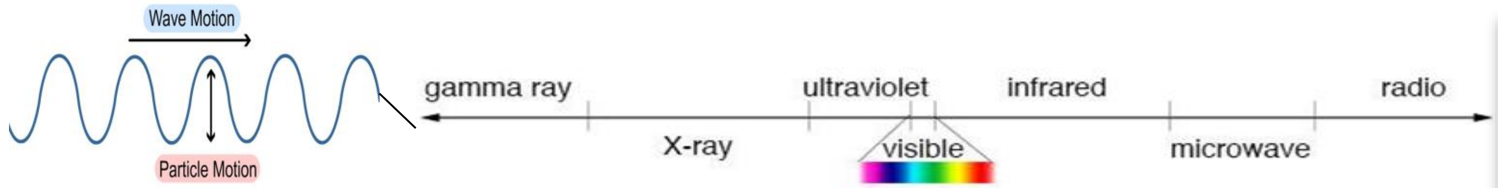
PiXL
Partners in excellence



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

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

	Type	Application	Suitability (HT)
Low frequency low wavelength	Radio	Television and radio	Travel through atmosphere for long distances
	Microwave	Satellite communications. Cooking food	Travel through atmosphere; agitates water molecules causing them to heat food
	Infrared	Electrical heaters, cooking food, infrared cameras	Heat energy transfer; detection of heat waves
	Visible	Fibre optic communications	Retina can detect light waves; light can travel through optic fibres and carry information
	Ultraviolet	Energy efficient lamps, sun tanning	Some materials can absorb UV and re-emit as visible, energy efficient, skin reacts to UV light causing tanning
	X-rays	Medical imaging and treatment	Pass through soft tissue, penetrate materials to different extents so can produce image
High frequency short wavelength	Gamma rays	Medical imaging and treatment	Kill tissue ; tracers can produce images of internal organs.

EM radiation dangers	
Radio wave Dangers	*No known dangers*
Microwave dangers	*Absorbed by water causing it to heat up □ burns under the skin.*
Infrared dangers	*Surface heating causing burns.*
Visible	*Damage to eyes*
Ionisation	*High energy radiation causes ions to form in our cells, damaging DNA and causing cancer.*
Ultraviolet dangers	*Cell Damage that could lead to skin cancer, snow blindness.*
X-ray dangers	*Cell Damage that could lead to cancer*
Gamma ray dangers	*Cell damage that could lead to cancer*

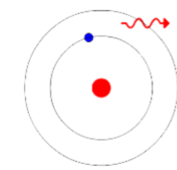
P1 Radiation and Waves What is the Electromagnetic Spectrum?

Electromagnetic wave — *Continuous spectrum of transverse waves*

Short wavelengths have high frequency and high energy.

e.g. Gamma

Atoms and electromagnetic waves



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

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

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

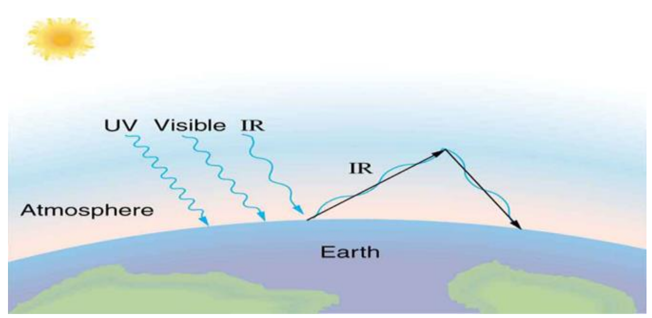
Atoms can receive energy from external sources.
This energy can cause electrons to "jump" to a **higher energy level**.
When the electron falls back to its original energy level it will release the stored energy in the form of a **photon of electromagnetic radiation.**

Earth and Global warming

Ultraviolet, visible light, infra-red radiation penetrate atmosphere and heat up Earth's surface.

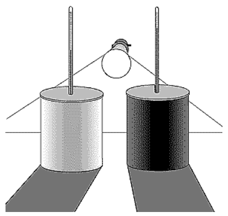
Longer wavelengths are radiated back, trapped by atmosphere.

Energy lost is not at the same rate as energy being absorbed so Earth heats up.



