

Mechanical	<i>Force acts upon an object</i>
Electrical	<i>Electric current flow</i>
Heat	<i>Temperature difference between objects</i>
Radiation	<i>Electromagnetic waves or sound</i>

Energy pathways

Change in thermal energy = mass X specific heat capacity X temperature change $\Delta E = m \times c \times \Delta \theta$

Specific Heat Capacity
Energy needed to raise 1kg of substance by 1°C
 Depends on: mass of substance, what the substance is and energy put into the system.

HIGHER: efficiency can be increased using machines.

Efficiency = $\frac{\text{Useful power output}}{\text{Total power input}}$

Efficiency = $\frac{\text{Useful output energy transfer}}{\text{Total input energy transfer}}$

Efficiency
How much energy is usefully transferred

Kinetic energy	<i>Energy stored by a moving object</i>	$\frac{1}{2} \times \text{mass} \times (\text{speed})^2$ $\frac{1}{2} mv^2$
Elastic Potential energy	<i>Energy stored in a stretched spring, elastic band</i>	$\frac{1}{2} \times \text{spring constant} \times (\text{extension})^2$ $\frac{1}{2} ke^2$ (Assuming the limit of proportionality has not been exceeded)
Gravitational Potential energy	<i>Energy gained by an object raised above the ground</i>	Mass X gravitational field strength X height mgh

System	<i>An object or group of objects that interact together</i>	EG: Kettle boiling water.
Energy stores	<i>Kinetic, chemical, internal (thermal), gravitational potential, elastic potential, magnetic, electrostatic, nuclear</i>	Energy is gained or lost from the object or device.
Ways to transfer energy	<i>Light, sound, electricity, thermal, kinetic are ways to transfer from one store to another store of energy.</i>	EG: electrical energy transfers chemical energy into thermal energy to heat water up.
Unit	<i>Joules (J)</i>	

Work	<i>Doing work transfers energy from one store to another</i>	By applying a force to move an object the energy store is changed.	Work done = Force X distance moved $W = Fs$
Power	<i>The rate of energy transfer</i>	1 Joule of energy per second = 1 watt of power	Power = energy transfer ÷ time $P = E \div t$ Power = work done ÷ time, $P = W \div t$

	Units
Specific Heat Capacity	<i>Joules per Kilogram degree Celsius (J/Kg°C)</i>
Temperature change	<i>Degrees Celsius (°C)</i>
Work done	<i>Joules (J)</i>
Force	<i>Newton (N)</i>
Distance moved	<i>Metre (m)</i>
Power	<i>Watts (W)</i>
Time	<i>Seconds (s)</i>

Useful energy	<i>Energy transferred and used</i>
Wasted energy	<i>Dissipated energy, stored less usefully</i>

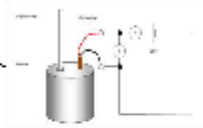
Prefix	Multiple	Standard form
Kilo	1000	10^3
Mega	1000 000	10^6
Giga	100 000 000	10^9

Energy stores and changes

AQA ENERGY – part 1

Closed system	<i>No change in total energy in system</i>
Open system	<i>Energy can dissipate</i>

Energy Conservation and Dissipation



Dissipate
To scatter in all directions or to use wastefully
 When energy is 'wasted', it dissipates into the surroundings as internal (thermal) energy.

Ways to reduce 'wasted' energy
Energy transferred usefully
 Insulation, streamline design, lubrication of moving parts.

Principle of conservation of energy
The amount of energy always stays the same.
 Energy cannot be created or destroyed, only changed from one store to another.

	Units
Energy (KE, EPE, GPE, thermal)	<i>Joules (J)</i>
Velocity	<i>Metres per second (m/s)</i>
Spring constant	<i>Newton per metre (N/m)</i>
Extension	<i>Metres (m)</i>
Mass	<i>Kilogram (Kg)</i>
Gravitational field strength	<i>Newton per kilogram (N/Kg)</i>
Height	<i>Metres (m)</i>

HIGHER: When an object is moved, energy is transferred by doing work.

