Curriculum Map/Learning Journey

ST IVO ACADEMY
Astrea Academy Trust
INSPIRING BEYOND MEASURE

Year	Physics
7	Welcome to the lab
	Energy costs and transfers
	Forces and pressure
8	Waves, light and sound
	Energy revisited and energy project
	Electricity and magnetism
9	Waves EM Spectrum
	Conservation of Energy
10	Forces and Motion
	Radiation
	Forces and Effects
	Electricity and Circuits
	Triple Content: Astronomy
11	Magnetic Fields
	EM Induction
	Particles and Matter
	Triple Content: Static Electricity

KS4 : Autumn Term

SCIENCE: Electromagnetic Spectrum

ST IVO ACADEMY

Astrea Academy Trust

Keyword	Definition
electromagneti c waves	A group of waves that all travel at the same speed in a vacuum, and are all transverse.
frequency	The number of vibrations (or the number of waves) per second. One hertz (Hz) is one wave per second.
infrared (IR)	EM radiation that has a longer wavelength than visible. We can feel infrared radiation as warmth.
interface	The boundary between two materials.
refraction	The change in direction when a wave goes from one medium to another.
transverse wave	A wave in which the vibrations are at right angles to the direction the wave is travelling.
ultraviolet (UV)	EM radiation that has a shorter wavelength than visible light. Used to detect forged bank notes.
vacuum	A place where there is no matter at all.
visible light	Electromagnetic waves that can be detected by the human eye.
gamma rays	Electromagnetic radiation with the shortest wavelengths and highest frequencies.
microwaves	Electromagnetic radiation with a longer wavelength than infrared radiation but a shorter wavelength than radio waves.
radio waves	Electromagnetic radiation with the longest wavelengths and lowest frequencies.
visible spectrum	Electromagnetic waves that the human eye can detect. The colours that make up white light (red, orange, yellow, green, blue, indigo, violet).
X-rays	Electromagnetic radiation that has a shorter wavelength than ultraviolet radiation but a longer wavelength than gamma rays.
oscillations	Movements back and forth. In radio aerials, oscillations are repeated changes in voltage and current.
Mutation	A change in the DNA instructions in a cell.

Key facts to remember:

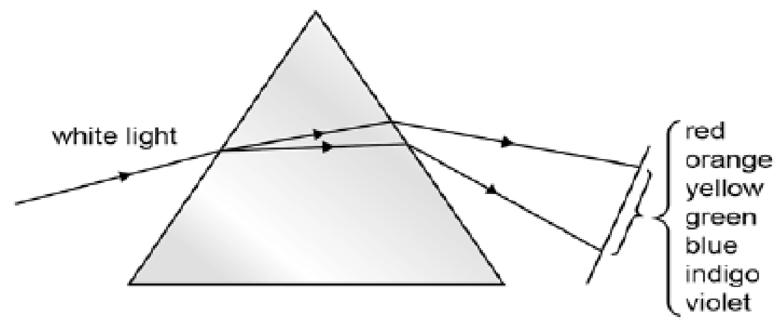
All EM (electromagnetic) waves are transverse waves.

Al l EM waves travel at the same speed (velocity) through a vacuum (space) at 300 million m/s.

EM waves are grouped based on their wavelengths and frequency. There are 7 basic EM waves. Radio waves, microwaves, infrared, visible light, UV, Xrays , gamma waves.

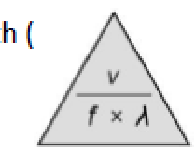
Our eyes can only detect a small part of this spectrum –visible light.

Different colours of light have different wavelengths from **longest** to **shortest: red**, orange, yellow, green, blue, indigo, **violet.** (ROYGBIV) or pneumonic; Richard Of York Gave Battle In Vain)



Wave Speed Equation

wave speed (m/s) = frequency (Hz) × wavelength (



KS4 : Autumn Term

SCIENCE: Electromagnetic Spectrum

The electromagnetic spectrum is <u>continuous</u>

ST IVO ACADEMY

Astrea Academy Trust

Short wavelength, high frequency

Long wavelength, low frequency

Part of EM spectrum	Uses of EM waves	Dangers of EM Waves
Gamma rays	Sterilising food and medical equipment. Detection of cancer and treatment or cancer	mutation or damage to cells in the body
X-rays	Observing the internal structure of objects, airport security scanners, medical x-rays	
UV	Security marking, fluorescent lamps, detecting forged bank notes, disinfecting water	damage to surface cells & eyes, leading to skin cancer and eye conditions. Sunburn.
Visible light	Vision, photography, illumination	
Infrared	cooking, thermal imaging, short range communications, optical fibres, television remote controls, security systems	skin burns
microwaves	cooking, communications and satellite transmissions	internal heating of body cells
Radio waves	broadcasting, communications, satellite transmissions	

To Remember

Potential **danger** increases with increasing frequency

Radio waves have the **LOWEST** frequencies and **LONGEST** wavelength.
Gamma waves have the **HIGHEST** frequencies and **SHORTEST** wavelengths.

Practise questions:

All the long waves in the electromagnetic spectrum are used in communication. Which part (or parts) of the electromagnetic spectrum is used:

a) to transmit mobile phone signals
b) to transmit radio and TV broadcasts
c) to send information along optical fibres
d) by lighthouses to warn ships of danger
e) to send remote control signals to TVs?

GCSE 6 mark question:

Infrared and ultraviolet waves have different frequencies. Both types of wave can have harmful effects on humans.
Compare and contrast the harmful effects of infrared and ultraviolet waves.

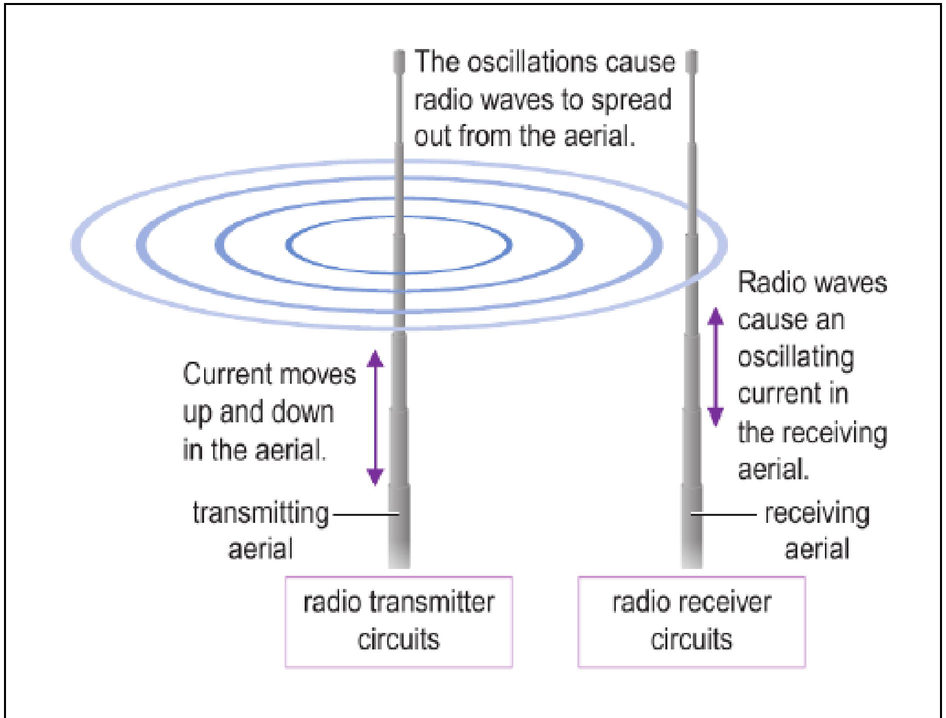
HIGHER ONLY- Long Wavelengths

EM waves for Communication

Radio waves are transmitted easily through air. They do not cause damage if absorbed by the body. They can also be reflected to change their direction.

How radio waves are produced:

Radio waves are produced by oscillations in electrical circuits. AC are made up of oscillating charges. As the charges oscillate, they produce oscillating electric and magnetic fields. A metal rod can be used as an aerial to receive radio waves. The radio waves are absorbed by the metal and cause oscillations in electric circuits connected to the aerial.



Discovering infrared:

Herschel (1738-1822) put dark, coloured filters on his telescope to help observe the sun safely. He noticed different coloured filters heated up the telescope to different extents. He used a prism to split sunlight into a spectrum and put a thermometer in each of the colours in turn.

Practise GCSE question questions:

Describe how are radio waves are produced and detected?

PHYSICS: Conservation of Energy

Energy Stores

Chemical	In Chemicals – e.g. in fuels or batteries
Kinetic	In moving objects
Thermal	In warm objects
Elastic Potential	In stretched or compressed objects
Gravitational Potential	Due to the position of an object in a gravitational field
Nuclear	In the nucleus of atoms
Magnetic	Magnetic objects in a magnetic field
Electrostatic	Charged objects in an electric field

Energy Transfers

By Forces	When a force moves through a distance
By Heating	Because of a temperature difference e.g. Convection, Conduction
By Electricity	When a charge moves through a potential difference
By Radiation	e.g. Electromagnetic waves or sound

Energy Transfers by Heating

Conduction	Transfers energy by passing vibrations between particles in solids
Convection	Transfers energy in fluids (liquids and gases). Warm fluid is less dense and rises, setting up a convection current
Radiation	Infra-red radiation is absorbed and emitted by objects.

Gravitational Field Strength is given the symbol g and has a value of 10 N/kg on Earth.

Stores and Transfers: Key Facts and equations

Law of Conservation of Energy: Energy cannot be created or destroyed, only transferred from one store to another

$$\text{Kinetic Energy (J)} = \frac{1}{2} \times \text{mass (kg)} \times \text{speed}^2\ (\text{m/s})^2 \qquad KE = \frac{mv^2}{2}$$

$$\text{Change in gravitational potential energy (J)} = \text{mass (kg)} \times \text{gravitational field strength (N/kg)} \times \text{change in height (m)} \qquad \Delta GPE = mg\Delta h$$

Energy Efficiency: Key Facts and Equations

Efficiency tells us how much energy is transferred to a useful store.
It is a number between 0 and 1.

$$\text{Efficiency} = \frac{\text{Useful Energy Transferred (J)}}{\text{Total Energy Input (J)}}$$

Energy that is not usefully transferred is wasted.

Energy is often lost to the surroundings by heating. The energy is spread out (dissipated) and is wasted.

In mechanical (moving) systems this energy loss is minimised by using lubrication to minimise friction.

In systems where thermal energy is useful insulation is used to slow down energy transfer to the surroundings

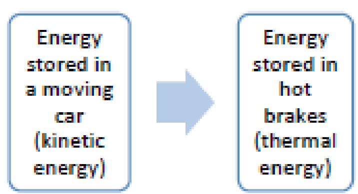
GCSEPod: Efficiency

Things to do

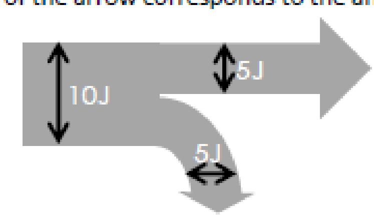
Can you come up with a mnemonic to help you remember the Energy Stores? What about the Energy Transfers?

You need to remember all three equations on this page for your exams. Take some time to memorise them now!

