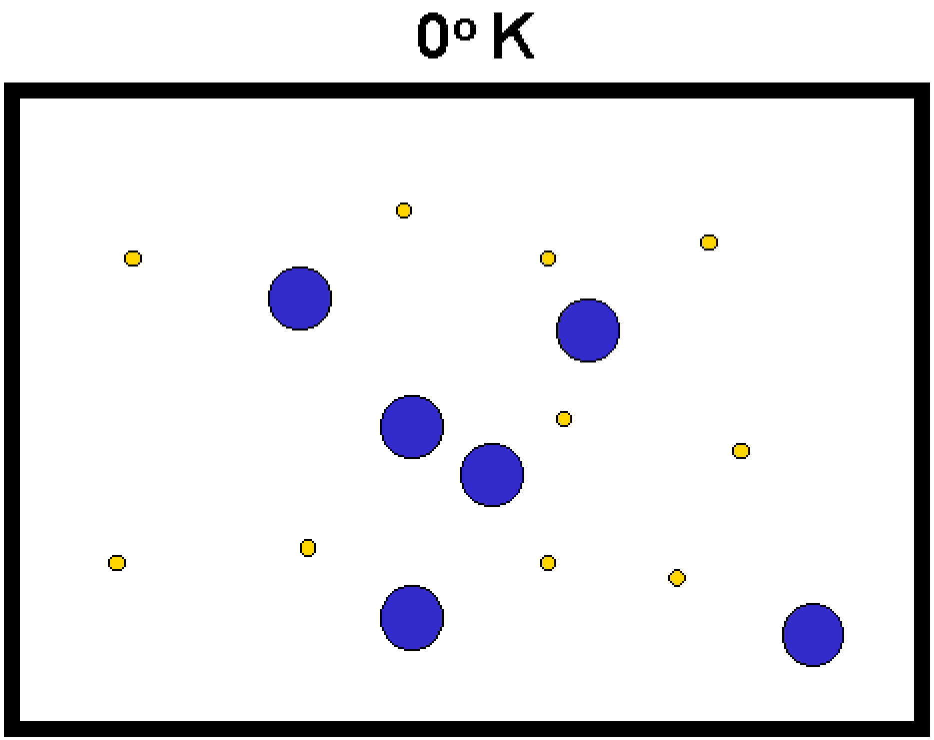
14.14 Describe the term absolute zero, −273 °C, in terms of the lack of movement of particles

Absolute zero is the theoretical temperature where particles have no kinetic energy at all.

It's very hard to get to, impossible in fact.

But it's still cool!





14.15 Convert between the kelvin and Celsius scales

$$T_{(°C)} = T_{(K)} - 273$$

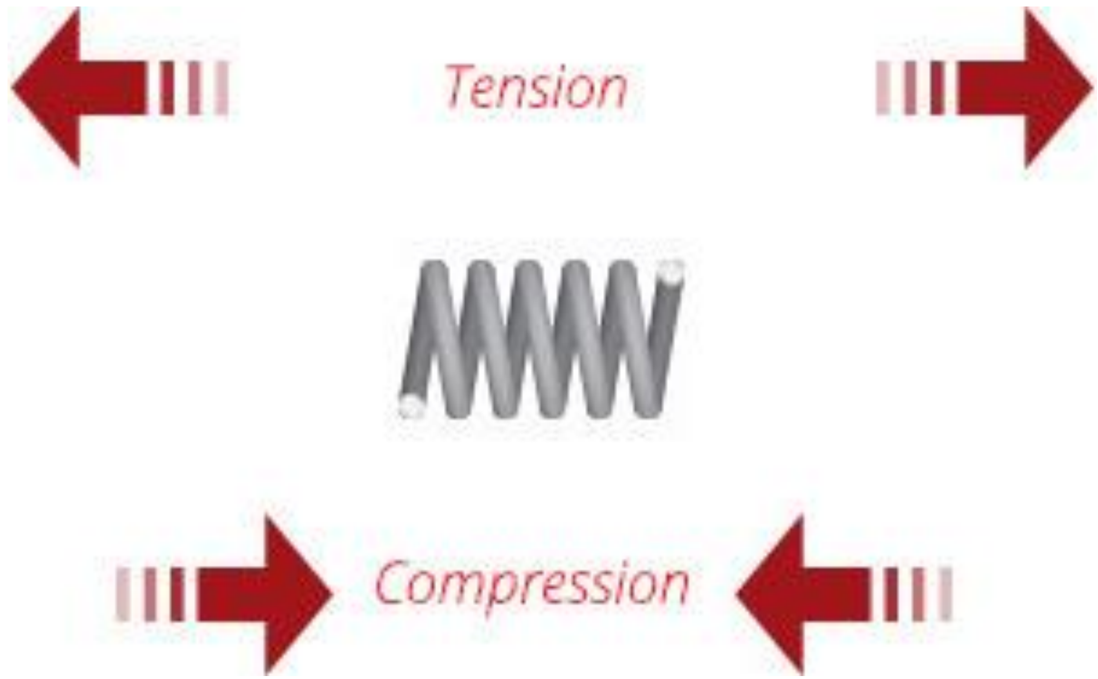
$$°C - 273 = K$$

$$36°C = -237K$$

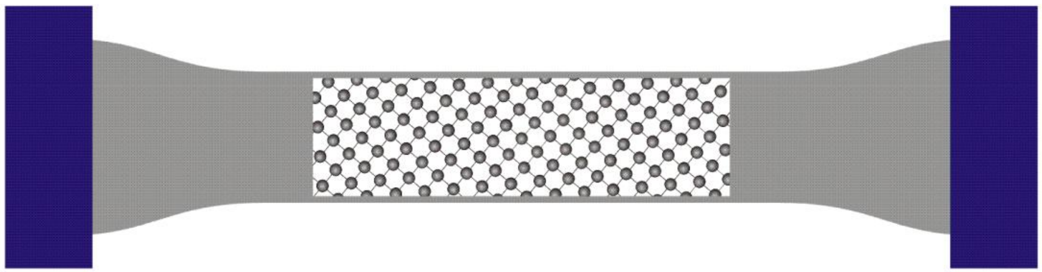
Topic 14 – Particle model

1. Describe the differences between solids, liquids and gasses using kinetic theory.
2. State the equation for density when you have volume and mass
3. Describe how to find the density of an irregular object
4. Describe how to find the density of a regular object
5. Describe how to find the density of a liquid.
6. Describe the reasons for differences in density between the different states of matter.
7. Describe what is meant by the conservation of mass
8. Describe 6 state changes that matter can undertake.
9. Describe the effect of heating a system, referencing temperature and change of state.
10. Define the term specific heat capacity
11. Define the term specific latent heat.
12. Describe the differences between specific hat capacity and specific latent heat.
13. Describe the effect of thermal insulation on energy transfers in systems.
14. Describe an experiment to investigate the specific latent heat of water.
15. Describe an experiment to investigate the specific latent heat of water.
16. Describe the cause of gas pressure
17. Describe the effect of changing the temperature on gas pressure.
18. Describe what is meant by absolute zero
19. Describe how to convert from degrees Celsius to degrees kelvin

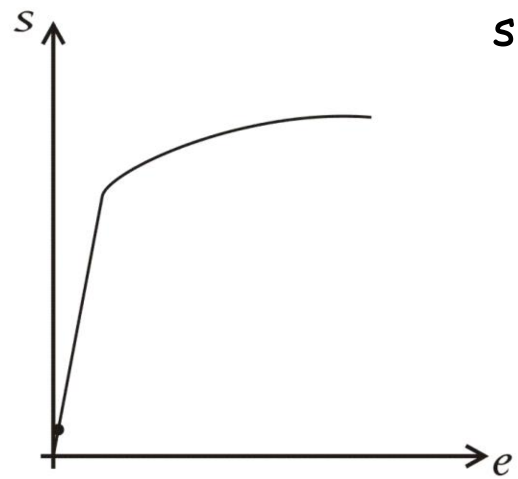
15.1 Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force

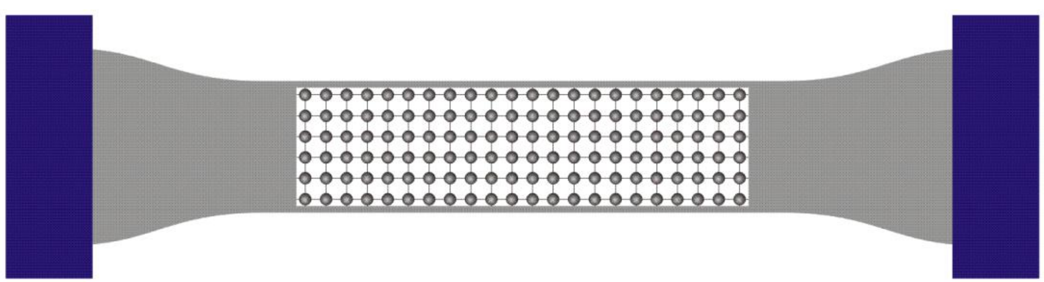


15.2 Describe the difference between elastic and inelastic distortion



Inelastic distortion.
The atoms in the spring re-align and do not go back to the original shape.