Work done = Force X distance moved

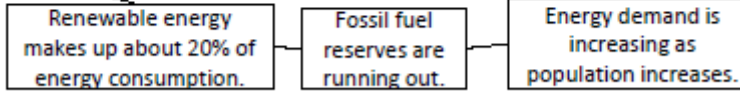
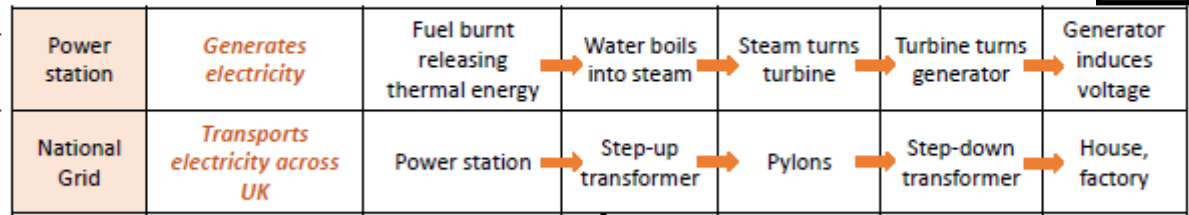
Frictional forces cause energy to be transferred as thermal energy. This is wasted.

Reducing friction - using wheels, applying lubrication. Reducing air resistance - travelling slowly, streamlining.

Using renewable energy will need to increase to meet demand.

Transport	<i>Petrol, diesel, kerosene produced from oil</i>	Used in cars, trains and planes.
Heating	<i>Gas and electricity</i>	Used in buildings.
Electricity	<i>Most generated by fossil fuels</i>	Used to power most devices.

Power station – NB: You need to understand the principle behind generating electricity. An energy resource is burnt to make steam to drive a turbine which drives the generator.



Non-renewable energy resource	<i>These will run out. It is a finite reserve. It cannot be replenished.</i>	e.g. Fossil fuels (coal, oil and gas) and nuclear fuels.
Renewable energy resource	<i>These will never run out. It is an infinite reserve. It can be replenished.</i>	e.g. Solar, Tides, Waves, Wind, Geothermal, Biomass, Hydroelectric