Flow Diagrams show Energy Transfers

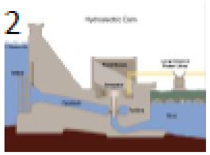


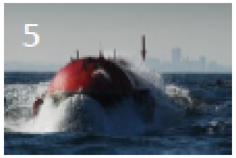
Sankey diagrams show how much energy is transferred
The width of the arrow corresponds to the amount of energy

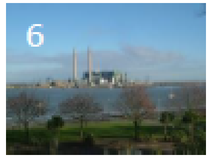


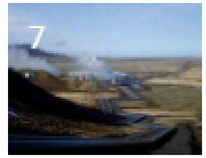
ST IVO ACADEMY
Astrea Academy Trust

PHYSICS: Conservation of Energy









GCSEPod: Energy Resources

Renewable Energy Resources – Won't run out, usually better for the environment	
1. Solar Power	Converts sunlight into electricity e.g. solar panels. Only useful in daylight
2. Hydroelectricity	Uses falling water to turn turbines. Water can be pumped uphill to store energy for later. Dams flood land that could be used for farming.
3. Wind Turbines	Use wind to generate electricity. Only useful when its windy. Unsightly.
4. Tidal Power	Uses flow of water from tides to turn turbines. Only available at certain, but predictable, times. May affect wildlife.
5. Wave Power	Uses motion of waves to generate electricity.
6. Biofuels	Crops grown and burnt to produce electricity. Takes up land that could be used for food production.
7. Geothermal	Uses hot rocks underground to heat water. Only available in some places.

Non-renewable Energy Resource – Finite resource that will run out one day	
Fossil Fuels Gas Oil Coal	Contribute to Global Warming as they release Carbon Dioxide.
Nuclear Fuels	Don't contribute to Climate Change. Produce nuclear waste which is difficult to dispose of.

Check Your Understanding

Describe the energy transfers for a petrol driven lawnmower, starting with the energy stored in the fuel and finishing with where the energy ends up.

Draw a sankey diagram for a television. For every 100J of energy transferred in to the TV 60J are wasted as thermal energy, 10J are transferred as (useful) sound energy. How is the rest of the energy transferred, and how much?

What is the efficiency of the TV in the question above?

Why does oiling the chain of your bike make it more efficient?

Some central heating systems have hot-water tanks to store hot water. How are these made more efficient?

What is the law of conservation of energy?

If I lift a 3kg mass from the floor to my shoulder (1.8m) how much gravitational potential energy does it gain?

Assuming I'm 100% efficient how much energy did I use to lift the mass?

If I throw a 500g ball at 1.5 m/s how much Kinetic Energy does it have? Remember to convert the mass into kg.

A 90kg person climbs up a 10m diving board. Calculate how much gravitational potential energy they have.

If the person jumps off the diving board state how much kinetic energy they have just before they hit the water. (Remember the law of conservation of energy)

Use this number to work out how fast they are travelling as they hit the water.

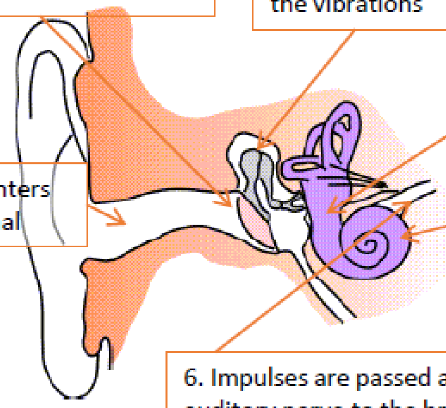
Do the same calculations for a 120kg person climbing the same diving board. What do you notice?

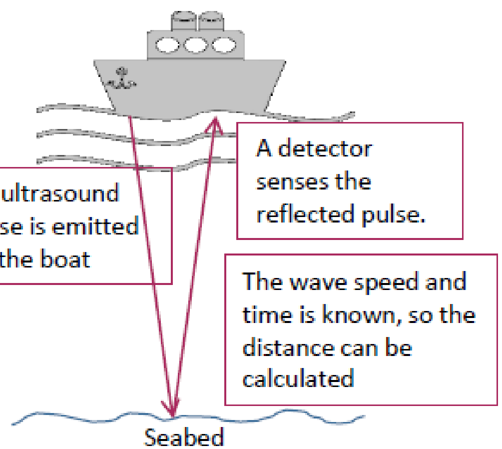
6 Mark Question
There are several large-scale energy resources which are suitable alternatives to fossil fuels in some situations.
Two of these alternatives are hydro-electric power and solar power.
Compare hydro-electric power with solar power as energy resources for the large-scale generation of electricity.

PHYSICS: Waves and the EM Spectrum
Triple Content

ST IVO ACADEMY
Astrea Academy Trust

Keywords	
Absorb	When a wave disappears as the energy it is carrying transfers to the medium through which it is travelling
Reflection	When a wave bounces off a surface instead of passing through it or being absorbed
Refraction	The change in direction when waves go from one medium to another
Transmit	When a wave passes through a material and is not absorbed or reflected
Ultrasound	Sound waves with a frequency above 20 000 Hz, too high for the human ear to detect
Infrasound	Sound waves with a frequency below 20 Hz, too low for the human ear to detect
Total Internal Reflection	The reflection of a ray of light inside a medium when it reaches an interface. TIR only happens when the angle of incidence inside the material is greater than the critical angle
Critical Angle	The angle of incidence above which total internal reflection occurs
Real Image	An image through which light rays pass, so that it can be seen on a screen
Virtual Image	An image that light rays do not pass through, they only appear to come from the image
P Wave	Longitudinal seismic waves that travel through the Earth
S Wave	Transverse seismic waves that travel through the Earth





Remember the total distance travelled by the wave is 2x the distance from the boat to the seabed.

Example Calculation

Sound travels at 1500 m/s in seawater. If the pulse takes 0.04 seconds to return to the boat how deep is the water?

Distance travelled = speed x time

Distance travelled = 1500 x 0.04

= 60 metres

Depth of water = ½ Distance travelled

= ½ x 60

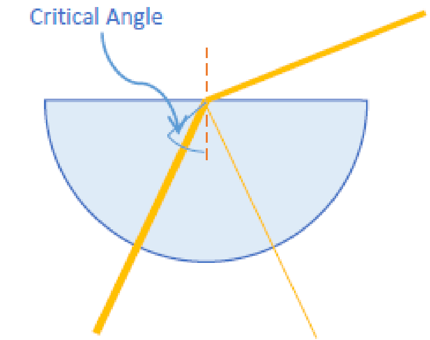
= 30m

PHYSICS: Waves and EM Spectrum
Triple Content

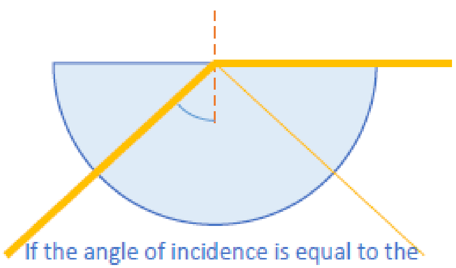
ST IVO ACADEMY
Astrea Academy Trust

Total Internal Reflection Experiment

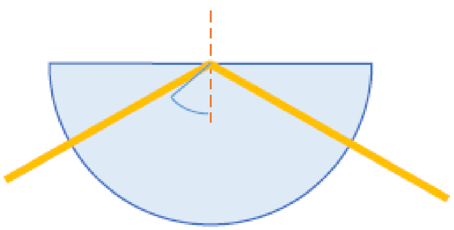
We use a semi-circular glass block so the light enters the block along the normal and isn't refracted.



If the angle of incidence is less than the critical angle then most of the light is refracted.



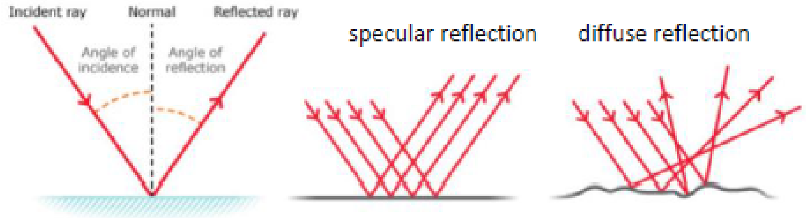
If the angle of incidence is equal to the critical angle then most of the light is refracted along the interface.



If the angle of incidence is greater than the critical angle then all the light is reflected: Total Internal Reflection

Law of Reflection:

angle of incidence = angle of reflection



Very smooth surfaces reflect light evenly, this is specular reflection. Most surfaces are rough and scatter light in all directions, this is diffuse reflection.

Light and Colour

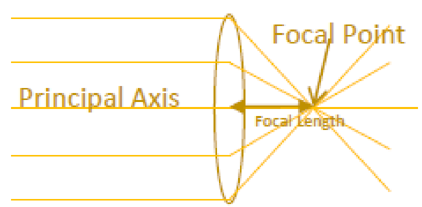
See Year 7 Knowledge Organiser on Waves

Coloured filters absorb all but the colour they transmit. So a green filter transmits green light and absorbs the rest.

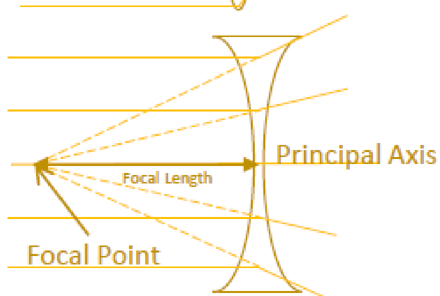
Coloured objects absorb all but the colour they reflect. So a yellow object reflects only yellow light and absorbs the rest.

White objects reflect all the colours of light that fall on them. Black objects absorb all the colours of light that fall on them.

Thicker lenses have shorter focal lengths. They are said to have a higher power.



Converging Lens:
If object is outside 2x focal length image is real, upside down and smaller.
If object is inside focal length image is virtual, right way up and enlarged.



Diverging Lens:
Produces virtual image, smaller, right way up and closer to lens than object.

Check Your Understanding

- Describe in bullet points how a human is able to hear a drum. You should describe how the wave is transmitted and detected.
- A bat emits a sound wave, travelling at 340 m/s. The wave is reflected from a wall and returns 50 milliseconds later. How far away is the wall?
- Draw a diagram to show how a blue filter absorbs and transmits light.
- What will happen if this light is now passed through a red filter?
- Draw a diagram to show how a purple object absorbs and transmits light. Assume purple light is made up of blue and red light waves.
- Draw a ray diagram to scale for an object 5cm away from a converging lens with focal length 1.5cm.
- Write out the law of reflection.

Exam Question
Explain the meaning of the term **critical angle.** You may use a diagram to help your answer.

As the temperature of an object increases more energy is emitted at higher frequencies.
To keep an object at a constant temperature the energy emitted must equal the energy absorbed.

KS4: Physics: Radioactivity

Keyword	Definition
Alpha particle	A particle made of two protons and two neutrons, emitted as ionising radiation from some radioactive isotopes.
Beta particle	A high speed electron, emitted as ionising radiation from some radioactive isotopes.
Gamma ray	A high energy photon, emitted as ionising radiation from some radioactive isotopes.
Nucleon	A particle found in the nucleus (neutron or proton).
Mass number	The number of protons and neutrons in the nucleus of an atom.
Nucleon number	Number of nucleons in the nucleus, another term for mass number.
Atomic number	The number of protons in the nucleus of an atom. Also known as the proton number.
Ion	An atom or group of atoms with an electrical charge due to the gain or loss of electrons
Ionising radiation	Radiation that can cause charged particles (ions) to be formed. It can cause tissue damage and DNA mutations.
Emission spectrum	A set of wavelengths of light or other electromagnetic
Absorption spectrum	A spectrum of light (or other EM radiation) that includes black lines. Caused by some wavelengths being absorbed by the material that the light (or radiation) passes through.
Cosmic rays	Charged particles with a high energy that come from stars, neutron stars, black holes and supernovae.
Geiger-Muller (GM) tube	A device that can detect ionising radiation and is used to measure the activity of a radioactive source.
Decay (radioactive)	When an unstable nucleus changes by giving out ionising radiation to become more stable.
Positron	The anti-particle of an electron, having the same mass but opposite charge. Positron emission is a form of beta decay.
Half-life	The average time taken for half of the radioactive nuclei in a sample of radioactive material to decay.