Elastic distortion.
The atoms in the spring stretch and go back to the original shape.

15.3 Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) F k x

force exerted on a spring (N) = spring constant (N/m) × extension (m)

$$\boldsymbol{F} = \boldsymbol{k} \times \boldsymbol{x}$$

This relationship can be applied to springs in both **compression** and **tension**, as long as the **limit of proportionality is not exceeded**.

Variable	**Symbol**	**Unit**	**Symbol**
Force	F	Newton	N
Spring constant	K	Newtons per meter	N/m
Extension	x	meters	m

15.4 Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))2 E 1 k x2

Energy required to stretch (J) = 0.5 x spring constant (N/m) x extension ^{2} (m)

$$E = 0.5\ x\ k\ x\ X^2$$

This relationship can be applied to springs in both **compression** and **tension**, as long as the **limit of proportionality is not exceeded**.

Variable	**Symbol**	**Unit**	**Symbol**
Energy	E	Joules	J
Spring constant	K	Newtons per meter	N/m
Extension	x	meters	m

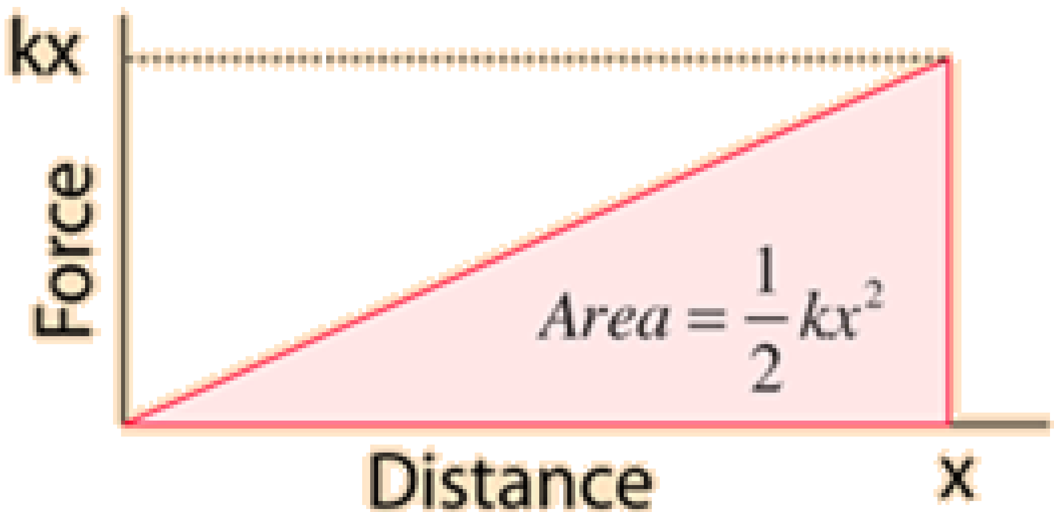
15.4 Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))2 E 1 k x2

$$E = 0.5 \times k \times X^2$$

The amount of **energy** required to stretch a spring depends on…

… how **hard it is to stretch** a spring …

… times the extension of the spring



15.5 Describe the difference between linear and non-linear relationships between force and extension

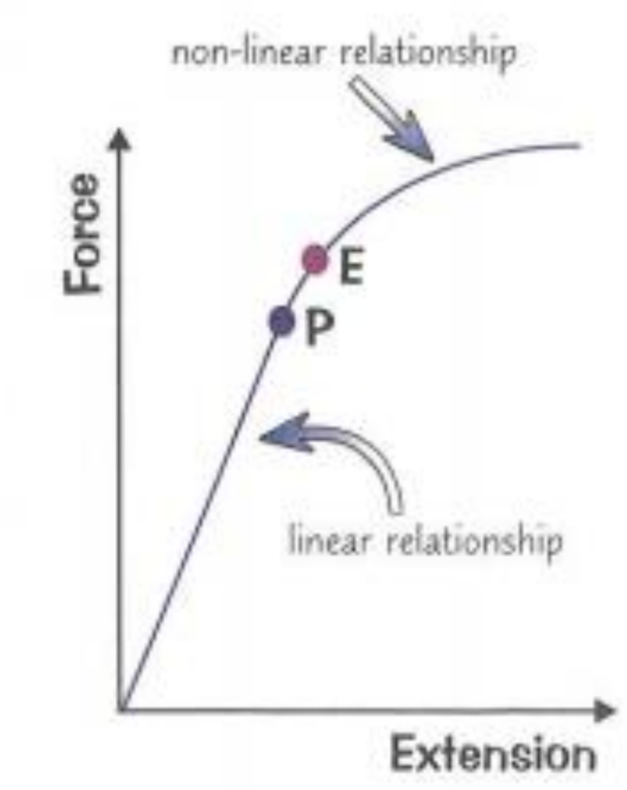
When the graph stops being linear, the spring is no longer elastic.

Springs stretch in proportion to the force added up to the limit of proportionality (P). This is the linear portion of the graph.

After the limit of proportionality the amount of force doesn't make a predictable extension.

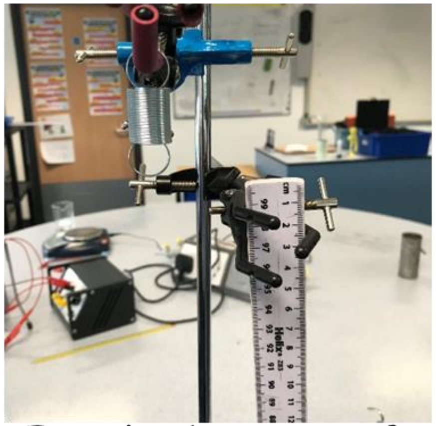
The elastic limit is where the object becomes permanently stretched.

This is where the non-linear part of the graph begins.



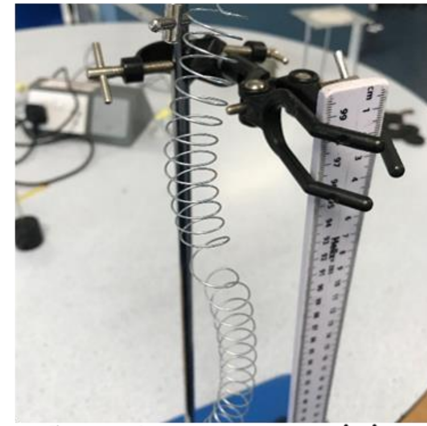
15.6 Core Practical: Investigate the extension and work done when applying forces to a spring

Core practical 8: Investigating springs

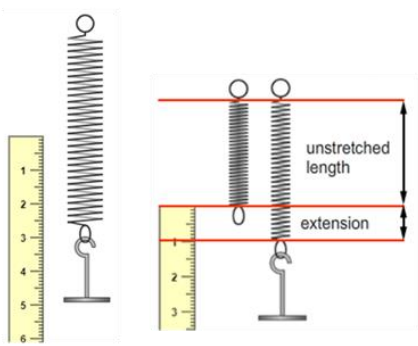


Fix the bottom of the meter ruler to beside the bottom of the spring.