Black body radiation

Black surfaces	*Good emitters, good absorbers*
White surfaces	*Poor emitters, poor absorbers*
Shiny surfaces	*Good reflectors*



Black body radiation	*All objects absorb or reflect infrared radiation*	Hotter objects emit more infrared radiation.
Constant temperature	*Rate of absorption = rate of radiation*	Intensity and wavelength of energy affects temperature.

Black surfaces absorb infrared waves better than white or shiny surfaces.

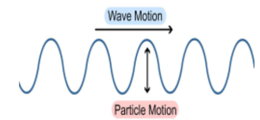
Black surfaces also emit infrared radiation quicker than light coloured surfaces

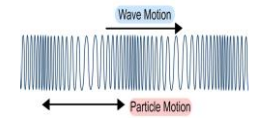
P1 Radiation and Waves How Do Waves Behave?

Calculating wave speed

Wave speed	Wave speed = frequency X wavelength	
Wave period	Wave period = 1 ÷ frequency	T = 1 ÷ f
Speed	Speed = distance ÷ time	v = d ÷ t

Transverse and Longitudinal waves



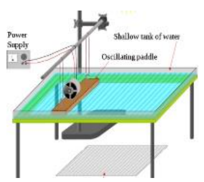


Transverse wave	*Vibration causing the wave is at right angles to the direction of energy transfer*	Energy is carried outwards by the wave.	Water and light waves, S waves.
Longitudinal wave	*Vibration causing the wave is parallel to the direction of energy transfer*	Energy is carried along the wave.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

Waves in air, fluids and solids

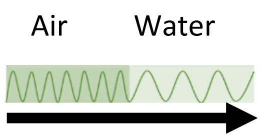
Properties

Measuring speed

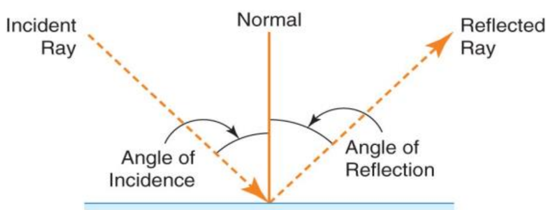


In water, use a ripple tank.

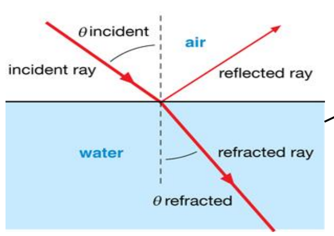
In air, use echoes.



Sound waves travelling through different mediums, the frequency stay constant.



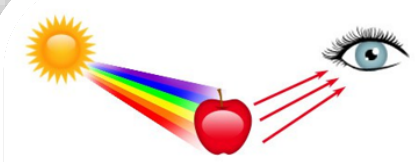
Angle of incidence = angle of reflection (i) = (r)



Light refracts as it slows down in a denser substance

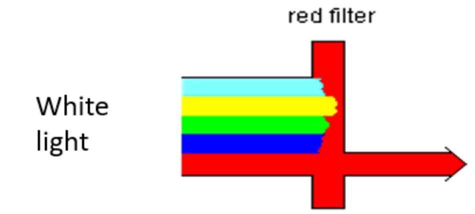
Emission	Wave produced by source
Reflection	Wave bounces off the surface.
Refraction	Waves changes direction at boundary.
Transmitted	Passes through the object.
Absorbed	Passes into but not out of, transfers energy and heats up the object.

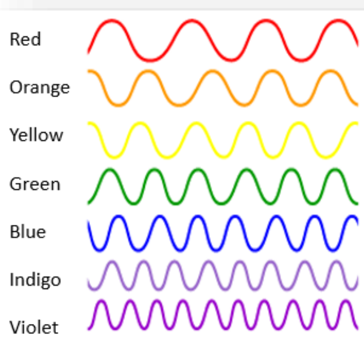
Waves	*Transfer energy without transferring matter.*
Oscillate	*When particles vibrate backwards and forwards or up and down.*
Wavelength	*Distance from one point on a wave to the same point of the next wave measured in metres (m)*
Amplitude	*The maximum disturbance from its rest position*
Frequency	*Number of waves per second*
Period	*Time taken to produce 1 complete wave in seconds (s)*
Hertz	*The unit of frequency. 1 Hz = 1 wave per second.*
Velocity	*The speed of a wave in m/s.*
Medium	*The material that waves travel through. Light waves are the only waves that have no medium.*



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

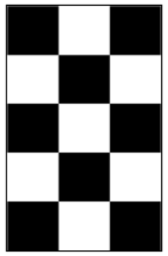
If light **transmits** through a coloured object, the colour passing through is the colour we see. As with reflected light, all other wavelengths of light are absorbed by the transparent or translucent material.