Radiation	**Range (cm)**	**Ionising power**	**Stopped by**	**Electrical field deflection**
Alpha	3-5	Highly ionising	Paper	Deflected towards negative plate
Beta	about 15	Ionising	Aluminium	Deflected towards positive plate
Gamma	much longer	Weakly ionising	Lead or Concrete, though some gets through	None

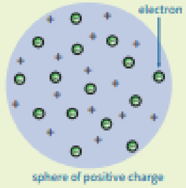
ST IVO ACADEMY
Astrea Academy Trust

Dalton's model

John Dalton thought the atom was a neutral solid sphere you cannot divide into smaller parts.

Plum pudding model

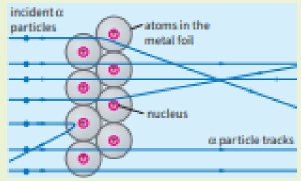
The discovery of negatively charged electrons led to the plum pudding model – a cloud of positive charge with electrons embedded in it.



Alpha scattering experiment

Positively charged alpha particles were fired at a thin sheet of gold foil.

- Most went straight through
- Some were deflected by small amounts
- 1 in 10 0000 deflected through large angles



Nuclear model

To explain the results, scientists deduced that there is a small positively charged nucleus at the centre of the atom where most of the mass is concentrated. The negative electrons orbit the nucleus.

Bohr's model

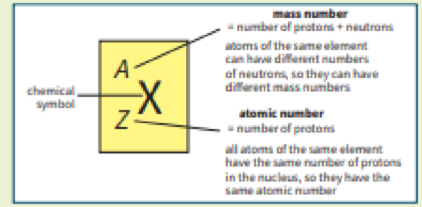
Bohr suggested the electrons orbit at specific distances called energy levels.

Basic structure of an atom

The nucleus, which is 10 000 times smaller than the radius of the atom, consists of two particles:

- positively charged protons
- neutrons which are neutral

An atom is uncharged overall and has equal numbers of protons and electrons.



Isotopes are atoms of the same element, with the same number of protons but a different numbers of neutrons.

Radioactive decay

Radioactive decay is when nuclear radiation is emitted by unstable atomic nuclei so that they become more stable. It is a *random* process. This radiation can knock electrons out of atoms in a process called **ionisation**.

Type of radiation	Change in the nucleus	Ionising power	Range in air	Stopped by	Decay equation
α alpha particle (two protons and two neutrons)	nucleus loses two protons and two neutrons	highest ionising power	travels a few centimetres in air	stopped by a sheet of paper	$^{A}_{Z}\text{X} \rightarrow ^{(A-4)}_{(Z-2)}\text{Y} + ^{4}_{2}\alpha$
β beta particle (fast-moving electron)	a neutron changes into a proton and an electron	high ionising power	travels ≈ 1 m in air	stopped by a few millimeters of aluminium	$^{A}_{Z}\text{X} \rightarrow ^{A}_{(Z+1)}\text{Y} + ^{0}_{-1}\beta$
γ gamma radiation (short-wavelength, high-frequency EM radiation)	some energy is transferred away from the nucleus	low ionising power	virtually unlimited range in air	stopped by several centimetres of thick lead or metres of concrete	$^{A}_{Z}\text{X} \rightarrow ^{A}_{Z}\text{X} + ^{0}_{0}\gamma$

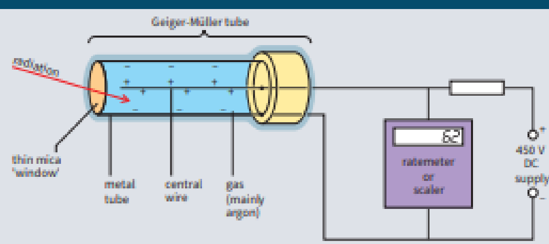
Activity and count rate

The **activity** of a radioactive source is the rate of decay of an unstable nucleus, measured in becquerel (Bq).

1 Bq = 1 *decay per second*

Detectors (e.g., **Geiger-Müller tubes**) record a **count rate** (number of decays detected per second).

$$\text{count rate after } n \text{ half-lives} = \frac{\text{initial count rate}}{2^n}$$



Half-life

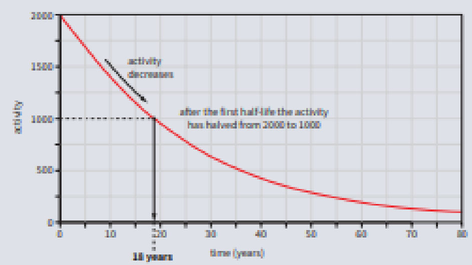
The **half-life** of a radioactive source is the time

- for half the number of unstable nuclei in a sample to decay
- for the count rate or activity of a source to halve.

The half-life of a source can be found from a graph of its count rate or activity against time.

To find the reduction in activity after a given number of half-lives:

1. calculate the activity after each half-life
2. subtract the final activity from the original activity.



The time taken for the activity to halve is 18 years. This is the half-life of this substance.

(**HT only**) **Net decline** can be given as a ratio: $\textit{net decline} = \frac{\text{reduction in activity}}{\text{original activity}}$

ST IVO ACADEMY
Astrea Academy Trust
INSPIRING BEYOND MEASURE

KS4: Physics: Radioactivity

Ionising radiation

Living cells can be damaged or killed by ionising radiation.

The risk depends on the half-life of the source and the type of radiation.

Alpha radiation is very dangerous inside the body because it affects all the surrounding tissue. Outside the body it only affects the skin and eyes because it cannot penetrate further.

Beta and gamma radiation are dangerous outside and inside the body because they can penetrate into tissues.

Radiation dose

Radiation dose, measured in sievert (Sv), measures the health risk of exposure to radiation. It depends on the type and amount of radiation.

Background radiation

Background radiation is radiation that is around us all the time. It comes from:

- natural sources like rocks and cosmic rays
- nuclear weapons and nuclear accidents.

Background radiation is always present but the levels are higher in some locations and in some jobs.

Nuclear waste

When fuel rods are removed from the reactor, they are stored in large tanks in water for up to a year until they cool down.

Machines are then used to open up fuel rods and extract the unused plutonium and uranium. Any material that is left then has to be stored securely as they have lots of radioactive isotopes with long half-lives. This is done to prevent radioactive contamination.

Irradiation versus contamination

irradiation	when an object is exposed to nuclear radiation	cause harm through ionisation	prevented by shielding, removing, or moving away from the source of radiation
contamination	when atoms of a radioactive material are on or in an object		object remains exposed to radiation as long as it is contaminated contamination can be very difficult to remove

Nuclear radiation in medicine

Exploration of internal organs

Gamma-emitting **tracers** are injected or swallowed by a patient. Gamma cameras can then create an image showing where the tracer has gone.

The half-life of the tracer must be short enough so that most of the nuclei will decay shortly after the image is taken to limit the patient's radiation dose (normally about six hours).

Control or destruction of unwanted tissue

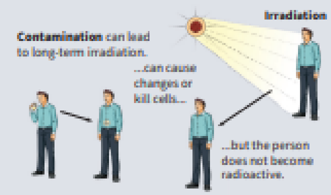
1. Narrow beams of gamma radiation can be focused on tumour cells to destroy them. Gamma is used because it can penetrate tumours from outside the body.
2. Beta- or gamma-emitting implants can be surgically placed inside (or next to) tumours. Their half-lives must be long enough to be effective, but short enough that it does not continue to irradiate the patient after treatment.

Protection against irradiation and contamination

You can protect against irradiation and contamination by:

- maintaining a distance from the radiation source
- limiting time near the source
- shielding from the radiation.

Studies on the effects of radiation should be published, shared with other scientists, and checked by **peer review** as they are important for human health.



Nuclear fission

Nuclear fission is when a large unstable nucleus absorbs an extra neutron and splits into two smaller nuclei of roughly equal size.

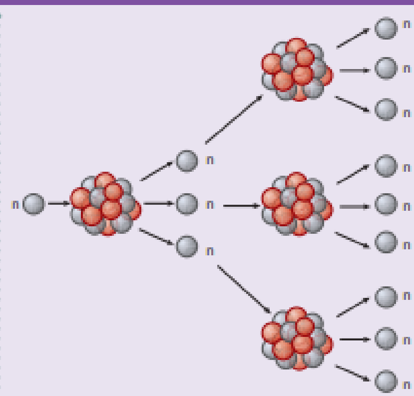
During nuclear fission:

- gamma radiation is emitted and energy is released
- two or three neutrons are emitted that can go on to cause a **chain reaction**.

The chain reaction in a power station reactor is controlled by absorbing neutrons.

Nuclear explosions are uncontrolled chain reactions.

On rare occasions an unstable nucleus splits apart without absorbing a neutron. This is called **spontaneous fission**.



Nuclear fusion

Nuclear fusion is when two light nuclei join to make a heavier one.

Some of the mass is converted to energy and transferred as radiation.

Nuclear fusion in the sun's core releases energy. A fusion reactor has to be at a very high temperature so the nuclei can overcome their repulsion.

Nuclear fusion in the future

Future fusion reactors could meet energy needs for a growing population. This is because:

- The fuel for fusion reactors is easily available as heavy hydrogen is naturally present in sea water.
- The product, helium, is an unreactive gas and non-radioactive so is harmless.
- The energy released could be used to generate electricity in the future.

Key terms

Make sure you can write a definition for these key terms.

atom alpha activity atomic number background radiation beta chain reaction contamination count rate electron fission fusion gamma Geiger-Müller tube half-life ionisation irradiation isotope mass number net decline neutron plum pudding model proton peer review radiation dose radioactive decay spontaneous tracer

ST IVO ACADEMY
Astrea Academy Trust

PHYSICS: Forces doing work and Forces and their Effects

Keywords	
Energy	Something that is needed to make things happen or change
Power	The amount of energy transferred per second. Units Watts (W)
Watts (W)	Unit of power. 1 Watt = 1 Joule per second
Work done	Energy transferred when a force acts through a distance
Action-reaction forces	Pairs of forces on interacting objects.
Force field	The space around something where a non-contact force affects things (e.g. a magnetic field or gravitational field)
Normal contact force	The force that acts at right angles to a surface as a reaction to a force on that surface
Non-contact force	A force between two objects that are not touching. Gravity, magnetism and electrostatic forces are all examples of non-contact forces.

Equations (You need to learn and be able to use these)

$$\textit{work done}\ (\text{J}) = \textit{force}\ (\text{N}) \times \textit{distance moved in direction of force}\ (\text{m})$$

$$E = Fd$$

$$\textit{power}\ (W) = \frac{\textit{work done (J)}}{\textit{time taken (s)}} \qquad P = \frac{E}{t}$$

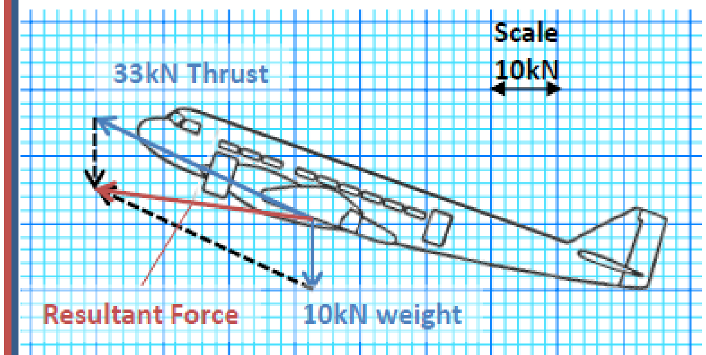
Check Your Understanding

6 mark question: Al walks directly up a hill and he takes 12 minutes to get to the top. Bev walks up the same hill on a shallower path that zig zags as it goes up. She takes 15 minutes to get to the top. Explain who has exerted the greater power, and who has transferred more energy while getting to the top of the hill. Include any assumptions you make in your answer.