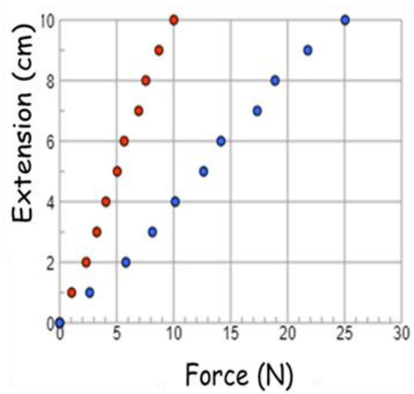
Add a mass to the bottom of the spring and measure the extension. 100g = 1 Newton



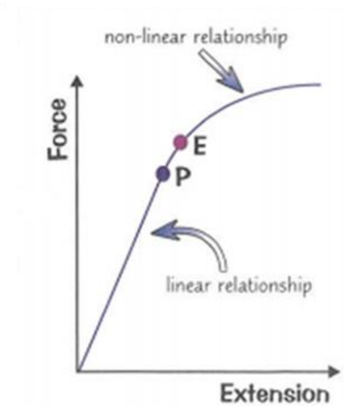
Continue to add masses until the spring passes the elastic limit.



Make sure you measure the extension at the same point of the spring.



Draw a graph of force (x-axis) and extension (y-axis)



Label the limit of proportionality and elastic limit on the graph.

Topic 15 – Forces and matter

1. Describe the difference between elastic and inelastic distortion
2. State the equation for linear elastic distortion when you have the spring constant and the force
3. State the equation to calculate the energy in stretching a spring when you have the spring constant and the extension.
4. Describe the difference between linear and non-linear relationships between force and extension
5. Describe an experiment to discover the spring constant of a given spring.

Symbol Equations	Word Equations	Unit Equations	Symbols		Name and Unit	
$x = av\, x\, t$	$distance = average\ speed\ x\ time$	$(m) = \left(\frac{m}{s}\right) x\ (s)$	x	Δh	Distance (m) Meters	Height (m) Meters
$a = \frac{(v-u)}{t}$	$acceleration = \frac{change\ in\ velocity}{time\ taken}$	$(\frac{m}{s^2}) = \frac{(\frac{m}{s})}{(s)}$	av	P	Speed (m/s) Meters / second	Power (W) Watts
$F = m\ x\ a$	$force = mass\ x\ acceleration$	$(N) = (Kg)\ x\ (\frac{m}{s^2})$	t	E	Time (s) Seconds	Energy (J) Joules
$W = m\ x\ g$	$weight = mass\ x\ gravitational\ field\ strength$	$(N) = (Kg)\ x\ (\frac{N}{Kg})$	a	Q	Acceleration (m/s^2) Meters per second squared	Charge (C) Coulombs
$\mathbf{p = m\ x\ v}$	$\mathbf{momentum = mass\ x\ velocity}$	$\mathbf{\left(Kg.\frac{m}{s}\right) = (Kg) x\ (\frac{m}{s})}$	v	V	End velocity (m/s) Meters per second	Voltage (V) Volt
$v = f\ x \lambda$	$wave\ speed = frequency\ x\ wavelength$	$\left(\frac{m}{s}\right) = (Hz)\ x\ (m)$	u	I	Start velocity (m/s) Meters per second	Current (A) Amps
$v = \frac{x}{t}$	$wave\ speed = \frac{distance}{time}$	$(\frac{m}{s}) = \frac{(m)}{(s)}$	F	R	Force (N) Newtons	Resistance (Ω) Ohms
$E = F\ x\ d$	$work\ done = force\ x\ distance\ moved$	$(J) = (N)\ x\ (m)$	m	P	Mass (Kg) Kilograms	Power (W) Watts
$\Delta GPE = m\ x\ g\ x\ \Delta h$	$\Delta GPE = mass\ x\ gravitational\ fieldx\ vertical\ height$	$(J) = (Kg)\ x\ \left(\frac{N}{Kg}\right) x\ (m)$	W	k	Power (W) Watts	Constant No Unit
$KE = \frac{1}{2} x\ m\ x\ v^2$	$\Delta Kinetic\ Energy = \frac{1}{2}\ x\ mass\ x\ (speed)^2$	$(J) = \frac{1}{2}\ x\ (Kg)\ x\ (\frac{m}{s})$	g	X	Gravity (N/Kg) Newtons per kilo	Extension (m) Meters
$\rho = \frac{m}{V}$	$density = \frac{mass}{volume}$	$(\frac{kg}{L}) = \frac{(Kg)}{(L)}$	p	G-	Momentum ($Kg.ms^{-1}$) Kilogram meters/ sec	Giga- 10^9
$P = \frac{E}{t}$	$power = \frac{work\ done}{time\ taken}$	$(W) = \frac{(J)}{(s)}$	f	M-	Frequency (Hz) Hertz	Mega- 10^6
$P = \frac{E}{t}$	$power = \frac{energy\ transferred}{time\ taken}$	$(W) = \frac{(J)}{(s)}$	λ	K-	Wavelength (m) Meters	Kilo- 10^3
$E = Q\ x\ V$	$energy\ transferred = charge\ moved\ x\ voltage$	$(J) = (C)\ x\ (V)$	ρ	c-	Density (Kg/m^3) Kilogram / meter cubed	Centi- 10^2
$Q = I\ x\ t$	$charge = current\ x\ time$	$(C) = (A)\ x\ (s)$	V	m-	Volume (m^3 Meters cubed	Milli- 10^{-3}
$V = I\ x\ R$	$voltage = current\ x\ resistance$	$(V) = (A)\ x\ (\Omega)$	E	µ-	Work Done (J) Joules	Micro- 10^{-6}
$P = I\ x\ V$	$electrical\ power = current\ x\ voltage$	$(W) = (A)\ x\ (V)$	F	n-	Force (N) Newtons	Nano- 10^{-9}
$P = I^2\ x\ R$	$electrical\ power = (current)^2\ x\ resistance$	$(W) = (A)\ x\ (\Omega)$	d	p-	Distance (m) Meters	Pico- 10^{-12}
$F = k\ x\ \times$	$force\ on\ a\ spring = spring\ constant\ x\ extension$	$(F) = (k)\ x\ (m)$	ΔGPE		Energy (J) Joules	

2 Motion
Speed
Acceleration

2 Forces
Newton's 2nd
Weight

2 Waves
Velocity
Velocity

2 Energy
Gravitational
Kinetic

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

$$acceleration = \frac{change\ in\ velocity}{time}$$

$$velocity = \frac{displacement}{time}$$

$$velocity = frequency\ x\ wavelength$$

$$force = mass\ x\ acceleration$$

$$weight = mass\ x\ gravitational\ field\ strength$$

$$GPE = mass\ x\ grav\ field\ x\ height$$

$$KE = 0.5\ x\ mass\ x\ velocity^2$$

Wait a moment. This doesn't work. Eff it!!!
Work
Momentum
Efficiency

$$work = force\ x\ distance$$

$$Efficiency = \frac{Useful}{Total}$$

$$momentum = mass\ x\ velocity$$

This is the queens **pet** cat.

The Queen's cat is called **Piv**

Piv likes to **Piir**

How much **E**cstasy in the **Q**ueen's "**V**an"?