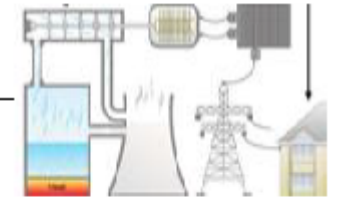
Using fuels

Energy resources

Global Energy Resources

AQA ENERGY – part 2

National Grid

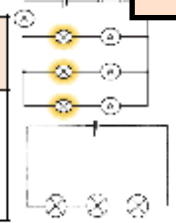


Energy resource	How it works	Uses	Positive	Negative
Fossil Fuels (coal, oil and gas)	<i>Burnt to release thermal energy used to turn water into steam to turn turbines</i>	Generating electricity, heating and transport	Provides most of the UK energy. Large reserves. Cheap to extract. Used in transport, heating and making electricity. Easy to transport.	Non-renewable. Burning coal and oil releases sulfur dioxide. When mixed with rain makes acid rain. Acid rain damages building and kills plants. Burning fossil fuels releases carbon dioxide which contributes to global warming. Serious environmental damage if oil spilt.
Nuclear	<i>Nuclear fission process</i>	Generating electricity	No greenhouse gases produced. Lots of energy produced from small amounts of fuel.	Non-renewable. Dangers of radioactive materials being released into air or water. Nuclear sites need high levels of security. Start up costs and decommission costs very expensive. Toxic waste needs careful storing.
Biofuel	<i>Plant matter burnt to release thermal energy</i>	Transport and generating electricity	Renewable. As plants grow, they remove carbon dioxide. They are 'carbon neutral'.	Large areas of land needed to grow fuel crops. Habitats destroyed and food not grown. Emits carbon dioxide when burnt thus adding to greenhouse gases and global warming.
Tides	<i>Every day tides rise and fall, so generation of electricity can be predicted</i>	Generating electricity	Renewable. Predictable due to consistency of tides. No greenhouse gases produced.	Expensive to set up. A dam like structure is built across an estuary, altering habitats and causing problems for ships and boats.
Waves	<i>Up and down motion turns turbines</i>	Generating electricity	Renewable. No waste products.	Can be unreliable depends on wave output as large waves can stop the pistons working.
Hydroelectric	<i>Falling water spins a turbine</i>	Generating electricity	Renewable. No waste products.	Habitats destroyed when dam is built.
Wind	<i>Movement causes turbine to spin which turns a generator</i>	Generating electricity	Renewable. No waste products.	Unreliable – wind varies. Visual and noise pollution. Dangerous to migrating birds.
Solar	<i>Directly heats objects in solar panels or sunlight captured in photovoltaic cells</i>	Generating electricity and some heating	Renewable. No waste products.	Making and installing solar panels expensive. Unreliable due to light intensity.
Geothermal	<i>Hot rocks under the ground heats water to produce steam to turn turbine</i>	Generating electricity and heating	Renewable. Clean. No greenhouse gases produced.	Limited to a small number of countries. Geothermal power stations can cause earthquake tremors.



Electrons carry current. Electrons are free to move in metal.

Cell	Battery	Switch	Lamp	Ammeter	Volt meter	Diode	LED	LDR	Fuse	Resistor	Variable resistor	Thermistor
Store of chemical energy	Two or more cells in series	Breaks circuit, turning current off	Lights when current flows	Measures current	Measures potential difference	Current flows one way	Emits light when current flows	Resistance low in bright light	Melts when current is too high	Affects the size of current flowing	Allows current to be varied	Resistance low at high temp



Current	Flow of electrical charge	Ampere (A)
Potential difference (p.d.)	How much electrical work is done by a cell	Volts (V)
Charge	Amount of electricity travelling in a circuit	Coulombs (C)

Circuit symbols

Current and Charge
Current, potential difference and resistance

Series and parallel circuits

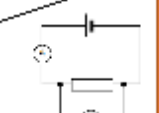
Series circuit	Current is the same in all components.	Total p.d. from battery is shared between all the components.	Total resistance is the sum of each component's resistance.
Parallel circuit	Total current is the sum of each component's current.	p.d. across all components is the same.	Total resistance is less than the resistance value of the smallest individual resistor.

Series	Parallel
A circuit with one loop	A circuit with two or more loops

Total p.d.
 If cells are joined in series, add up individual cell values

Charge = Current X time $Q = I \times t$

Changing current
 Controlling current
 Change the p.d. of the cells
 Add more components



$R = V \div I$
 Resistance = Potential difference ÷ Current

AQA Electricity
Domestic uses and safety

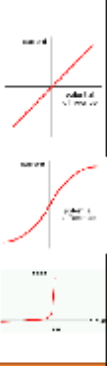
Energy transfers

Power (W) = potential difference X current $R = V \times I$
 Power = (current)² X resistance $P = I^2 \times R$
 Energy transferred = Power X time $E = P \times t$

Ammeter	Set up in series with components
Voltmeter	Set up parallel to components

Resistance (Ω)	A measurement of how much current flow is reduced
The higher the resistance, the more difficult it is for current to flow.	
Increasing resistance, reduces current.	
Increasing voltage, increases current.	

Thermistor	LDR	Alternating current	Direct current
Resistance varies with temperature	Resistance varies with light intensity	p.d. switches direction many times a second, current switches direction	p.d. remains in one direction, current flows the same direction
Resistance decreases as temperature increases.	Resistance decreases as light increases.	Generator.	Cell or battery.