ST IVO ACADEMY

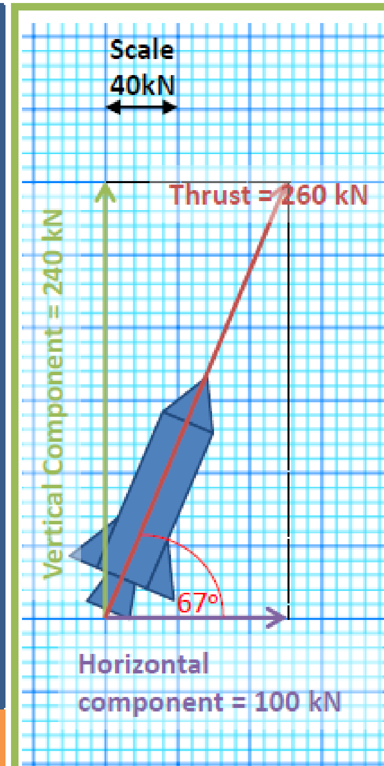
Astrea Academy Trust

H Higher Only



Drawing a scale diagram to find resultant force.

1) Draw arrows to represent the forces. The arrows should be at the correct angles and the length should represent the size of the force on the scale.
2) Draw lines to make a parallelogram.
3) Join the diagonal to show the resultant force. Measure this line and use the scale to work out the size of the resultant force.

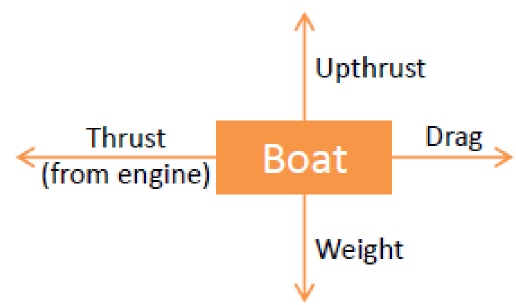


Drawing a scale diagram to resolve forces into components.

1) Draw force arrow to scale at the correct angle
2) Draw a rectangle with the sides in the directions you are interested in
3) The resolved forces are the sides of the rectangle (e.g. vertical and horizontal)

Free body force diagrams show all the forces acting on an object.

All the forces shown need to be acting on the same object.

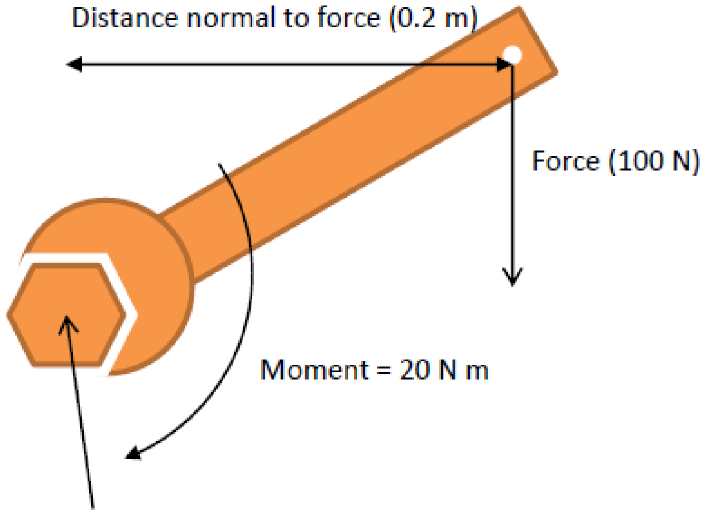


PHYSICS: Forces doing work and Forces and their Effects TRIPLE CONTENT

ST IVO ACADEMY
Astrea Academy Trust

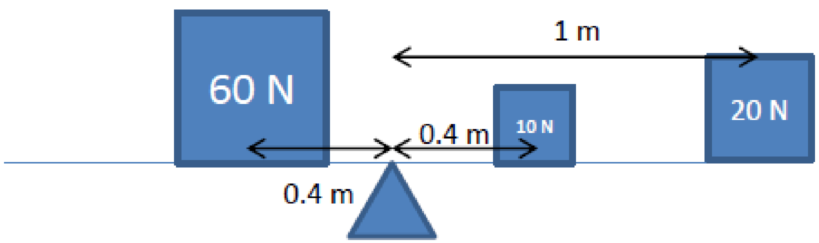
Rotational Forces

Moment of a force = force x distance normal (perpendicular) to the direction of the force
(N m) = (N) x (m)



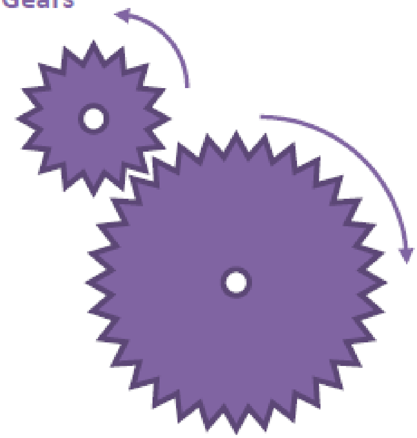
Law of moments:

When a system is in equilibrium the sum of the clockwise moments is equal to the sum of the anticlockwise moments



Clockwise moments: (20 x 1) + (10 x 0.4) = 24 N m
Anticlockwise moment: 60 x 0.4 = 24 N m

Gears



The smaller gear has half the number of teeth of the larger gear and so must have half the diameter.

For every complete turn of the smaller gear, the larger gear will complete half a rotation.

If the small gear turns anti-clockwise the large gear will turn in the opposite direction (clockwise).

For any two gears the ratio of the diameters, or the ratio of the number of teeth, will tell you how many times the smaller gear will turn for each complete turn of the larger (or vice versa)

Example: If gear A has 48 teeth and gear B has 16 teeth then gear B will turn 48/16 = 3 times for every complete turn of gear A.

Check Your Understanding

A man applies a force of 200 N on a spanner at a perpendicular distance of 0.7 m from the bolt. What is the size of the moment?

Some sacks are hanging from a point 0.1 m from a pivot. They are balanced by a weight of 200 N hanging 1 metre from the pivot and a weight of 10 N hanging 1.3 m from the pivot. Calculate the weight of the sacks.

A rock of weight 6 000 N is placed on a lever 0.3 m from the pivot. What force will someone need to apply on the other end of the lever, 2 m from the pivot, in order to lift the rock?

How could the person in the question above adjust the system so that they need to apply less force to move the rock?

Why is it easier to undo a stiff bolt with a longer spanner?

Gear X has 40 teeth and is connected to gear Y which has 10 teeth. How many times will gear Y turn if gear X completes 4 rotations?

If gear X is turned clockwise which way will gear Y turn?

Gear Z, with 20 teeth, is connected to gear Y. How many turns will it complete if gear X completes one turn?

Charge

An atom has no **charge** because it has equal numbers of positive protons and negative electrons.

When electrons are removed from an atom it becomes *positively* charged. When electrons are added to an atom it becomes *negatively* charged.

Static charge

Insulating materials can become charged when they are rubbed with another insulating material. This is because electrons are transferred from one material to the other. Materials that gain electrons become negatively charged and those that lose electrons become positively charged.

Positive charges do not usually transfer between materials.

Electric charge is measured in coulombs C.

Sparks

If two objects have a very strong electric field between them, electrons in the air molecules will be strongly attracted towards the positively charged object. If the electric field is strong enough, electrons will be pulled away from the air molecules and cause a flow of electrons between the two objects – this is a **spark**.

Drawing electric fields

A charged object creates an **electric field** around itself.

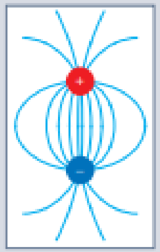
If a charged object is placed in the electric field of another charged object it experiences **electrostatic force**. This means that the two charged objects exert a non-contact force on each other:

- like charges repel each other
- opposing charges attract each other.

The electric field, and the force between two charged objects, gets stronger as the distance between the objects decreases.

Drawing electric fields

Electric fields can be represented using a diagram with field lines. These show the direction of the force that a small positive charge would experience when placed in the electric field.



When drawing electric fields, make sure:

- field lines meet the surface of charged objects at 90°
- arrows always point away from positive charges and towards negative charges.

Resistance

When electrons move through a circuit, they collide with the ions and atoms of the wires and components in the circuit. This causes **resistance** to the flow of charge.

The unit of resistance is the ohm (Ω).

A long wire has more resistance than a short wire because electrons collide with more ions as they pass through a longer wire.

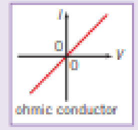
The resistance of an electrical component can be found by measuring the current and potential difference:

potential difference (V) = current (A) × resistance (Ω)

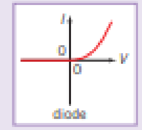
$V = IR$

Current-potential difference graphs

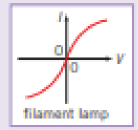
A graph of current through a component against the p.d. across it (I–V graph), is known as the component characteristic.



Current is directly proportional to the p.d. in an ohmic conductor at a constant temperature. The resistance is constant.



The current through a diode only flows in one direction – called the forward direction. There needs to be a minimum voltage before any current will flow.

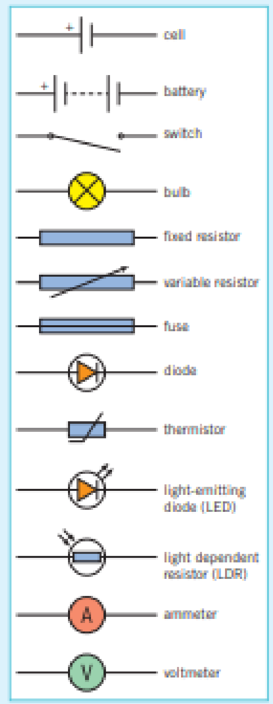


As more current flows through the filament, its temperature increases. The atoms in the wire vibrate more, and collide more often with electrons flowing through it, so resistance increases as temperature increases. The resistance of a thermistor decreases and temperature increases. The resistance of a light dependent resistor (LDR) decreases as light intensity increases.

The resistance of an ohmic conductor can be found by calculating the gradient at that point and taking the inverse:

$$\text{resistance} = \frac{1}{\text{gradient}}$$

Circuit components



Electric current

Electric current is when **charge** flows. The charge in an electric circuit is carried by electrons.

The unit of current is the ampere (amp, A).

1 ampere = 1 coulomb of charge flow per second

Charge (C) = current (A) × time (s)

In circuit diagrams, current flows from the positive terminal of a cell or battery to the negative terminal. This is known as conventional current.

In a single closed loop, the current has the same value at any point in the circuit.

Metals are good conductors of electricity because they contain delocalised electrons, which are free to flow through the structure.

Potential difference

Potential difference (p.d.) is a measure of how much energy is transferred between two points in a circuit. The unit of potential difference is the volt (V).

- The p.d. across a component is the work done on it by each coulomb of charge that passes through it.
- The p.d. across a power supply or battery is the energy transferred to each coulomb of charge that passes through it.

For electrical charge to flow through a circuit there must be a source of potential difference.

Potential difference (V) = energy transferred (J) / charge (C)

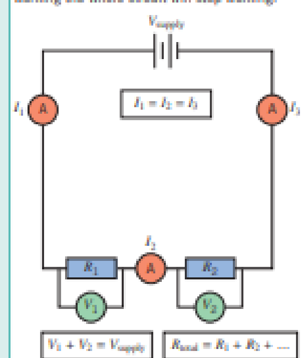
Key terms

Make sure you can write a definition for these key terms.

ampere
charge
coulomb
current
electric field
electrostatic force
LDR
parallel
potential difference
resistance
series
static
thermistor

Series circuits

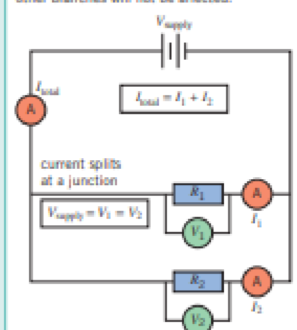
In a series circuit, the components are connected one after the other in a single loop. If one component in a series circuit stops working the whole circuit will stop working.