Each colour within the visible spectrum has its own narrow band of **wavelength** and **frequency**.

Colour filters work by **absorbing certain wavelengths** (and colour) and **transmitting other wavelengths** (and colour).



The colour of an opaque object is determined by which wavelengths of light are more **strongly reflected**.
Wavelengths that are **not reflected are absorbed**.

If **all wavelengths are reflected** equally the object will appear **white**. If **all the wavelengths of light are absorbed** equally the object will appear **black**.

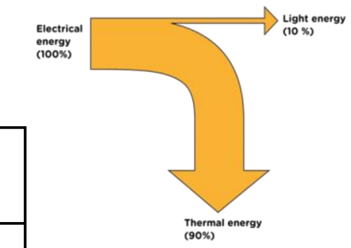
Energy pathways	
Mechanical	*Force acts upon an object*
Electrical	*Electric current flow*
Heat	*Temperature difference between objects*
Radiation	*Electromagnetic waves or sound*

HIGHE: efficiency can be increased using machines.

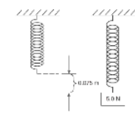
Efficiency = Useful power output / Total power input

Efficiency = Useful output energy transfer / Total input energy transfer

Efficiency	*How much energy is usefully transferred*	
Useful energy	*Energy transferred and used*	
Wasted energy	*Dissipated energy, stored less usefully*	



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



Energy stores and changes

P2 Sustainable Energy

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.

Power	*The rate of energy transfer*	1 Joule of energy per second = 1 watt of power	Power = energy transfer ÷ time P = E ÷ t Power = work done ÷ time, P = W ÷ t

Measurement	*Units*
Work done	*Joules (J)*
Power	*Watts (W)*
Time	*Seconds (s)*

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

Closed system	*No change in total energy in system*
Open system	*Energy can dissipate*

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.

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

Using renewable energy will need to increase to meet demand.

Renewable energy makes up about 20% of energy consumption.

Fossil fuel reserves are running out.

Energy demand is increasing as population increases.

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.

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

Using fuels

Energy resources

Generating Electricity

P2 Sustainable Energy

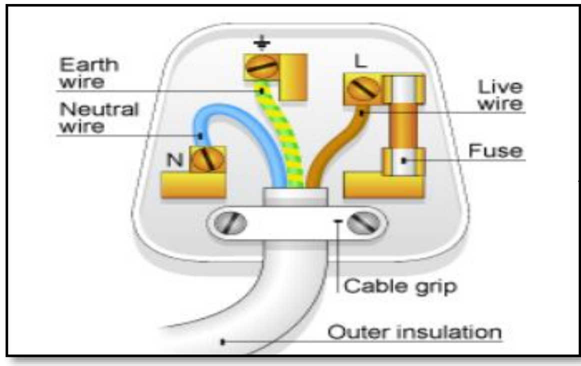
Transformers

Step up transformers increase voltage but reduce the current

Step down transformers decrease voltage but increase the current

Transformers only work with alternating currents ((current flows back and forth)

A lot of energy can be dissipated into the cables as heat which causes a need for transformers



Electricity will travel from live wire to the earth when possible. The Earth is able to absorb electrical charges

Mains voltage is 230V in the UK and the current is AC at 50Hz

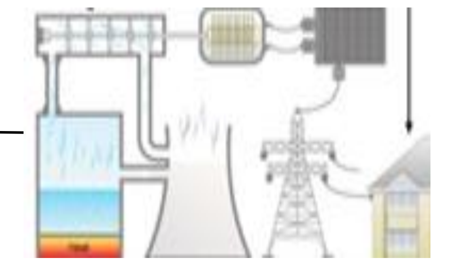
Mains Electricity

P2 Sustainable Energy

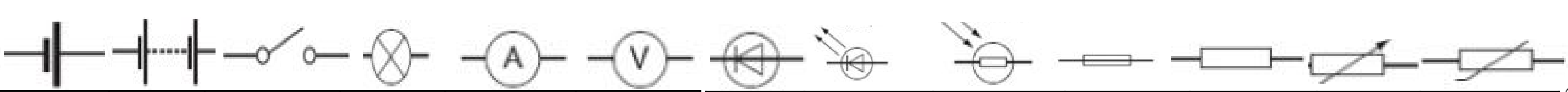
National Grid

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.