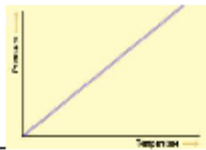
Ohmic conduct or	At a constant temperature, current is directly proportional to the p.d. across the resistor.
Filament lamp	As current increases, the resistance increases. The temperature increases as current flows.
Diode	Current flows when p.d. flows forward. Very high resistance in reverse.

Current - Potential difference graphs

3 pin plug	Live - Brown	Carries p.d. from mains supply.	p.d. between live and earth = 230V
	Neutral - Blue	Completes the circuit.	p.d. = 0V
	Earth - Green and Yellow stripes	Only carries current if there is a fault.	p.d. = 0V

National Grid
 Distributes electricity generated in power stations around UK

Step-up transformers	Step-down transformers
Increase voltage, decrease current	Decrease voltage, increase current
Increases efficiency, reduces heat loss.	Makes safer for houses.



Pressure of a fixed volume of gas increases as temperature increases (temperature increases, speed increases, collisions occur more frequently and with more force so pressure increases).

Temperature of gas is linked to the average kinetic energy of the particles.

If kinetic energy increases so does the temperature of gas.

No kinetic energy is lost when gas particles collide with each other or the container.

Gas particles are in a constant state of random motion.

$$P = m \div V$$

$$\text{Density} = \text{mass} \div \text{volume.}$$

Kinetic theory of gases

Particle model

State	Particle arrangement	Properties
Solid	<i>Packed in a regular structure. Strong forces hold in place so cannot move.</i>	Difficult to change shape.
Liquid	<i>Close together, forces keep contact but can move about.</i>	Can change shape but difficult to compress.
Gas	<i>Separated by large distances. Weak forces so constantly randomly moving.</i>	Can expand to fill a space, easy to compress.

	Units
Density	<i>Kilograms per metre cubed (kg/m³)</i>
Mass	<i>Kilograms (kg)</i>
Volume	<i>Metres cubed (m³)</i>
Energy needed	<i>Joules (J)</i>
Specific latent heat	<i>Joule per kilogram (J/kg)</i>
Change in thermal energy	<i>Joules (J)</i>
Specific heat capacity	<i>Joule per kilogram degrees Celsius (J/kg°C)</i>
Temperature change	<i>Degrees Celsius (°C)</i>
Pressure	<i>Pascals (Pa)</i>

AQA PARTICLE MODEL OF MATTER

Internal energy and energy transfers

Specific Heat Capacity

Energy needed to raise 1kg of substance by 1°C

Depends on:

- Mass of substance
- What the substance is
- Energy put into the system.

Change in thermal energy = mass X specific heat capacity X temperature change.

$$\Delta E = m \times c \times \Delta \theta$$

Density *Mass of a substance in a given volume*

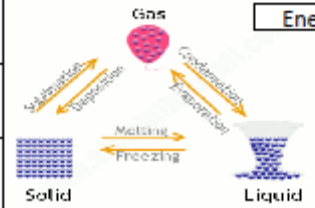
Freezing	Liquid turns to a solid. Internal energy decreases.
Melting	Solid turns to a liquid. Internal energy increases.
Boiling / Evaporating	Liquid turns to a gas. Internal energy increases.
Condensation	Gas turns to a liquid. Internal energy decreases.
Sublimation	Solid turns directly into a gas. Internal energy increases.
Conservation of mass	When substances change state, mass is conserved.
Physical change	No new substance is made, process can be reversed.