Components with a higher resistance will transfer a larger share of the total p.d. because $V = IR$ (and current is the same through all components).

Parallel circuits

A parallel circuit is made up of two or more loops through which current can flow. If one branch of a parallel circuit stops working, the other branches will not be affected.



The total resistance of two or more components in parallel is always less than the smallest resistance of any branch. This is because adding a loop to the circuit provides another route for the current to flow, so more current can flow in total even though the p.d. has not changed. Adding more resistors in parallel decreases the total resistance of a circuit.

Mains electricity

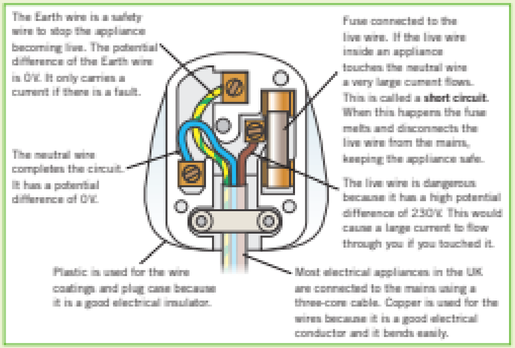
A cell or a battery provides a **direct current (dc)**. The current only flows in one direction and is produced by a **direct potential difference**.

Mains electricity provides an **alternating current (ac)**. The current repeatedly reverses direction and is produced by an **alternating potential difference**.

The positive and negative terminals of an alternating power supply swap over with a regular frequency.

The frequency of the mains electricity supply in the UK is 50 Hz and its voltage is 230 V.

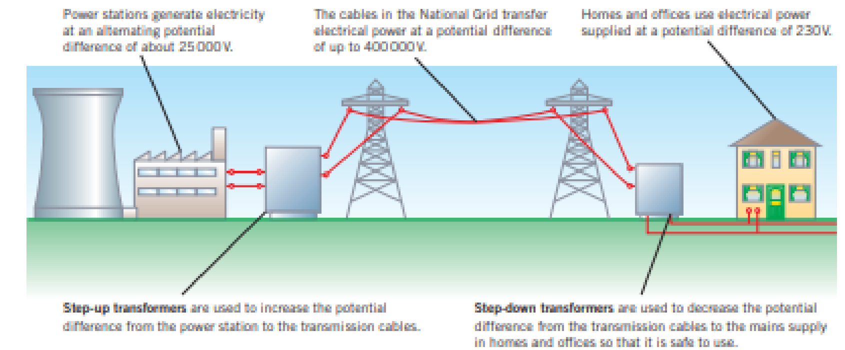
Plugs



The National Grid

The **National Grid** is a nationwide network of cables and transformers that link power stations to homes, offices, and other consumers of mains electricity.

Transformers are devices that can change the potential difference of an alternating current.



By making the grid potential difference much higher, a smaller current is needed to transfer the same power. Therefore, the National Grid is an efficient way to transfer power due to less heating loss in the wire.

Why do transformers improve efficiency?

A high potential difference across the transmission cables means that a lower current is needed to transfer the same amount of power, since:

power (W) = current (A) × potential difference (V)

$$P = IV$$

A lower current in the cables means less electrical power is wasted due to heating of the cables, since the power lost in heating a cable is:

power (W) = current² (A) × resistance (Ω)

$$P = I^2R$$

This makes the National Grid an efficient way to transfer energy.

If 100% efficiency is assumed:

primary potential difference × primary current = secondary potential difference × secondary current

$$V_p I_p = V_s I_s$$

Energy transfer in electrical appliances

Electrical appliances transfer energy.

For example, an hairdryer transfers energy electrically from a chemical store (e.g., the fuel in a power station) to the kinetic energy store of the fan inside the hairdryer and to the thermal energy store of the heating filaments inside the hairdryer.

When you turn an electrical appliance on, the potential difference of the mains supply causes charge (carried by electrons) to flow through it.

You can calculate the **charge flow** using the equation:

charge flow (C) = current (A) × time (s)

$$Q = It$$

You can find the energy transferred to an electrical appliance when charge flows through it using:

energy transferred (J) = charge flow (C) × potential difference (V)

$$E = QV$$

You can find the energy transferred by an electrical appliance using the equation:

energy transferred (J) = power (W) × time (s)

Key terms

Make sure you can write a definition for these key terms.

alternating current, alternating potential difference, charge flow, coulombs, direct current, direct potential difference, fuse, National Grid, short circuit, step-down transformer, step-up transformer

GCSE: Autumn Term

Physics: Astronomy

ST IVO ACADEMY

Astrea Academy Trust

INSPIRING BEYOND MEASURE

The Solar System

- Everything that orbits the Sun including:
- Planets – large objects that orbit a star – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Neptune, Uranus
- Dwarf planets – too small to be considered a planet – eg Pluto
- Moons – natural satellites that orbit a planet
- Artificial satellites – human made that orbit other objects
- Asteroids – consist of metal and rock that orbit the Sun
- Comets – consist of ice and dust that orbit the Sun – orbits are typically highly elliptical

Theories of Solar System structure

- The model of the Solar System has changed over time as new evidence has been collected.

1. **Geocentric model:** Earth is at the centre of the Solar System. Developed as the Sun, Moon and planets are observed to move across the sky in a repeated fashion. No telescopes existed to give more information. Accepted from ancient Greeks to 1500's
2. **Heliocentric model**: the Sun is at the centre of the Solar System. Adopted as more evidence gathered through development of the telescope. Galileo observed moons orbiting Jupiter proving not everything orbited Earth.

Gravity

- The force from gravity between objects results in orbits
- An object in a circular orbit at constant speed is constantly accelerating
- Centripetal force acts towards the centre of the orbit
- The force of gravity depends on the mass of the body creating it (the higher the mass the stronger the gravitational force) AND the distance to the object (the closer you are the stronger the force).
- The closer to an object you are the faster you need to travel in order to stay in orbit around it

Theories of the creation of the Universe

- The universe is expanding. This observation lead to development of models to explain its creation.

1. **Steady state:** The universe has always existed as it is currently observed and will always remain this way. As it expands new matter is being constantly created. This results in the density of the Universe remaining constant. There no beginning or end to the Universe.
2. **The Big Bang:** At the start of the Universe all matter occupied a single point. This point was extremely dense and hot. It then 'exploded' – space expanded and is still doing so. Finite age to Universe of ~13.8 billion years.

- Big bang current accepted model for creation of Universe based on current evidence.

Red-shift

- Gives evidence of galaxies moving away from each other and expansion of the Universe. Can be explained using State state or Big Bang.
- Different elements absorb different fixed frequencies of light - each element has a fingerprint like pattern of absorbed frequencies.
- Light from distant galaxies has these patterns but at slightly lower frequencies than expected (ie the pattern is shifted towards red light).
- Measurements demonstrate all galaxies are moving away from us quickly
- The further the galaxy from us the bigger the red shift therefore more distant galaxies are moving away faster than nearer ones

Cosmic Microwave Background (CMB)

- Low frequency electromagnetic (EM) radiation (mainly in the microwave region of the EM) can be detected from all parts of the Universe
- Can only be explained by big bang model as it shows Universe has a beginning – CMB radiation is leftover energy of initial explosion

Life cycle of stars

1. Star formed from cloud of dust and gas called a nebula
2. Gravity pulls dust and gas together forming a protostar. Density and temperature increases. At high enough temperatures hydrogen nuclei undergo fusion to form helium nuclei. Huge amounts of energy released during fusion keeping core hot.
3. Main sequence star – stable period. Outward pressure from thermal expansion balances inward force from gravity. The larger the star the shorter this stable period lasts.
4. Hydrogen in core runs out. Force from gravity becomes greater then outward pressure from thermal expansion. Star compressed increasing density and temperature. Outer layers then expand becoming a red giant if star is small or a red supergiant if star is large. Surface cools and so becomes red.
5. Small to medium sized star– ejects outer layer of dust and gas – hot dense solid core remains – white dwarf
6. Big star – undergo more fusion – expand and contract several times as balance shifts between thermal expansion and gravitational compression - eventually explode in a supernova
7. Exploding supernova ejects outer layers – very dense core remains – a neutron star. If massive enough this collapses forming a black hole.

Telescopes

- Allow us to see distant objects through diffraction and reflection
- Image quality can be improved by increasing the aperture or quality of the object lens (lens that light enters telescope through)
- Telescopes in space have a clear view than those on Earth
- Earth's atmosphere absorbs many frequencies of EM radiation
- Light pollution on Earth makes it hard to see dim objects in space
- Atmospheric interference minimised by putting telescopes on mountains and dark places

- Different regions of EM spectrum studied to gain as much information about Universe as possible.
- Earliest telescopes used visible light – from 1940s onwards telescopes were developed for all regions of EM spectrum
- X-ray telescopes show high-temperature events like exploding stars
- Radio telescopes discovered CMB
- Modern telescopes are used alongside computers enabling better images to be created, the collection and storage huge amounts of data 24 hours a day without humans and faster analysis of data.

PHYSICS: Magnetism and EM Induction

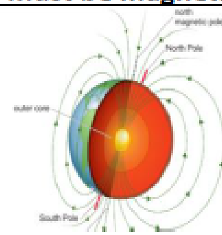
ST IVO ACADEMY
Astrea Academy Trust

Evidence that the that core of the Earth must be magnetic

A compass needle is a magnet.

Compasses always point to the Earth's North Pole (Magnetic North).

The North Pole is a magnetic south pole (because it attracts the north of bar magnet).



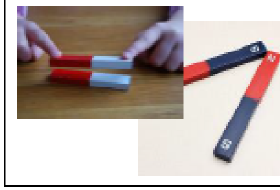
Magnetic materials

- Nickel
- Iron
- Steel
- Cobalt

Uses for magnets

- Loudspeakers
- Compasses
- Generators
- MRI scanners
- Door locks

Unlike poles attract, like poles repel



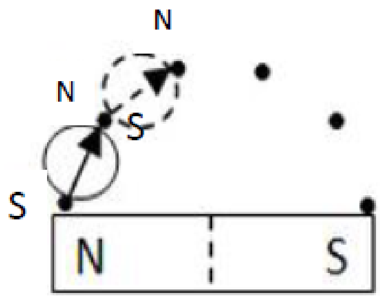
A magnetic field is induced around a wire when the wire is carrying a current

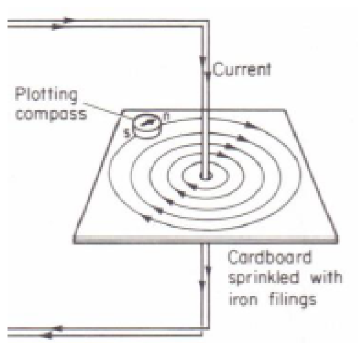
The Right Hand Rule

- The magnetic field is strongest near the wire
- The strength of the field increases if the electric current increases

Induced magnets are only magnets when they are in the field of another magnet

How to find the shape of a magnetic field

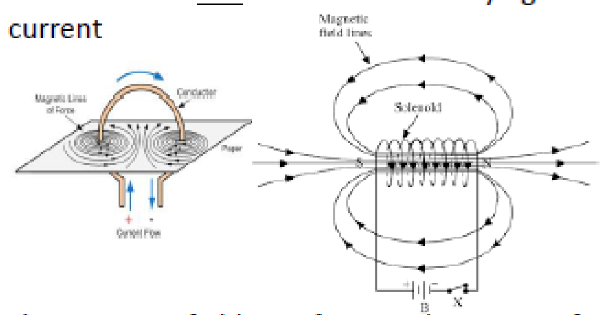




Place a compass at different places around magnet to show the shape and direction of the magnetic field. Iron filings show the field strength but not the direction. **Closer together field lines show a stronger field**

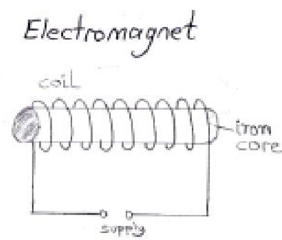
Solenoids

A solenoid is a coil of wire that is carrying a current



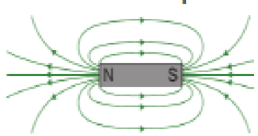
The magnetic fields reinforce in the centre of the solenoid to make the field strongest here. They cancel out on the outside to make the field weaker here. The field is uniform inside the solenoid.