Power station	***Generates electricity***	Fuel burnt releasing thermal energy →	Water boils into steam →	Steam turns turbine →	Turbine turns generator →	Generator induces voltage
National Grid	***Transports electricity across UK***	Power station →	Step-up transformer →	Pylons →	Step-down transformer →	House, factory

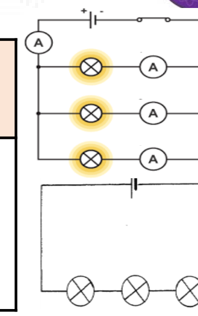


Energy resource	***How it works***	Uses	Positive	Negative
Fossil Fuels (coal, oil and gas)	***Burnt to release thermal energy used to turn water into steam to turn turbines***	Generating electricity, heating and transport	Provides most of the UK energy. Large reserves. Cheap to extract. Used in transport, 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	***Nuclear fission process***	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	***Plant matter burnt to release thermal energy***	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	***Every day tides rise and fall, so generation of electricity can be predicted***	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	***Up and down motion turns turbines***	Generating electricity	Renewable. No waste products.	Can be unreliable depends on wave output as large waves can stop the pistons working.
Hydroelectric	***Falling water spins a turbine***	Generating electricity	Renewable. No waste products.	Habitats destroyed when dam is built.
Wind	***Movement causes turbine to spin which turns a generator***	Generating electricity	Renewable. No waste products.	Unreliable – wind varies. Visual and noise pollution. Dangerous to migrating birds.
Solar	***Directly heats objects in solar panels or sunlight captured in photovoltaic cells***	Generating electricity and some heating	Renewable. No waste products.	Making and installing solar panels expensive. Unreliable due to light intensity.
Geothermal	***Hot rocks under the ground heats water to produce steam to turn turbine***	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*



Circuit symbols

Current, potential difference and resistance

Current and Charge

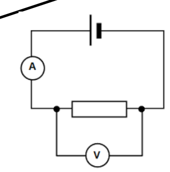
Current	*Flow of electrical charge*	Ampere (A)
Potential difference (p.d.)	*How much electrical work is done by a cell*	Volts (V)
Charge	*Amount of electricity travelling in a circuit*	Coulombs (C)

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

Controlling current

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

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



$R = V \div I$

Resistance = Potential difference ÷ Current

Resistance (Ω)	*A measurement of how much current flow is reduced*

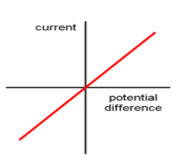
The higher the resistance, the more difficult it is for current to flow.

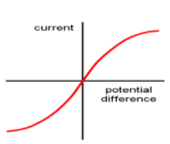
Increasing resistance, reduces current.

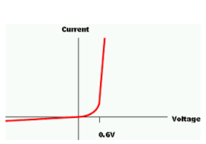
Increasing voltage, increases current.

Thermistor	LDR
Resistance varies with temperature	*Resistance varies with light intensity*
Resistance decreases as temperature increases.	Resistance decreases as light increases.

Current – Potential difference graphs







Ohmic conductor	*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.*

P3 Electric Circuits

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*

Energy transfers

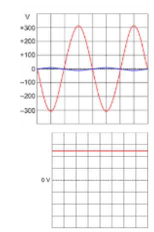
Work is done when charge flowing.

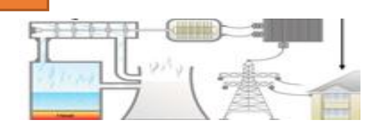
Power (W) = potential difference X current — $R = V \times I$

Power = (current)^2 X resistance — $P = I^2 \times R$

Energy transferred = Power X time — $E = P \times t$

Domestic uses and safety





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.

Alternating current	Direct current
p.d. switches direction many times a second, current switches direction	*p.d. remains in one direction, current flows the same direction*
Generator.	Cell or battery.