The **V**an is **I**mportant and **R**oyal

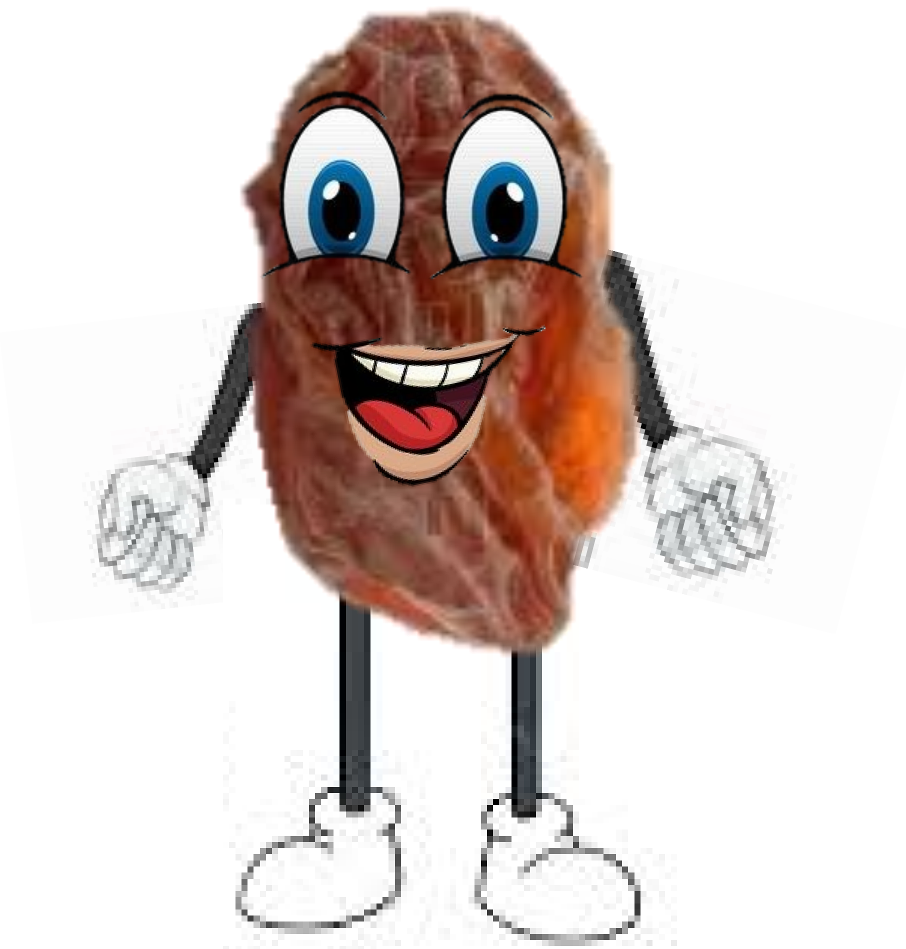
But this is treason, so we better **QuIT**.

The Queen lives in Buckingham palace.
There are no radiators though so it's very cold.
It's a **Coulomb** **(cool – home)**

One needs a blanket…

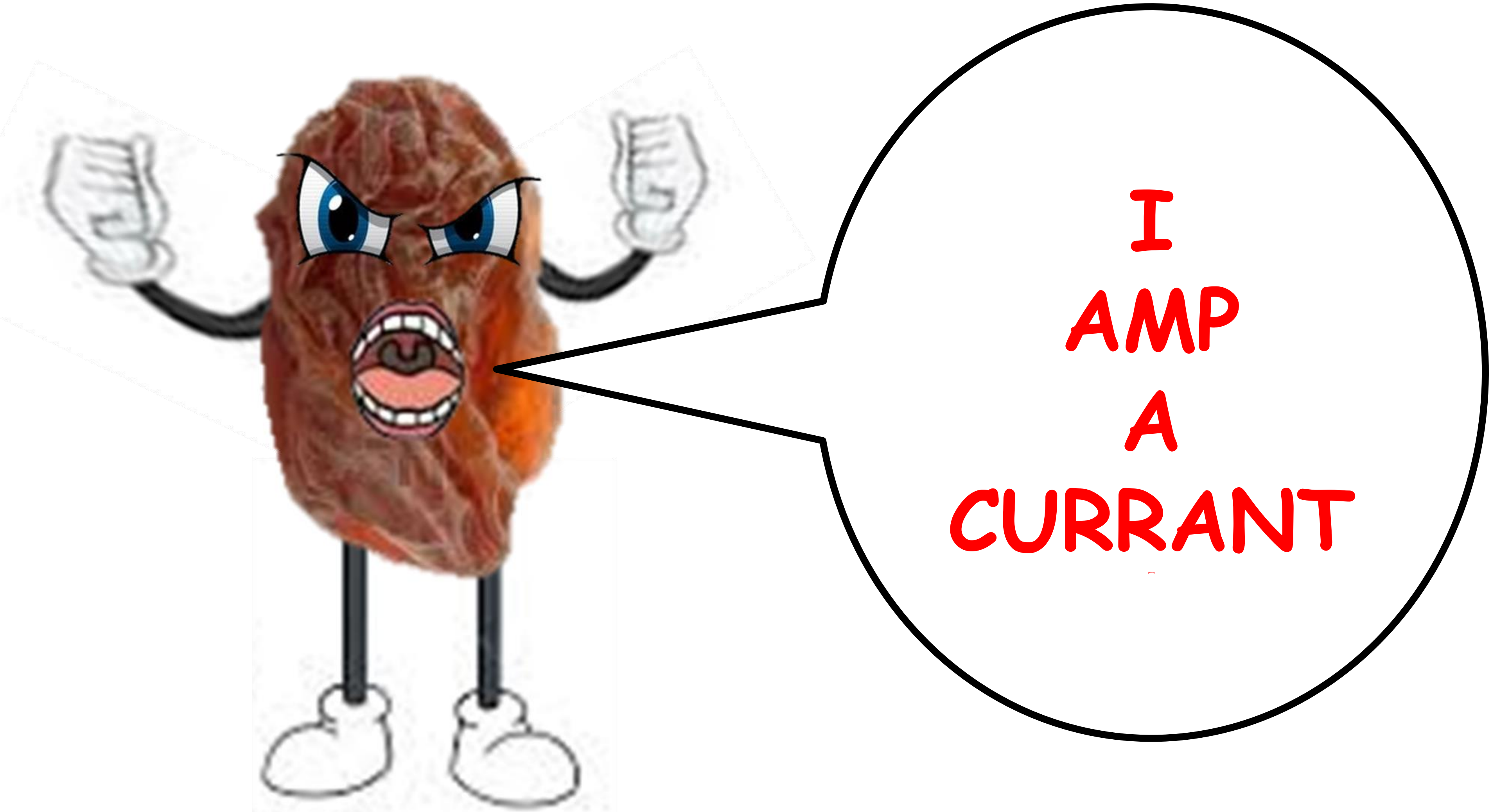
As the **Q**ueen was leading the **charge** she wearing sunglasses.
She and I are also very tight.
She's my cool-homie
Coulombs

The Queen was leading a charge to break the Indian **Resistance**
Gandhi just sat there mediating.



Hey there little Raisin!!!

Aren't you just the cutest!!!


I
AMP
A
CURRANT

Core Practicals – Method and Questions

Core practical 1: Investigating force, mass and acceleration

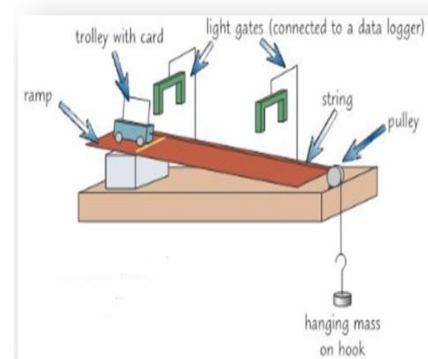
Set up the experiment so the slope of the ramp allows the cart to roll slightly. This controls for the force of gravity and friction.

Ensure your hanging masses have room to avoid hitting the floor. To keep the mass of the system constant, take masses from the trolley and add to the hanger.

Ensure the interrupt card on top of the cart can pass easily through the light gate. Using a light gate controls for human reaction time errors.

Use a stopwatch to time between the gates if you are using them to calculate speed. This will introduce human reaction time errors

Make sure you use the equation $a = \frac{\Delta V}{t}$ to calculate the answer. Remember to include this in your answers.