A solenoid is an electromagnet (a magnet you can turn on by switching on the current)



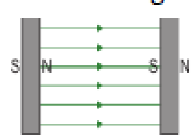
Bar magnet

Different strength and direction in different places



Uniform magnetic field

Same strength and direction throughout



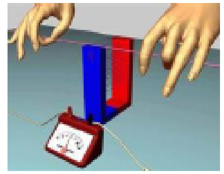
PHYSICS: Magnetism and EM Induction

ST IVO ACADEMY
Astrea Academy Trust

When a wire moves relative to a magnetic field, an electric current is induced in the wire (wow!)

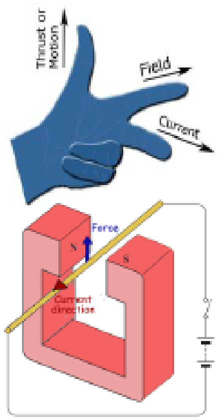
Factors affecting the strength of the current produced

1. Number of turns in the coil of wire
2. How fast the magnet is moving
3. Strength of the magnetic field



The Motor Effect

When the magnetic field from a permanent magnet interacts with a magnetic field from a wire, it pushes it. This force is called the motor effect. An equal and opposite force acts on the magnet.



Fleming's Left Hand Rule links the direction of the magnetic field, the direction of the current and the direction of the force.

First Finger – Field (B)
Second Finger: Current (I)
Thumb: Motion (F)

magnetic fields point north to south
electric currents flow + to -

Magnetism equations	
To be able to use:	
Force = Magnetic Flux Density x Current x Length	F = BIL

Magnetic flux density (B) is a measure of the strength of a magnetic field in an area; it is measured in Tesla (T) or N/Am

Transformers

The National Grid uses transformers to transport electricity with a smaller current and a higher potential difference . This improves efficiency by reducing heat loss in transmission lines.

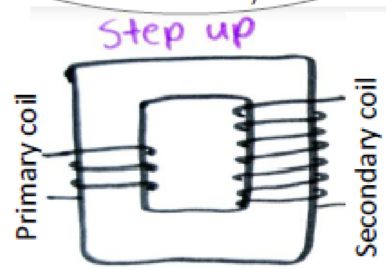
How Transformers work

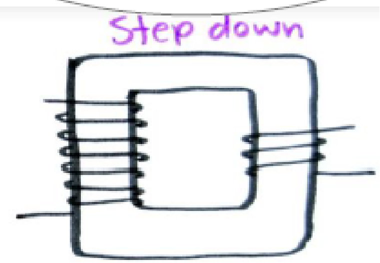
Transformers consist of two coils wire would around an iron core.

1. Alternating current supplied to the primary coil
2. Creates a continuously changing magnetic field
3. The iron core carries the magnetic field to the secondary coil
4. A changing potential difference is induced in the secondary coil
5. The size of the potential difference depends on the number of coils the secondary and primary coils have

Used at power stations (low current means less heat loss due to resistance in wires)

Used near homes (to convert power to a low p.d. which is safer)





Step-up transformers
increase potential difference (and decrease current)

Step-down transformers
decrease potential difference (and increase current)

If a transformer is 100% efficient, the energy per second (power) going in, must be the same as the power coming out

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

primary p.d. (V_p), *primary current* (I_p), *secondary p.d* (V_s), *secondary current* (I_s)

★Energy is always conserved, so the power in the secondary coil must equal the power in the primary coil (P=E/t)

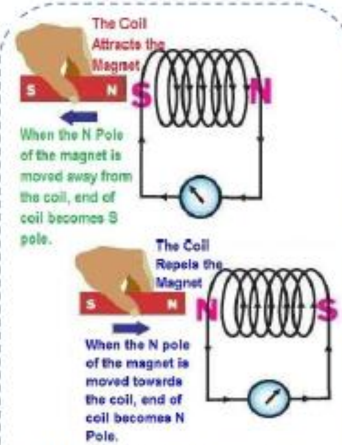
★P=IV, so as potential difference increases, current decreases

PHYSICS: Magnetism and EM Induction

Extra Page for Triple Science Only

ST IVO ACADEMY
Astrea Academy Trust

Using induced currents (motion → current)

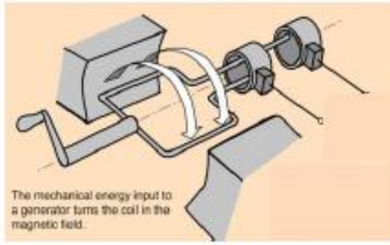


In the lab: currents can be induced by moving a magnet relative to a wire

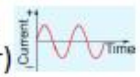
The magnetic field of the current opposes the original change, For example, if a magnet is moved into a coil of wire, the induced magnetic field tends to repel the magnet back out of the coil.

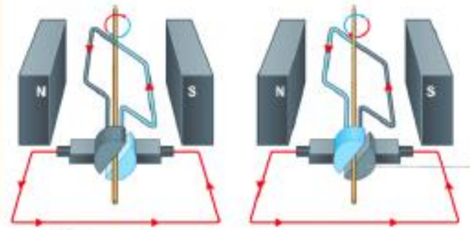
Large scale generation of electricity:

A coil of wire, wound onto an iron core, is rotated in a permanent magnetic field.



AC generator (an alternator)



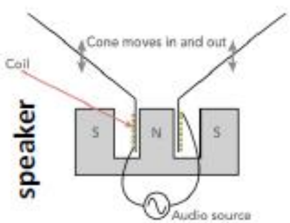


DC generator (a dynamo)

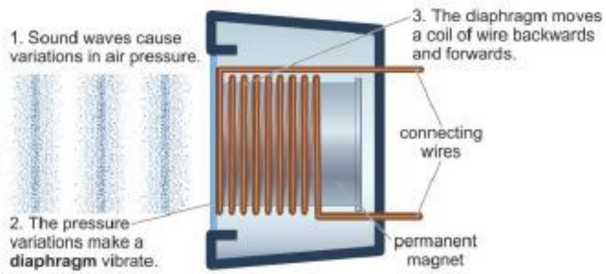
Alternators use two *slip rings* and **dynamos** use one *split ring commutator* to connect to the external circuit. The commutator* swaps the connections every half turn so the current in the external circuit always flows in the same direction.

A microphone converts the pressure variations in sound waves into variations in current in electrical circuits (motion → current). The reverse effect is used in loudspeakers and headphones (current → motion).

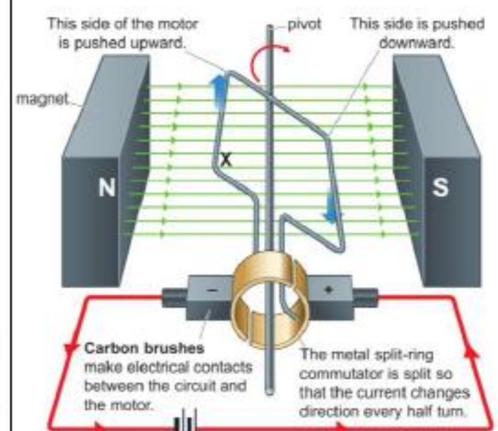
speaker



microphone



Motors (current → motion)



The force on a conductor in a magnetic field is used to cause rotation in **electric motors**.
Real motors contain many coils of wire

Magnetism equations

To be able to use:

Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns

$$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}} \qquad \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

KS4: Autumn Term
SCIENCE: Particle Model

ST IVO ACADEMY
Astrea Academy Trust

Keyword	Definition
change of state	The changing of matter from one state to another, for example from solid to liquid.
state of matter	One of three different forms that a substance can have: solid, liquid or gas.
physical change	A change in which no new substances are formed, such as changes of state.
chemical change	A change that results in the formation of new substances.
density	The mass of a substance per unit volume. It has units such as kg/m^3 or g/cm^3.
kinetic energy	A term used to describe energy when it is stored in moving things.
sublimation	When a solid changes directly to a gas without becoming a liquid first.
specific heat capacity	The energy needed to raise the temperature of 1 kg of a substance by 1 °C.
specific latent heat	The energy taken in or released when 1 kg of a substance changes state.
temperature	A measure of how hot or cold something is.
thermal energy	A term used to describe energy when it is stored in hot objects. The hotter something is, the more thermal energy it is storing. It is sometimes called heat energy.
absolute zero	The temperature at which the pressure of a gas drops to zero and the particles stop moving. It is −273 °C or 0 K.
kelvin (K)	The unit in the Kelvin temperature scale. One kelvin (1 K) is the same temperature interval as 1 °C.
Kelvin temperature scale	A temperature scale that measures temperatures relative to absolute zero.

Density is a measure of how much space (volume) a particular number of particles (mass) occupies.

Practical: To find density of a substance; mass and volume must be measured.

Apparatus: Measuring cyliner, Displacement (Eureka) can, balance

Finding the mass of the substance

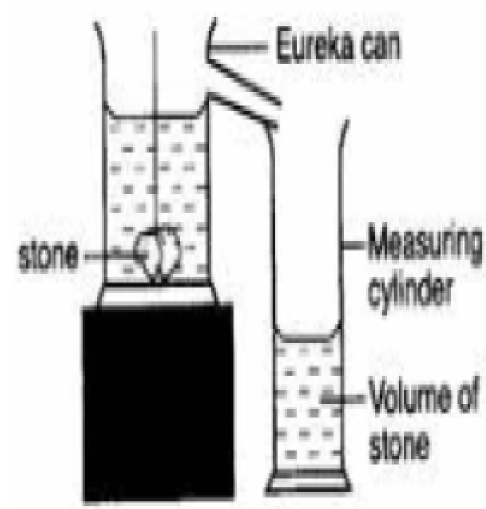
Use a balance (remember the unit (g)

Finding the volume

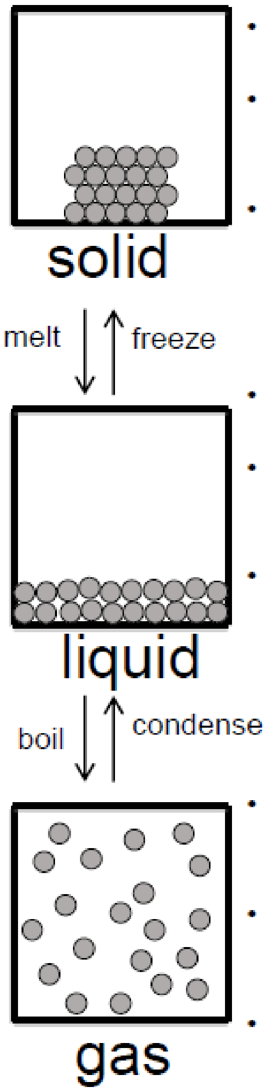
- Liquids: use a measuring cylinder (unit =cm^3)
- Regular solids (e.g. a cube): use a ruler and geometry
- Irregular solids (e.g. a stone), find the volume of water that is displaced when the object is submerged in water using a displacement can.
- Calculate the density (mass ÷ volume).