Mains supply	*Frequency 50Hz, 230V*

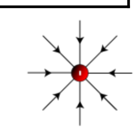
Static electricity

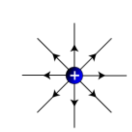
PHYSICS only

Static electricity	*Electrical charge is stationary*	When two insulating material are rubbed together, electrons move from one material to the other.

Like charges	*Repel*
Unlike charges	*Attract*

Shocks	Walking on carpet causes friction. Electrons move to the person and charge builds up. When the person touches a metal object, the electrons conduct away, making a spark.





Electric fields	Charged objects create electric fields around them. Strongest closest to the object. The field direction is the direction of force on a positive charge. Add more charge increases field strength.

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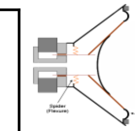
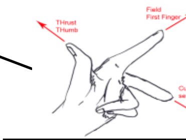
Relay	*A device using a small current to control a larger current in another circuit*	Solenoid is wound around an iron core. Small current magnetises the solenoid. This attracts to electrical contacts, making a complete circuit. Current flows from battery to starter motor.
Split-ring commutator	*Split ring touching two carbon brush contacts*	
Loud speakers	*Converts variations in electrical current into sound waves .*	Varying current flows through a coil that is in a magnetic field. A force on the wire moves backwards and forwards as current varies. Coil connected to a diaphragm. Diaphragm movements produce sound waves.
Generators	*Coil of wire rotating inside a magnetic field. The end of the coil is connected to slip rings.*	Produces altering current.
Microphones	*Converts pressure variations in sound waves into variations in current in electrical circuits.*	
Electric motor	*Coil of wire rotates about an axle*	Current flows through the wire causing a downward movement on one side and an upward movement on the other side.



Fleming's left-hand rule

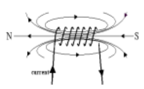
To predict the direction a straight conductor moves in a magnetic field.

Thumb	Direction of movement.
First finger	Direction of magnetic field.
Second finger	Direction of current.



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

Increase strength of magnetic field:
- *Use larger current*
- *Use more turns of wire*
- *Put turns of wire closer together*
- *Use iron core in middle*



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

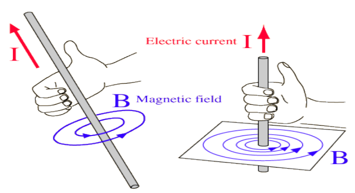
Right hand rule

Thumb	Direction of current.
Fingers	Direction of magnetic field.

Magnetic field around a wire

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

- 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.



Motor effect

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.

F = B X I X l

Force = magnetic flux density X current X length

If current and magnetic field are parallel to each other , no force on wire.

Magnetic flux	*Lines drawn to show magnetic field*	Lots of lines = stronger magnets.
Magnetic flux density	*Number of lines of magnetic flux in a given area*	Measures the strength of magnetic force.

P3 Electric Circuits

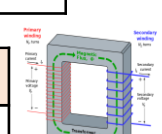
Induced potential, transformers and National Grid

National Grid	*Distributes electricity generated in power stations around UK*
Induced potential	*When a conducting wire moves through a magnetic field, p.d. is produced*
Generator effect	*Generates electricity by inducing current or p.d.*
Uses of the generator effect	*Dynamo, Microphones*

Transformer	*Two coils of wire onto an iron core*	Alternating current supplied to primary coil, making magnetic field change. Iron core becomes magnetised, carries changing magnetic field to secondary coil. This induces p.d.

Power lost = Potential difference X Current

Step-up transformers	Step-down transformers
Increase voltage, decrease current	*Decrease voltage, increase current*
Increases efficiency by reducing amount of heat lost from wires.	Makes safer value of voltage for houses and factories.



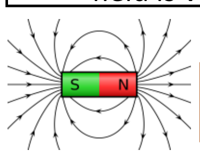
Power supplied to primary coil = power supplied to secondary coil

$V_p \times I_p = V_s \times I_s$

Voltage across the coil X number of coils (primary) = Voltage across the coil X number of coils (secondary)

$V_p \div V_s = n_p \div n_s$

Force	*Newton (N)*
Magnetic flux density	*Tesla (T)*
Current	*Amperes (A)*
Length	*Metres (m)*
Power	*Watts (W)*
p.d.	*Voltage (V)*



Permanent and Induced Magnetism

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

OCR P4 Explaining Motion Part 1

Forces and their interactions

Each Kg has a gravitational pull of 10N.