Change of state

Specific Latent Heat	<i>Energy needed to change 1kg of a substance's state</i>
Specific Latent Heat of Fusion	<i>Energy needed to change 1kg of solid into 1 kg of liquid at the same temperature</i>
Specific Latent Heat of Vaporisation	<i>Energy needed to change 1kg of liquid into 1 kg of gas at the same temperature</i>

Energy needed = mass X specific latent heat.

$$\Delta E = m \times L$$



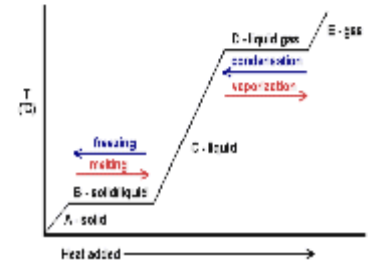
Internal energy

Energy stored inside a system by particles

Internal energy is the total kinetic and potential energy of all the particles (atoms and molecules) in a system.

Heating changes the energy stored within a system

Heating causes a change in state. As particles separate, potential energy stored increases. Heating increases the temperature of a system. Particles move faster so kinetic energy of particles increases.



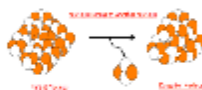


Radius of an atom
 $1 \times 10^{-10} \text{m}$



Electrons gained
Negative ion

Electrons lost
Positive ion



Atom	Same number of protons and electrons
Ion	Unequal number of electrons to protons
Mass number	Number of protons and neutrons
Atomic number	Number of protons

Particle	Charge	Size	Found
Neutron	None	1	In the nucleus
Proton	+	1	
Electron	-	Tiny	Orbits the nucleus

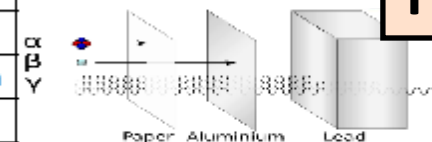
Isotope	${}^6_3\text{Li}$		${}^7_3\text{Li}$	
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Different forms of an element with the same number of protons but different number of neutrons

Discovery of the nucleus

Democritus	Suggested idea of atoms as small spheres that cannot be cut.
JJ Thomson (1897)	Discovered electrons—emitted from surface of hot metal. Showed electrons are negatively charged and that they are much less massive than atoms.
Thomson (1904)	Proposed 'plum pudding' model—atoms are a ball of positive charge with negative electrons embedded in it.
Geiger and Marsden (1909)	Directed beam of alpha particles (He^{2+}) at a thin sheet of gold foil. Found some travelled through, some were deflected, some bounced back.
Rutherford (1911)	Used above evidence to suggest alpha particles deflected due to electrostatic interaction between the very small charged nucleus, nucleus was massive. Proposed mass and positive charge contained in nucleus while electrons found outside the nucleus which cancel the positive charge exactly.
Bohr (1913)	Suggested modern model of atom—electrons in circular orbits around nucleus, electrons can change orbits by emitting or absorbing electromagnetic radiation. His research led to the idea of some particles within the nucleus having positive charge; these were named protons.
Chadwick (1932)	Discovered neutrons in nucleus—enabling other scientists to account for mass of atom.

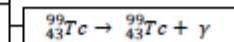
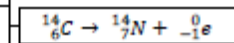
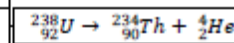
Decay	Range in air	Ionising power	Penetration power
Alpha	Few cm	Very strong	Stopped by paper
Beta	Few m	Medium	Stopped by Aluminium
Gamma	Great distances	Weak	Stopped by thick lead



P4

Radioactive decay	Unstable atoms randomly emit radiation to become stable
Detecting	Use Geiger Muller tube
Unit	Becquerel
Ionisation	All radiation ionises

Decay	Emitted from nucleus	Changes in mass number and atomic number	
Alpha (α)	Helium nuclei (${}^4_2\text{He}$)	-4	-2
Beta (β)	Electron (${}^0_{-1}\text{e}$)	0	+1
Gamma (γ)	Electromagnetic wave	0	0
Neutron	Neutron	-1	0



Atoms and Isotopes

Atoms and Nuclear Radiation

AQA ATOMIC STRUCTURE

PHYSICS ONLY: Hazards and uses of Radioactive emissions and of background radiation



Each Kg has a gravitational pull of 9.8N.