To memorise:

Density = mass ÷ volume
(kg/m^3) (kg) (m^3)
Or
(g/cm^3) (g) (cm^3)



Core Practical: Investigating water part 1



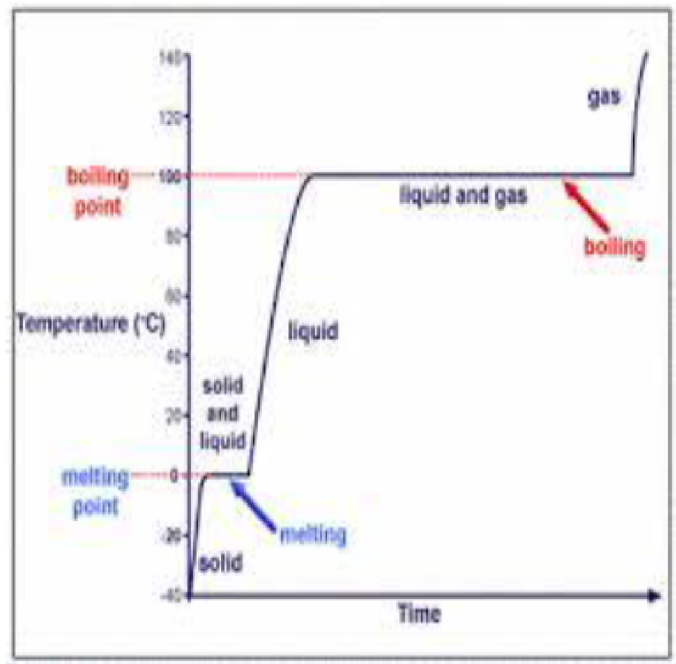
Solid
- Particles vibrating on the spot.
- Fixed shaped because the particles are arranged in a pattern
- Incompressible because the particles are all touching one another

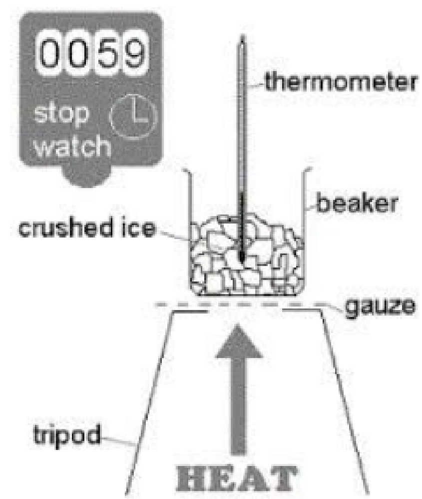
Liquid
- Particles can move past each other
- Liquids can flow because the particles are free to move past one another
- Incompressible because the particles are all touching one another

Gas
- Particles collide with each others and with the walls of their container
- Gases can flow because the particles are free to move past one another
- Compressible because the particles are not touching one another

Method:

1. Fill a beaker with crushed ice.
2. Place a thermometer into the beaker and record the temperature of the ice.
3. Using a Bunsen burner, gradually heat the beaker (1/2 air hole open and half a turn of gas tap).
4. Every 20s record the temperature and the current condition of the ice (e.g. partly melted, completed melted)
5. Continue this process until the ice melts into water and this water begins to boil.
6. Plot a graph temperature against time.





Core Practical: Investigating water part 2- Specific heat capacity of water

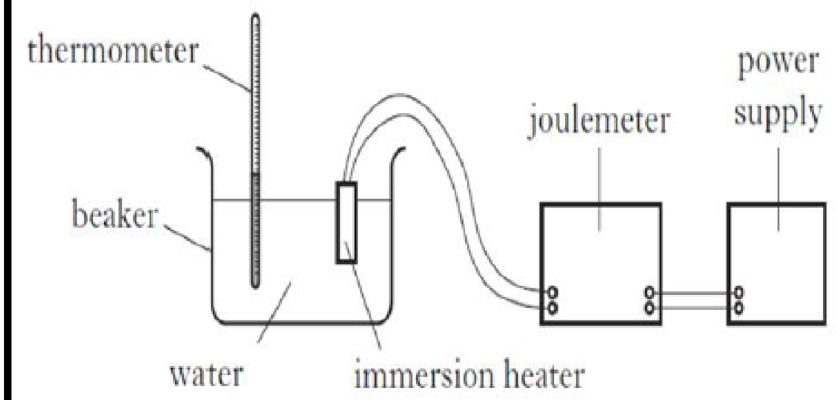
Aim: To find the specific heat capacity of water.

Method

1. Put a polystyrene cup in a beaker onto a balance, and zero the balance.
2. Then fill the cup **almost** to the top with water and write down the mass of the water. Carefully remove the cup from the balance.
3. Put a thermometer in the water and support it as shown in the diagram.
4. Put a 12 V electric immersion heater into the water, making sure the heating element is completely below the water level. Connect the immersion heater to a joulemeter.
5. Record the temperature of the water, and then switch the immersion heater on. Stir the water in the cup gently using the thermometer.
6. After five minutes, record the temperature of the water again and also write down the reading on the joulemeter.

Considering your results:

- Divide the mass of water by 1000 to find the mass in kilograms.
- Subtract the temperature of the water after five minutes from the starting temperature to find the temperature change.
- Calculate the specific heat capacity of water using the equation.



How to Reduce unwanted heat loss:
Insulate the container which holds the substance being heated

Sources of error
Immersion heater might not be completely in the substance being heated
Heat energy not all transferred to the substance being heated, some will be transferred to the surroundings.

Equation to calculate specific heat capacity

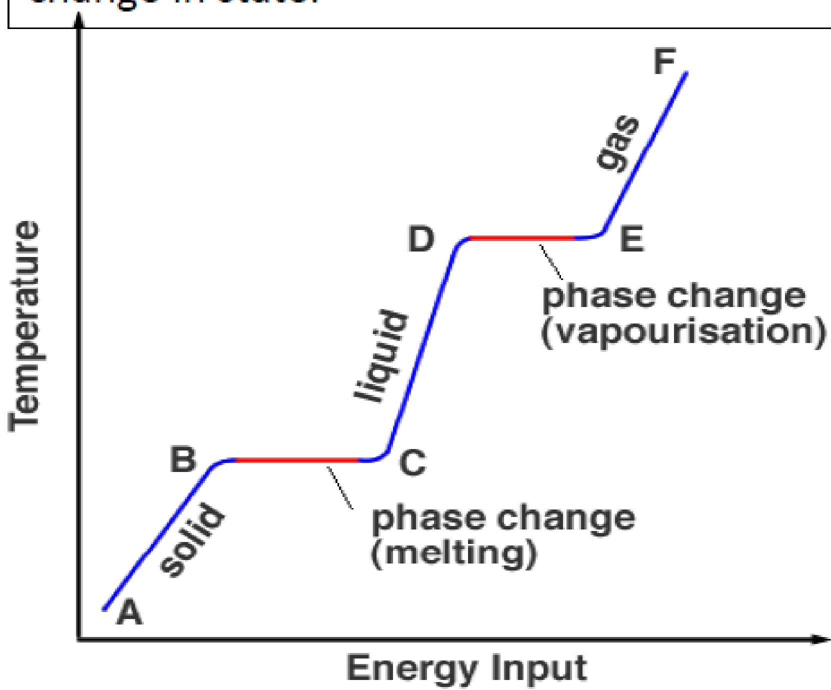
$$Q = m\,c\,\Delta T$$

Q = energy transfered (J)
m = mass of substance (kg)
c = specific heat capacity
ΔT = temperature change (K or °C)

change in thermal energy = mass × specific heat capacity × change in temperature

Specific latent heat is the amount of energy required to change the state of 1kg of a substance.

Energy is needed to make a substance melt or evaporate. The amount of energy depends on the mass of the substance and on its specific latent heat. The energy transferred during a change of state is called **latent heat**. **For heating**, latent heat is the energy ***gained*** to cause a change in state. **For cooling**, it is the energy ***released*** by a change in state.



Specific latent heat equation

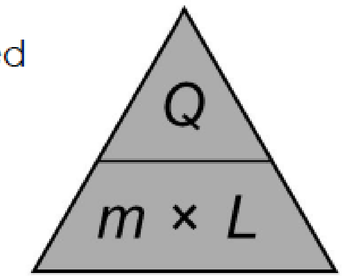
thermal energy needed for a change of state (J) = mass (kg) × specific latent heat (J/kg)

Q= mL

Q = thermal energy needed for a change of state (J)

m = mass (kg)

L = specific latent heat (J/kg)



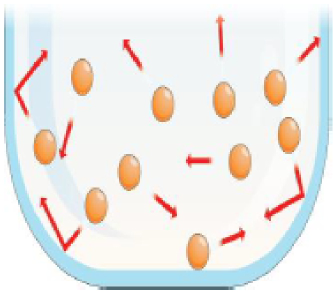
Exam style questions:

1. Brick has a specific heat capacity of 840J/kg°C.
Calculate how much energy the 800kg heater in photo A stores when the bricks are 40°C above the air temperature in the room.

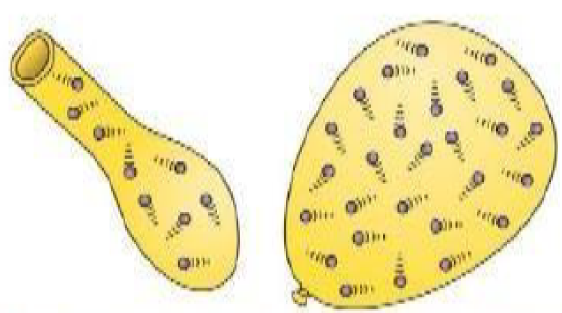
2. The specific latent heat of evaporation for water is 2257kJ/kg. How much energy does it take to evaporate 5kg of water at 100°C?

Gas Pressure

Gas particles are far apart and move around quickly. The temperature of a gas is a measure of the average kinetic energy of the gas particles. Pressure increases if a gas is heated because the particles will collide with the walls of the container **more frequently** and with **greater speed.**



Why do balloons get bigger as you blow them up? When you blow up a balloon, you are filling it with air particles. The more air particles you add, the bigger the balloon.



▲ The more particles you blow into a balloon, the bigger the balloon.