Unit	*Newton (N)*	1N
Kilo	*Kilonewton (KN) = 1000*	$1X 10^3$
Mega	*Meganewton (MN) = 1000,000*	$1 X 10^6$

Gravitational field strength	*Gravity exerted around an object.*	Earth's gfs = 10N/kg

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

Weight = mass X gravitational field strength | W = m X g

Gravity

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

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.

Contact and Resultant forces

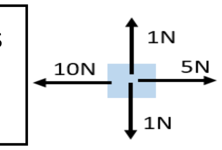
Resultant force	*The overall effect of all of the forces acting upon an object*	Two forces acting in the same direction are added.
		Two forces acting in the opposite direction are taken away.

HIGHER ONLY

Free body diagram	*Show magnitude and direction of all forces upon an object*

Work done against frictional forces, temperature of object rises.

Object moves left with a force of 5N



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

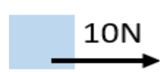
Work done and energy transfer

Work done	*When work is done, energy is transferred*	Work done = force X distance moved W = F X s
		1J of work is done when 1N of force moves an object through a distance of 1m, in the direction of the force.

Scalar and vector quantities

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

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)*

Moments, levers and gears

PHYSICS ONLY

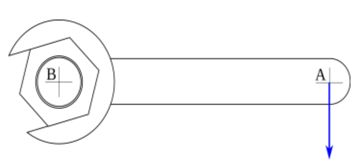
M = F X d

Moment = force X distance

Moment	*Turning effect of a force about a pivot*

Lever	*A small force exerted with a long lever applies a large force*

Gears	*Increase or decrease the rotational effect of a force*



Principle of moments
In a balanced system, the sum of the clockwise moments = the sum of the anti-clockwise moments

	Units
Energy (KE, EPE, GPE, thermal)	*Joules (J)*
Velocity	*Metres per second (m/s)*
Mass	*Kilogram (Kg)*
Gravitational field strength	*Newton per kilogram (N/Kg)*
Height	*Metres (m)*

Kinetic energy	*Energy stored by a moving object*	½ X mass X $(speed)^2$ ½ mv^2
Gravitational Potential energy	*Energy gained by an object raised above the ground*	Mass X gravitational field strength X height mgh

Power	*The rate of energy transfer*	1 Joule of energy per second = 1 watt of power	Power = energy transfer ÷ time P = E ÷ t Power = work done ÷ time, P = W ÷ t

OCR P4 Explaining Motion Part 2

Observing and recording motion

Describing motion

Aeroplane banks to change direction	Velocity changes.
Car travelling around a bend	Constant speed, direction changes.
Satellite orbiting the Earth	Constant speed, direction changes.

Changing velocity	*Objects in a circular motion, change direction but keep a constant speed*

HIGHER ONLY

Velocity	*The speed of an object with direction*	Vector

Speed of sound 330m/s.

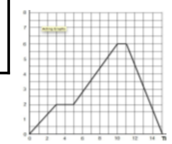
Speed = distance ÷ time — v = s ÷ t

Speed	*How fast an object moves*	Scalar
Displacement	*Includes the distance and direction an object moves*	vector
Distance	*How far an object moves*	scalar

Car on motorway	*30m/s*	Walking	*1.5m/s*
Train	*60m/s*	Running	*3m/s*
Jet plane	*200m/s*	Cycling	*6m/s*

Speed is rarely constant.

Distance-time graph	*Shows how far an object moves along a straight line*
Speed of object	*Use the gradient of graph*



Gradient = vertical ÷ horizontal

Accelerating objects	*It takes time for objects to reach top speed*	Draw a tangent to the curve, work out gradient.

HIGHER ONLY

Distance travelled	*Area under the graph shape*

HIGHER ONLY

Velocity-time graph	*Shows speed of an object*
Accelerating	*Object getting faster*
Decelerating	*Object slowing down*

Acceleration = change in velocity ÷ time taken

Acceleration	*Change in velocity*	Vector

Constant acceleration

(final velocity) ^{2} – (initial velocity) ^{2} = 2 X acceleration X distance

$V^2 - u^2 = 2 \times a \times s$

Forces and braking

Frictional forces decelerate a moving object and bring it to rest.