Gravitational field strength	Gravity exerted around an object.	Earth's gfs = 9.8N/kg
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Unit	Newton (N)	1N
Kilo	Kilonewton (KN) = 1000	1X 10 ³
Mega	Meganewton (MN) = 1000,000	1 X 10 ⁶

Centre of mass
The weight of an object acts through a single point

Force	Push or pull	Stretch, squash, turn.
Contact force	Exerted between two objects when they touch	Friction, air resistance, tension.
Non-contact force	Exerted between two objects without touching	Gravity, electrostatic forces, magnetic forces.

Resolving forces
An object pulled with a force at an angle
A single force can be split into two components acting at right angles to each other.

The component forces combined have the same effect.

Weight = mass X gravitational field strength $W = m \times g$

Weight	Force acting upon an object due to gravity	Newton (N)
Mass	How much matter	Kilograms (Kg)

Gravity

Resultant force
The overall effect of all of the forces acting upon an object

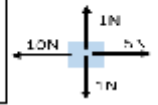
Two forces acting in the same direction are added.
Two forces acting in the opposite direction are taken away.

HIGHER ONLY
Work done against frictional forces, temperature of object rises.

Free body diagram

Show magnitude and direction of all forces upon an object

Object moves left with a force of 5N



Forces and their interactions

Contact and Resultant forces

AQA FORCES – part 1

Work done and energy transfer

If force is at right angles to direction of movement, NO work is done.

Work done

When work is done, energy is transferred

Work done = force X distance moved
 $W = F \times s$

1J of work is done when 1N of force moves an object through a distance of 1m, in the direction of the force.

Forces and elasticity

One force
More than one force

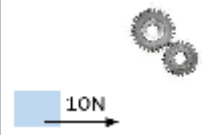
The object changes speed or direction
The object changes shape

Two balanced forces can stretch an object.
Two balanced forces can compress an object.
Three balanced forces can bend an object.

Scalar	A quantity that only has magnitude (size)	e.g. mass, time, speed, temperature, energy,
Vector	A quantity that only has magnitude and direction	e.g. force, velocity, momentum

Scalar and vector quantities

An arrow can be used to show vectors
Length of arrow = magnitude of vector
Direction of arrow = direction of vector



Velocity	Speed + direction	The speed of a car is 30m/s. A car moves forward with a velocity of 30m/s
Distance	How far	The table is 1m long
Displacement	Distance + direction	The beach is 1km due east of the town

Area	Metres squares (m ²)
Weight	Newton (N)
Mass	Kilograms (kg)
Gravitational field strength	Newton per kilogram (N/Kg)
Force	Newton (N)
Work done	Joules (J)
Distance	Metres (m)
Moment	Newton-metres (Nm)

HIGHER ONLY
Pressure

Pressure = Force ÷ Area

$P = F \div A$

Pressure and depth
Pressure on divers depends on weight of water above

Upthrust
Resultant force exerted by a fluid

Fluid
A liquid or gas
Flows and changes shape to fill a container.

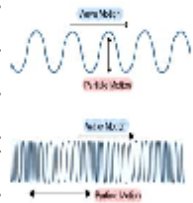
Hydraulic machine
Use liquids to transmit pressure

Atmospheric pressure
Caused by billions of air particles colliding with a surface.

Pressure = height X density X gfs



Wave speed	Wave speed = frequency X wavelength	$V = f \times \lambda$
Wave period	Wave period = $1 \div$ frequency	$T = 1 \div f$
Speed	Speed = distance \div time	$v = d \div t$



Transverse wave	<i>Vibration causing the wave is at right angles to the direction of energy transfer</i>	Energy is carried outwards by the wave.	Water and light waves, S waves.
Longitudinal wave	<i>Vibration causing the wave is parallel to the direction of energy transfer</i>	Energy is carried along the wave.	Sound waves, P waves.