Ensure that when you are asked to improve this experiment that you review sources of error and how to use more accurate equipment.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

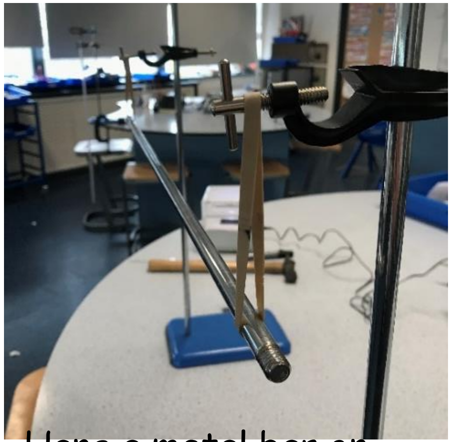
How to improve the apparatus:

How to improve the method:

What are the controls:

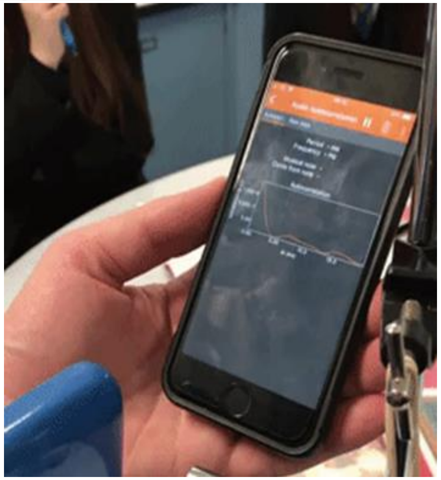
1. Why is one end of the ramp propped up?
2. How would you calculate the force pulling the trolley?
3. Why do you use the same force pulling the trolley each time?
4. Why do you need two light gates?
5. What effect does the mass on the end of the string have on the total mass in the table of results?
6. What are the main errors involved in this procedure?
7. How can you improve the procedure?
8. How could you keep the mass constant?

Core practical 2: Measuring waves in solids and liquids



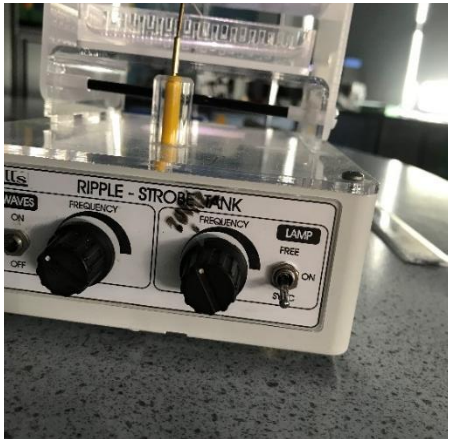
Hang a metal bar on rubber bands to allow it free movement. Measure the bar. The wavelength is twice the bar length

Hit the bar with a metal headed hammer, this will cause a sound wave to be created.

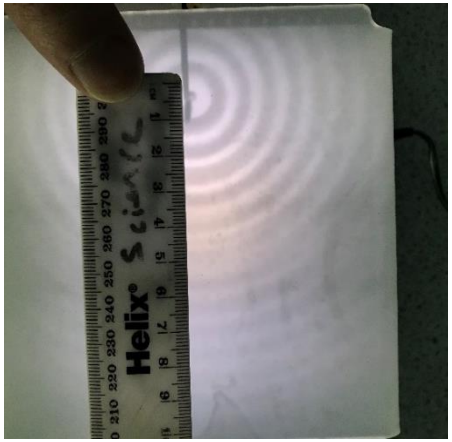


Use an app like "Phyphox" to measure the frequency of the wave. Use $v = f \times \lambda$

Set up the ripple tank with a synchronous strobe light so the waves appear stationary.



Use a known frequency on the wave generator by adjusting the knob.



Measure the wavelength with a ruler. A callipers would be more accurate.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

How to improve the apparatus:

How to improve the method:

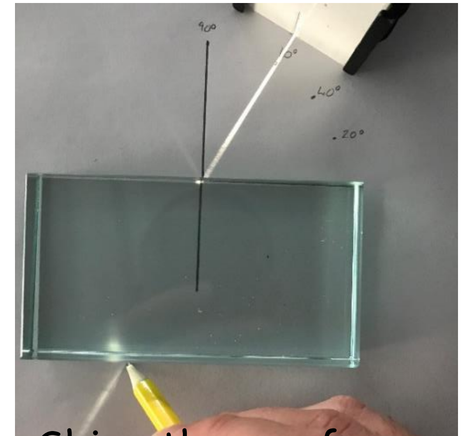
What are the controls:

1. Waves can be transverse or longitudinal. What type of wave is:
    1. a water wave on the surface of the water in a ripple tank?
    2. a sound wave in a metal rod?
2. How would you measure the speed of sound in air?
3. How would you measure the speed of water waves in a ripple tank?
4. Why can you not measure the speed of sound waves in a metal rod in the same way?
5. Is it possible to measure the speed of light?

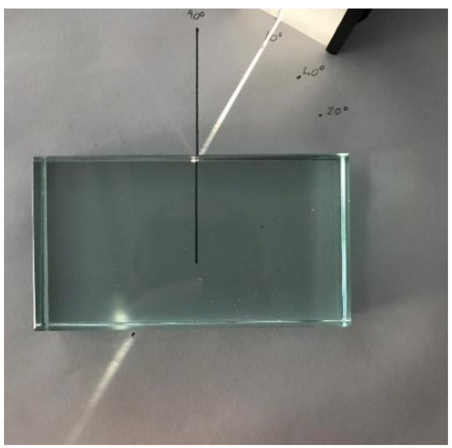
Core practical 3: Investigating refraction

Draw a normal line. This is 90° to the medium boundary. Mark a spot on the boundary that the normal intersects

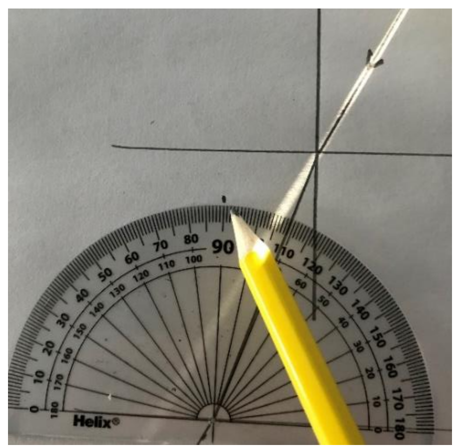
Mark out angles at 20° intervals from the normal using a protractor.



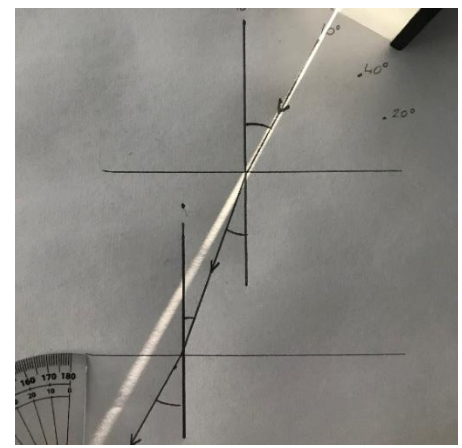
Shine the ray from the marked angles to the first spot on the boundary of the medium.



Mark where the ray exits the medium at two points so you can draw a line.



Draw another normal line at the point where the refracted ray exits the medium



Connect the entrance point and exit point with a line. Measure the angles of inference and refraction from normal to the ray.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

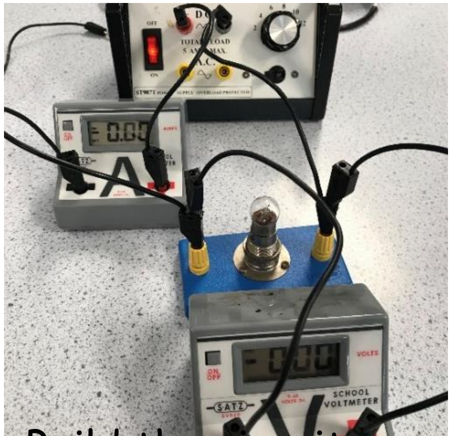
How to improve the apparatus:

How to improve the method:

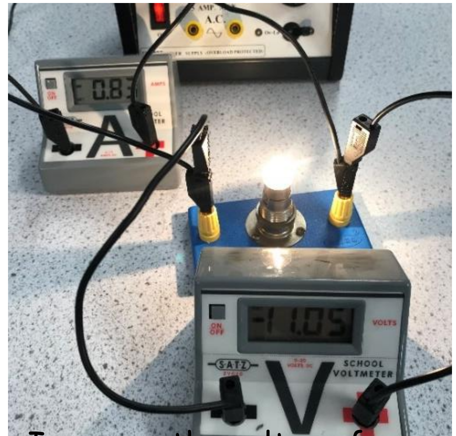
What are the controls:

1. Why did you use a ray box not a light bulb?
2. Why does a swimming pool appear to be less deep than it actually is?
3. What are the sources of error in this investigation?
4. How could you improve the method?
5. What causes mirages?
6. How can you produce a ray of light on a sheet of paper?