Topic Equation

To memorise:

Density = mass ÷ volume
(km/m^3)   (kg)   (m^3)

Equations to be able to use:

change in thermal energy = mass × specific heat capacity × change in temperature

thermal energy for a change of state = mass × specific latent heat

- 273°C **Absolute zero** 0 Kelvin
No movement of particles

Question:
What is the boiling point of water in Kelvin?
Boiling point = 100°C +273= 373K

Useful Links:
https://phet.colorado.edu/en/simulation/states-of-matter-basics
-Schoology
https://www.bbc.co.uk/bitesize/guides/z2gjtv4/revision/6

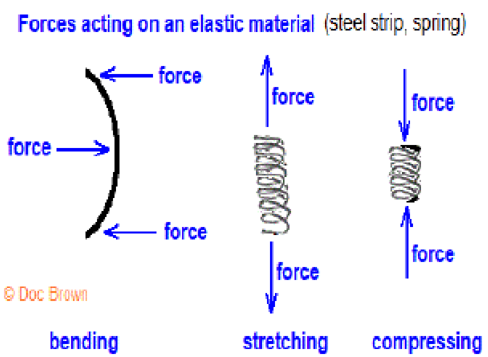
UNITS to Learn:
Kelvin = (K)
Thermal energy = J
Specific heat capacity = J/kg°C
Specific latent heat = J/kg

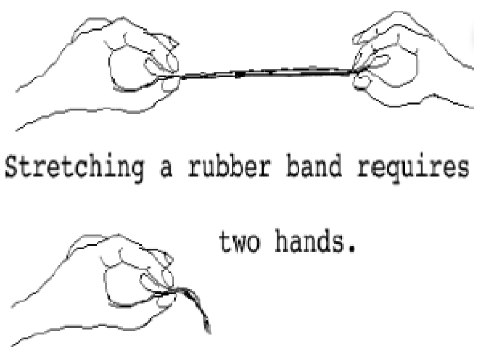
KS4: Physics: Forces and Motion

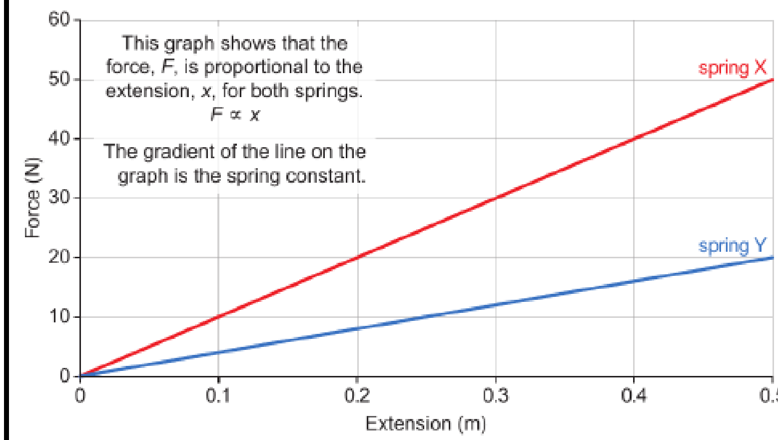
ST IVO ACADEMY
Astrea Academy Trust

Keyword	Definition
direct proportion	A linear relationship in which one variable doubles as the other does.
elastic	An elastic material changes shape when there is a force on it but returns to its original shape when the force is removed.
inelastic	An inelastic material changes shape when there is a force on it but does not return to its original shape when the force is removed.
extension	The amount by which a spring or other stretchy material has stretched. It is worked out from the stretched length minus the original length.
linear relationship	A relationship between two variables shown by a straight line on a graph. For a linear relationship the line does not have to go through the origin.
non-linear relationship	A relationship between two variables that does not produce a straight line on a graph.
spring constant	A measure of how stiff a spring is. The spring constant is the force needed to stretch a spring by 1 m.
work done	A measure of the energy transferred when a force acts through a distance.

Elastic objects return to their original shape after they've been stretched, **inelastic** ones don't!
Stretching, bending or compressing an object transfers **energy** and requires **more than one force. One force** is needed to hold one end whilst another force is needed to make the object move.







A Force-extension graph for two springs. The ∝ symbol means 'directly proportional to'.

To calculate the force exerted on a spring.
Extension is directly proportional to Force

F = k x X

F= force (N)
K= spring constant (N/m)
X= extension (m)

The spring constant, **k**, of a spring tells you how stretchy that spring is.

The spring constant (k) depends on the object that you are stretching.

Worked example W1

Calculate the spring constant for spring X in graph A.

$$k = \frac{F}{x}$$

$$= \frac{50\,N}{0.5\,m}$$

$$= 100\,N/m$$

You can choose any point on the graph to read off a force and extension.

Core Practical: Investigating force and extension with a spring

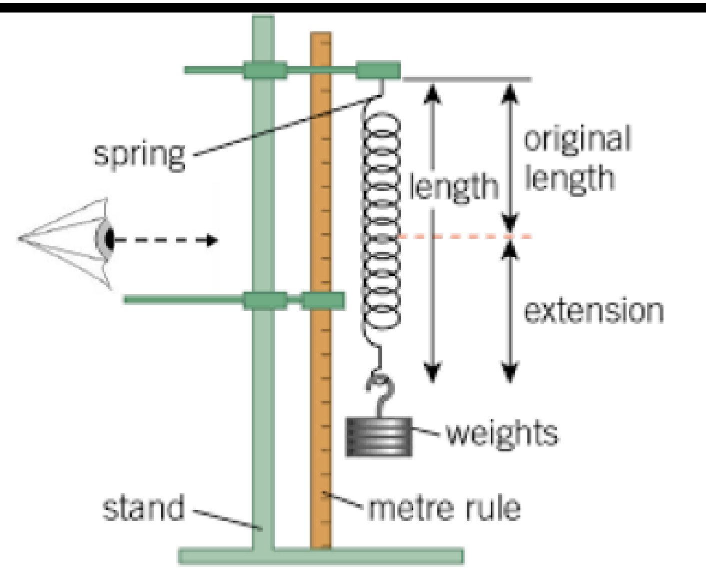
Safety: Hazard; Spring recoiling, wear eye protection
Apparatus: spring, clamp stand, 2 clamps and bosses, G-clamp, masses, ruler

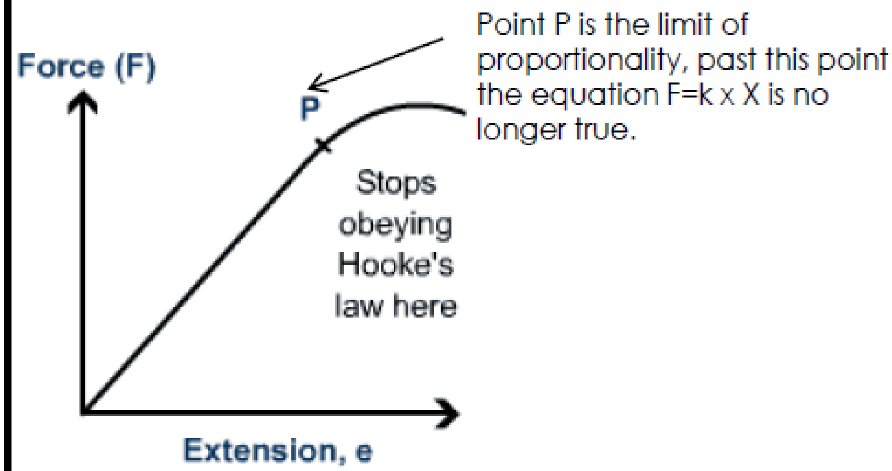
Method

1. Secure a clamp stand to the bench using a G-clamp or a large mass on the base.
2. Use bosses to attach two clamps to the clamp stand.
3. Attach the spring to the top clamp and a ruler to the bottom clamp.
4. Adjust the ruler so that it is vertical and with its **zero level** with the top of the spring.
5. Measure and record the unloaded length of the spring.
6. Hang a 100g mass (0.1kg) from the spring. Measure and record the new length of the spring.
7. Add a 100g mass to the carrier. Measure and record the new length of the spring.
8. Repeat step 7 until you have added a total of 500g.
9. Record your results in a suitable table.
10. 10. Plot a line graph with extension (y axis) and force on x axis.

Force (N)	Extension of spring (length-original length) (cm)	Extension of spring (m)
0		

Read the extension with your eye level with the bottom of the spring





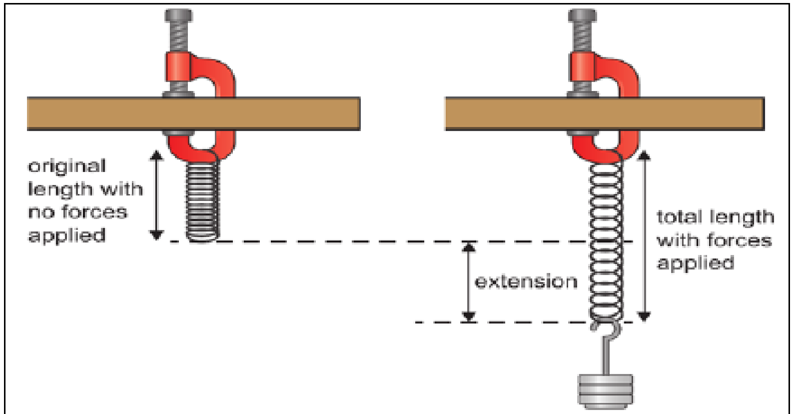
The spring constant, **k**, of a spring tells you how stretchy that spring is.
Use the **gradient** of the line (force ÷ extension) to find the spring constant (k).

Core Practical: Investigating force and extension with a spring

Hazard	Risk	Precaution
Equipment falling off table	Heavy objects falling on feet - bruise/fracture	Use a G-clamp to secure the stand
Sharp end of spring recoiling if the spring breaks	Damage to eyes and cuts to skin	Wear eye protection and support and gently lower masses whilst loading the spring
Masses falling to floor if the spring fails	Heavy objects falling on feet - bruise/fracture	Gently lower load onto spring and step back

Two equations:
To learn off by heart:
$F = k \times X$

To be able to use:
$E = \frac{1}{2} kx^2$



C The *extension* of a spring is not the same as its length.

Worked example W2

Calculate the energy transferred when a spring with a spring constant of 100 N/m is stretched by 0.2 m.

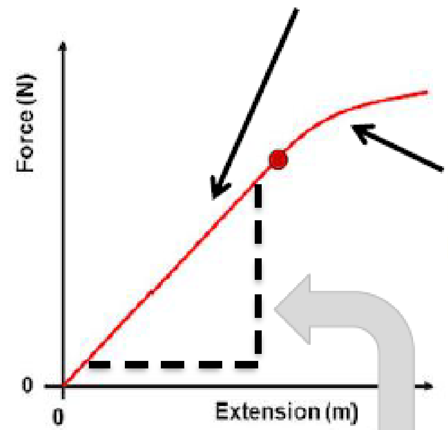
$$E = \frac{1}{2} \times k \times x^2$$
$$= \frac{1}{2} \times 100\,\text{N/m} \times (0.2\,\text{m})^2$$
$$= 2\,\text{J}$$

To calculate work done for linear relationship (i.e. if the spring is not stretched past its limit):

$E = \frac{1}{2} kx^2$

E= energy
K= spring constant
X= extension

For an elastic object (e.g a spring) the extension is directly **proportional** to the force applied. For example, if the force is doubled, the extension doubles. The relationship is **linear.**



If a spring is stretched so much that is becomes distorted, force will no longer be proportional to extension. A **non-linear** relationship.

ST IVO ACADEMY
Astrea Academy Trust

WHERE CAN PHYSICS TAKE YOU?

CONSTRUCTION

With almost 300,000 business trading in construction, this **sector accounts for 7% of all employment in the UK**. That's 2.3 million jobs.

Career paths: Architect, civil engineer, construction manager

ENERGY & UTILITIES

Today, about 500,000 people work in the energy sector. But with the demand for green energy growing, **by 2020 half a million people could be working in renewables alone.**

Career paths: Electrician, gas engineer, geoscientist, plumber

ENGINEERING

The proportion of young engineers has dropped over the last decade. This means there will be **high demand for younger workers** in the years to come!

Career paths: Electronic/mechanical/software engineer

IT & THE INTERNET

People with qualifications in information technology have **one of the highest rates of employment in the UK.**

Career paths: Cyber security analyst, database developer, games developer

SCIENCE & RESEARCH

Between 2016 and 2023, jobs in science and research will grow at twice the rate of other industries, creating 142,000 new jobs. **One in every six jobs will be in science and research.**

Career paths: Aerospace engineer, data scientist, modelling scientist

TRANSPORT & LOGISTICS

The UK transport industry employs 1.5 million people across the country. Over the next 10 years, **100,000 new workers will be required in rail alone.**

Career paths: Air traffic controller, logistics analyst, mechanic, pilot

EMPLOYER — Cadent

Cadent needs excellent problem solvers to keep gas flowing securely and sustainably across the UK. Physics can help you understand the science behind the gas network, and gives you the communication and analytical skills needed.

EMPLOYER — Jaguar Land Rover

At Jaguar Land Rover, the next generation of innovators will create groundbreaking technologies. Physics gives you the scientific understanding and creativity to come up with new ideas and be successful on the company's engineering apprenticeships.