Wavelength	<i>Distance from one point on a wave to the same point of the next wave</i>
Amplitude	<i>The maximum disturbance from its rest position</i>
Frequency	<i>Number of waves per second</i>
Period	<i>Time taken to produce 1 complete wave</i>

Transverse and Longitudinal waves

Waves in air, fluids and solids

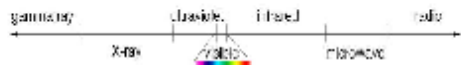
AQA Waves

e.g. Gamma

Electromagnetic waves

Short wavelengths have high frequency and high energy.

Electromagnetic wave	<i>Continuous spectrum of transverse waves</i>
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Absorbed light changes into thermal energy store.

HIGHER: Properties

	Units
Distance	Metres (m)
Wave speed	Metres per second (m/s)
Wavelength	Metres (m)
Frequency	Hertz (Hz)
Period	Seconds (s)

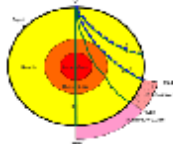
Seismic waves

P wave	S wave	Seismograph
<i>Longitudinal</i>	<i>Transverse</i>	<i>Shows P and S waves arriving at different times.</i>
<i>Fast</i>	<i>Slow</i>	
<i>Travel through solids and liquids</i>	<i>Travels through solids</i>	By using the times the waves arrive at the monitoring centres, the epicentre of earthquake can be found. ($v = x \div t$).
Produced by earthquakes.		

Black surfaces	<i>Good emitters, good absorbers</i>
White surfaces	<i>Poor emitters, poor absorbers</i>
Shiny surfaces	<i>Good reflectors</i>



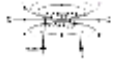
EM waves refract



Ultra sound	<i>Partially reflected off boundary</i>	Used for medical and foetal scans.
Sonar	<i>Reflected off objects</i>	Used to determine depth of objects under the sea.

EM wave	Danger	Use
Radio	Safe.	Communications, TV, radio.
Microwave	Burning if concentrated.	Mobile phones, cooking, satellites.
Infrared		Heating, remote controls, cooking.
Visible	Damage to eyes.	Illumination, photography, fibre optics.
Ultra violet	Sunburn, cancer.	Security marking, disinfecting water.
X-ray	Cell destruction, mutation, cancer.	Broken bones, airport security.
Gamma		Sterilising, detecting and killing cancer.

Electromagnet
Lots of turns of wire increase the magnetising effect when current flows
 Turn current off, magnetism lost.



Solenoid
A long coil of wire
 Magnetic field from each loop adds to the next.

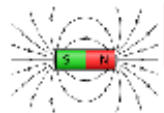
Reverse current, magnetic field direction reverses.

Further away from the wire, magnetic field is weaker.

Current large enough, iron filings show circular magnetic field.

If current is small, magnetic field is very weak.

Electric current flowing in a wire produces a magnetic field around it.



Permanent and Induced Magnetism

Magnets

Magnetic	<i>Materials attracted by magnets</i>	Uses non-contact force to attract magnetic materials.
North seeking pole	<i>End of magnet pointing north</i>	Compass needle is a bar magnet and points north.
South seeking pole	<i>End of magnet pointing south</i>	Like poles (N – N) repel, unlike poles (N – S) attract.
Magnetic field	<i>Region of force around magnet</i>	Strong field, force big. Weak field, force small. Field is strongest at the poles.
Permanent	<i>A magnet that produces its own magnetic field</i>	Will repel or attract other magnets and magnetic materials.
Induced	<i>A temporary magnet</i>	Becomes magnet when placed in a magnetic field.

Motor effect
HIGHER only
AQA
MAGNETISM AND ELECTROMAGNETISM

Magnetic fields from the permanent magnet and current in the foil interact. This is called the motor effect.

Reverse the current, foil moves upwards.

Aluminium foil placed between two poles of a strong magnet, will move downwards when current flows through the foil.

Size of force acting on foil depends on magnetic flux density between poles, size of current, length of foil between poles.