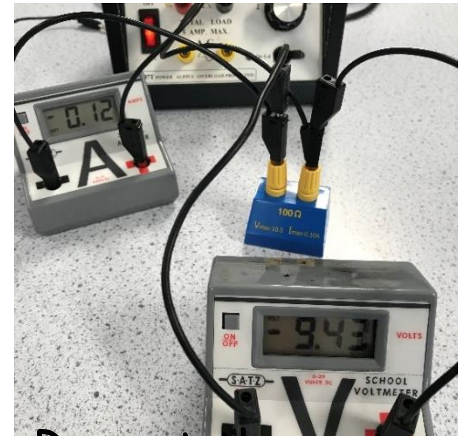
Core practical 5: Investigating resistance



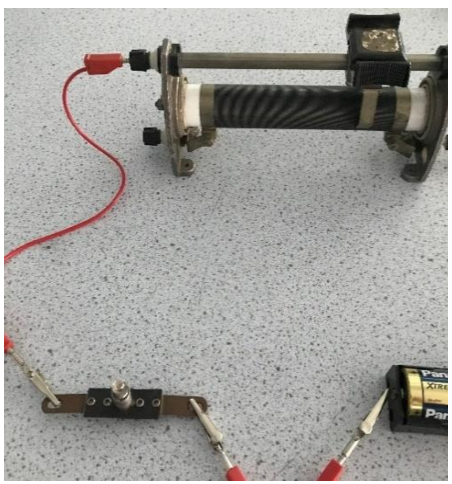
Build the circuit as shown in the diagram. Start at 0V on the power pack.



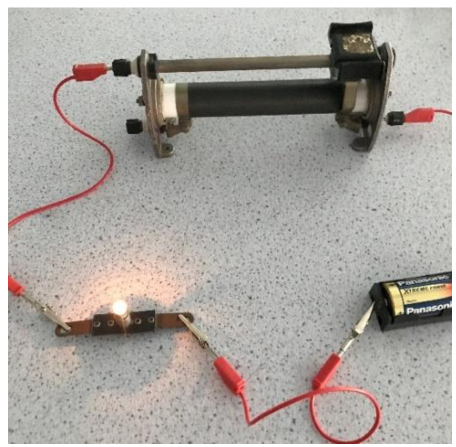
Increase the voltage from the power pack, recording the voltage and current across the bulb /resistor using ammeter and voltmeter.



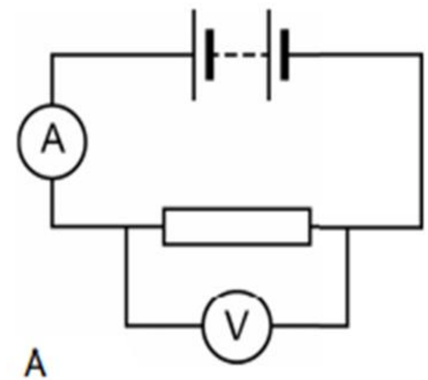
Repeat the experiment using an Ohmic resistor.



If you don't have access to a power pack, you can use a variable resistor (rheostat).



By changing the resistance of the current and voltage across the component.



Be sure to include the ammeter and voltmeter in your circuit diagram.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

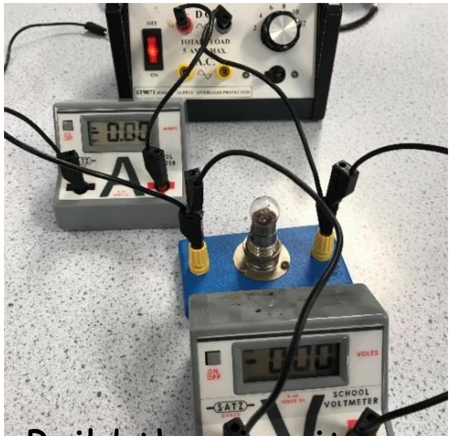
How to improve the apparatus:

How to improve the method:

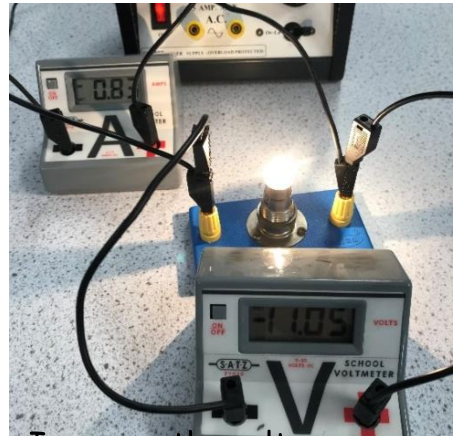
What are the controls:

1. What are the circuit symbols for the following components:
    1. battery, switch, resistor, variable resistor, filament lamp, ammeter, voltmeter
2. How is an ammeter connected into a circuit?
3. How is a voltmeter connected into circuit?
4. How could you vary the current and potential difference in a circuit?

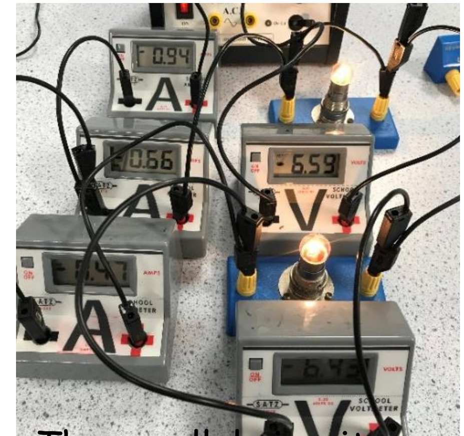
Core practical 5: Investigating resistance



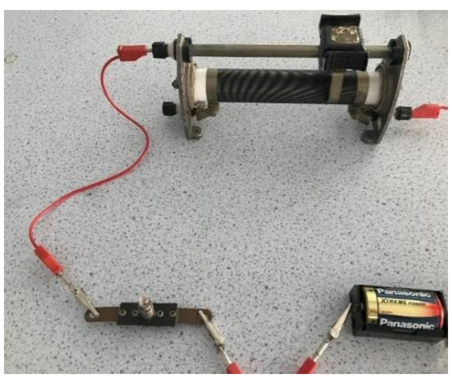
Build the circuits as shown in the diagram. Ensure you start at 0V (power pack off)



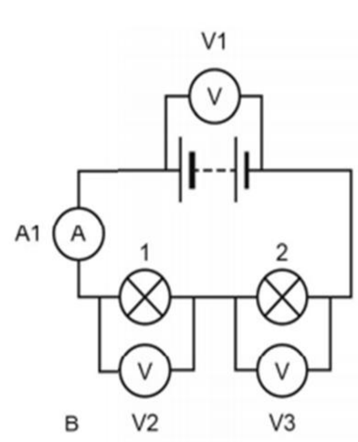
Increase the voltage reading from the power pack, recording the readings from the ammeters and voltmeters as you do so.



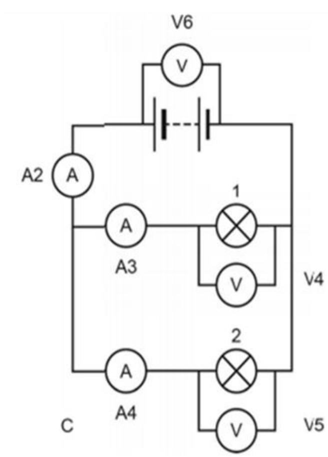
The parallel circuit can be confusing, make sure you label the ammeters, voltmeters and bulbs according to the circuit diagram.



You can use a rheostat instead of a power pack to change the voltage and current across the component.



Make sure you include the ammeters and voltmeters in your circuit diagram.



Series

$I_{TOT} = I_1 = I_2$

$V_{TOT} = V_1 + V_2$

$R_T = R_1 + R_2$

Parallel

$V_{TOT} = V_1 = V_2$

$I_{TOT} = I_1 + I_2$

$\frac{1}{R_{TOT}} = \frac{1}{R1} + \frac{1}{R2}$

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

How to improve the apparatus:

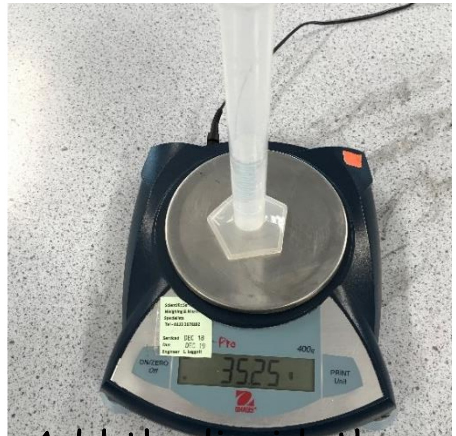
How to improve the method:

What are the controls:

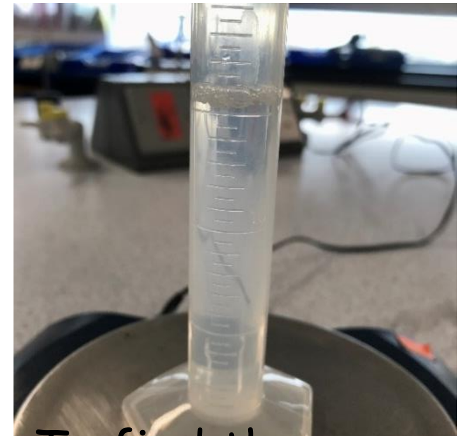
1. What are the circuit symbols for the following components:
    1. battery, switch, resistor, variable resistor, filament lamp, ammeter, voltmeter
2. How is an ammeter connected into a circuit?
3. How is a voltmeter connected into circuit?
4. How could you vary the current and potential difference in a circuit?

Core practical 6: Investigating densities

To find the mass of a liquid, find the mass of the graduated cylinder

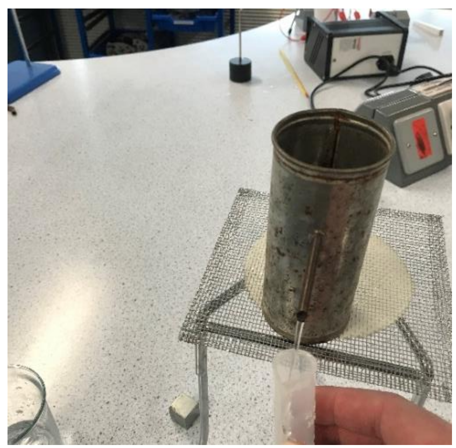


Add the liquid, then find the new mass. Find the difference. Convert to kilograms

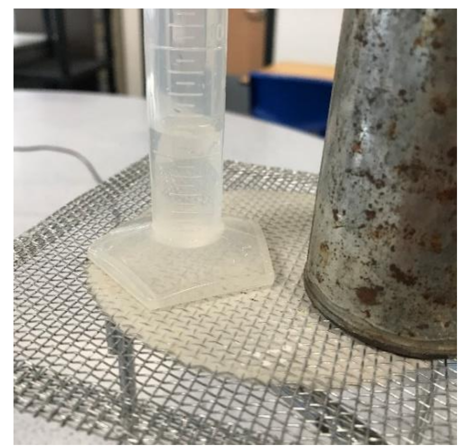


To find the volume, read from the bottom of the meniscus.

For an irregular solid or a regular solid. Use a balance, convert to kilograms.



For a regular solid, find the volume by measuring with a calipers. For an irregular solid, use an overflow can.



The volume of displaced water is the same as the volume of an irregular solid. If it floats, push it below the waterline with a pin.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

How to improve the apparatus:

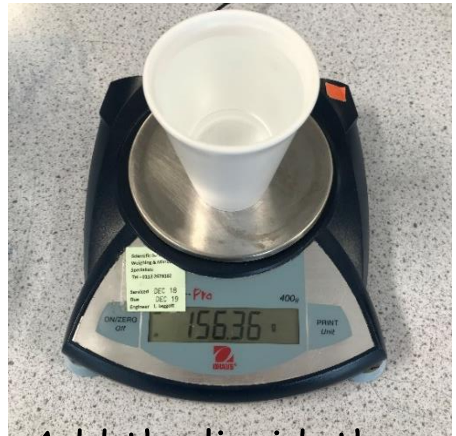
How to improve the method:

What are the controls:

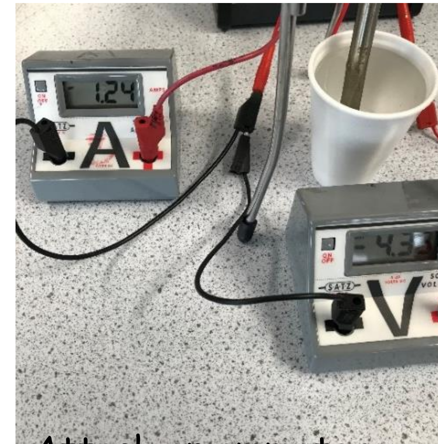
1. Think of examples of heavy objects that float on water.
2. Think of some light objects that sink in water.
3. Is the mass of an object the only factor that determines whether or not it will float on water?
4. What equation would you use to find density?
5. How do you convert from cm^3 to m^3?

Core practical 7: Investigating water

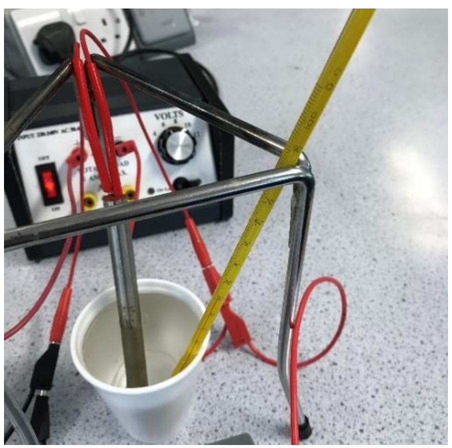
To find the mass of a liquid, find the mass of the polystyrene cup



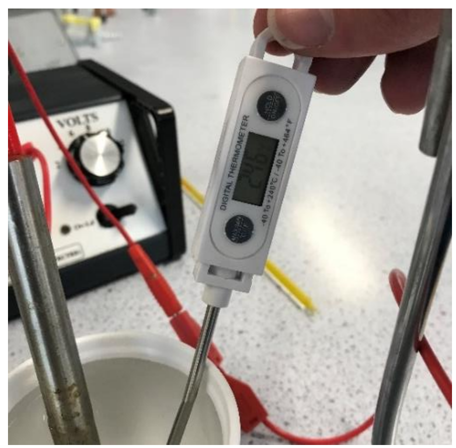
Add the liquid, then find the new mass. Find the difference. Convert to kilograms



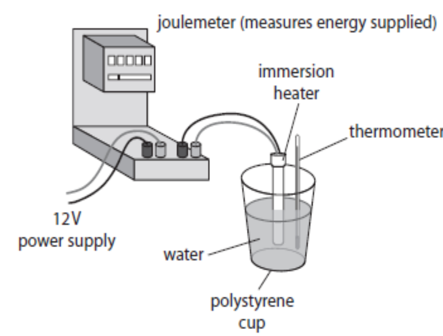
Attach an ammeter and voltmeter to the immersion heater. Use a stopwatch and E=VIt to calculate energy transferred.



Find the start temperature and final temperature after heating.



Use a digital thermometer for greater accuracy.



You can use a joulemeter instead of ammeters and voltmeters.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

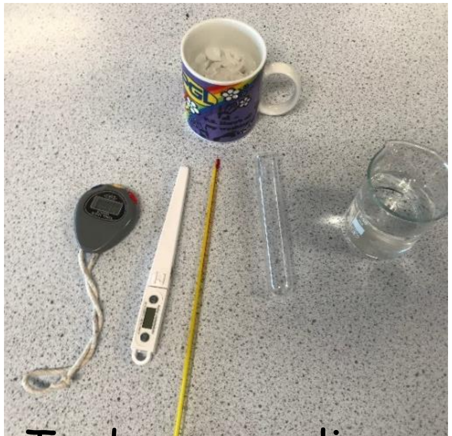
How to improve the apparatus:

How to improve the method:

What are the controls:

1. What two things might happen to water if you heat it?
2. How would you measure the temperature of ice?
3. What happens to the temperature of ice when it is melting?
4. What quantities will you need to measure before you can calculate specific heat capacity?
5. If you heat water in a beaker, some of the thermal energy supplied is lost to the surroundings. How can you reduce this energy loss?

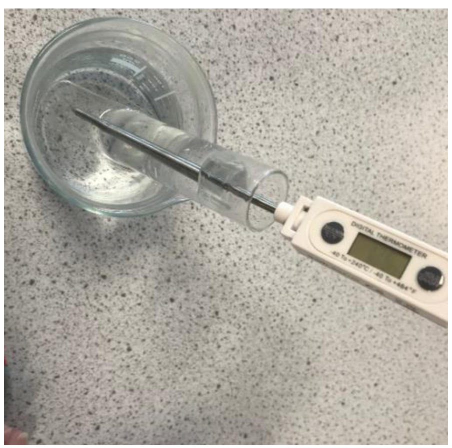
Core practical 7: Investigating water



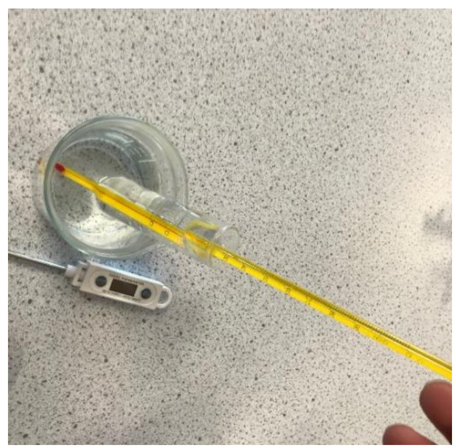
To draw a cooling – heating curve, you need water in a sloid state.

Find the initial temperature of the ice.

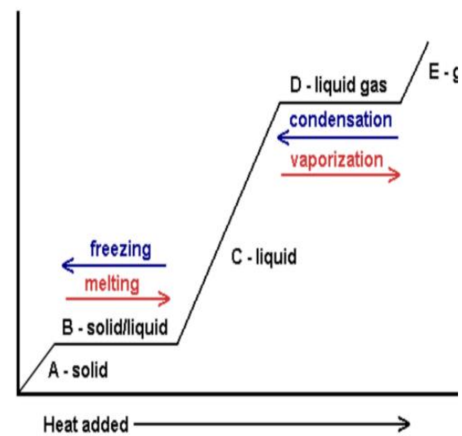
Use a stopwatch to measure the time.



Put the ice in a water bath and record the temperature every 30 seconds.



Digital thermometers are more accurate than traditional thermometers.



Plot a graph of time (x-axis) and temperature (y-axis)

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

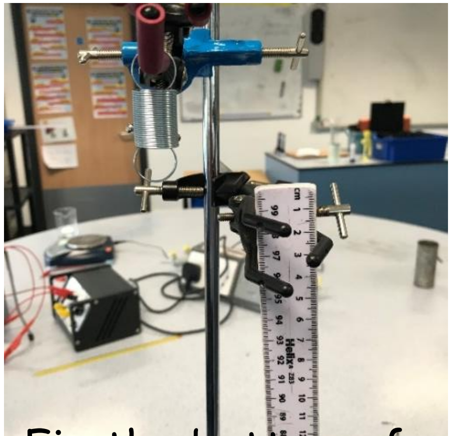
How to improve the apparatus:

How to improve the method:

What are the controls:

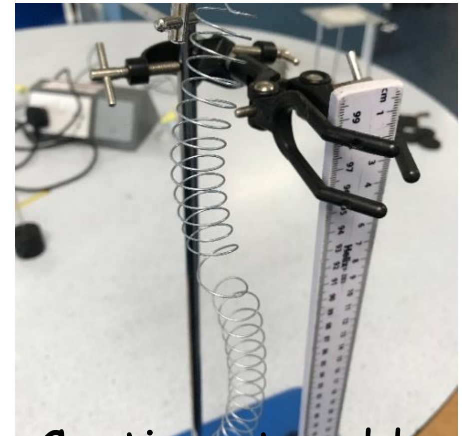
1. What two things might happen to water if you heat it?
2. How would you measure the temperature of ice?
3. What happens to the temperature of ice when it is melting?
4. What quantities will you need to measure before you can calculate specific heat capacity?
5. If you heat water in a beaker, some of the thermal energy supplied is lost to the surroundings. How can you reduce this energy loss?

Core practical 8: Investigating springs

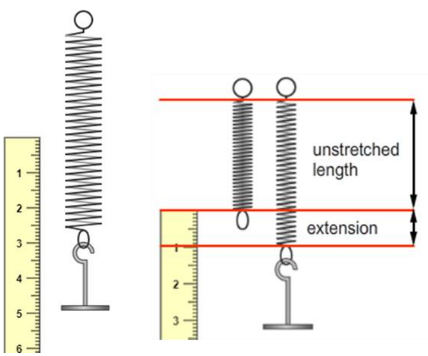


Fix the bottom of the meter ruler to beside the bottom of the spring.

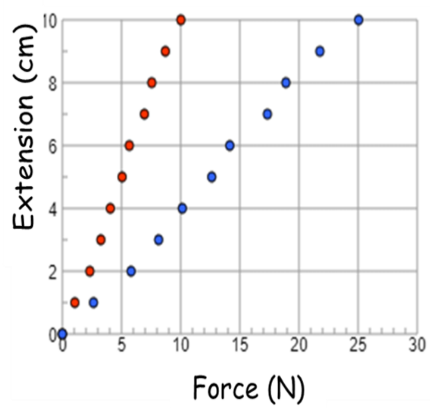
Add a mass to the bottom of the spring and measure the extension. 100g = 1 Newton



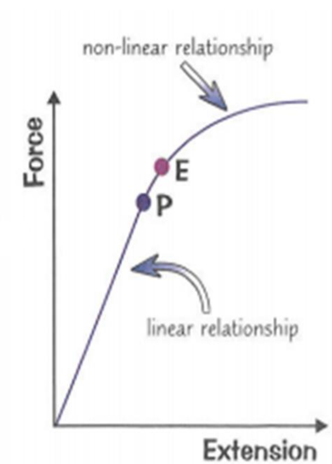
Continue to add masses until the spring passes the elastic limit.



Make sure you measure the extension at the same point of the spring.



Draw a graph of force (x-axis) and extension (y-axis)



Label the limit of proportionality and elastic limit on the graph.

What is the independent variable?

What is the dependent variable?

What conclusion would you reach?

How to improve the apparatus:

How to improve the method:

What are the controls:

1. Why is it difficult to measure the unstretched length of a spring?
2. How would you measure the extension of a spring?
3. What do the words 'elastic' and 'inelastic' mean when used in connection with stretching materials?
4. In what circumstances can you use the equation $F = k \times x$ when stretching materials?
5. Think of some examples where the energy stored in stretched spring might be used.
6. Define the elastic limit and the limit of proportionality.