Speed affects both thinking and braking distances.

Typical reaction time = 0.7s

Thinking distance	*Distance travelled whilst the driver reacts*
Braking distance	*Distance travelled whilst the car is stopped by the brakes*
Stopping distance	*Total thinking and braking distances*

Factors affecting stopping distances	*Drivers reaction times*	Drinking alcohol, taking drugs, tired.
	Braking distances	Weather conditions, worn brakes or tyres, road surface, size of braking force.

Braking and kinetic energy	*Work done by braking force, reduces kinetic energy*	Kinetic energy decreases, temperature of brakes increases due to frictional forces.

Forces, acceleration and Newton's Laws of motion

Falling objects

Falling objects accelerate due to gravity.	In no air resistance, objects accelerate at 9.8m/s^2	Air resistance slows falling objects down.

Terminal velocity	*Weight of an object is balanced by resistive forces*	Object moves at a constant velocity. Resultant force = 0.

Parachuting	*Size of air resistance depends on area of object and speed*

Larger the area, the larger the air resistance.

Larger the speed, the larger the air resistance.

Inertia	*When objects continue in the same state of motion*

Speed or direction only changes if a resultant force acts on the object

HIGHER ONLY

Newton's first Law	*Balanced forces*	When the resultant force on an still object = 0, the object is stationary.
		When the resultant force on a moving object = 0, the object is at a constant speed.
Newton's second Law	*Unbalanced forces*	When the resultant force is greater than 0, the object accelerates. It could speed up, slow down or change direction.
Newton's third Law	*Equal and opposite forces*	When two objects interact the forces exerted are equal and in an opposite direction.

Acceleration is proportional to resultant force.

Acceleration is inversely proportional to mass.

Force = mass X acceleration

HIGHER ONLY

F = m X a

Inertial mass	*How difficult it is to change the velocity of an object*

Inertial mass = force ÷ acceleration

If the mass is large, to change velocity a big force is needed.

Momentum

Is a vector

HIGHER ONLY

p = m X v

Momentum = mass X velocity

Conservation of momentum

When two objects collide, the momentum they have before the collision = the momentum they have after the collision

Closed system = no external forces acting on it.

HIGHER ONLY

Changes in momentum

Force is applied to stop momentum

If momentum changes slowly, the force applied is small so less damage.

Crumple zones

Speed / velocity	*Metres per second (m/s)*
Distance	*Metres (m)*
Time	*Seconds (s)*
Acceleration	*Metres per second squared (m/s^2)*
Force	*Newton (N)*
Mass	*Kilogram (Kg)*
Momentum	*Kilograms metres per second (Kgm/s)*

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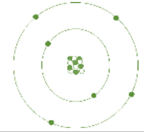
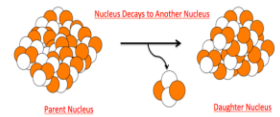
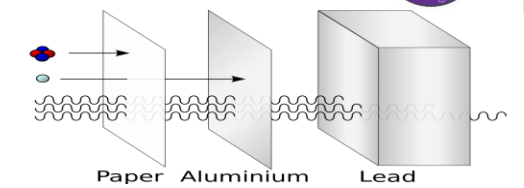
Radius of an atom	1×10^{-10}m



Electrons gained	Electrons lost
Negative ion	Positive ion



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



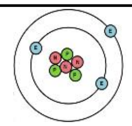
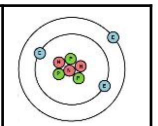
OCR P5

Atoms and Isotopes

Atom structure

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*	*In the nucleus*
Electron	*-*	*Tiny*	*Orbits the nucleus*

Isotope	$^{6}_{3}Li$		$^{7}_{3}Li$	
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.
J J 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.

Atoms and Nuclear Radiation

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 ($^{4}_{2}He$)*	*-4*	*-2*
Beta (β)	*Electron ($^{0}_{-1}e$)*	*0*	*+1*
Gamma (γ)	*Electromagnetic wave*	*0*	*0*
Neutron	*Neutron*	*-1*	*0*

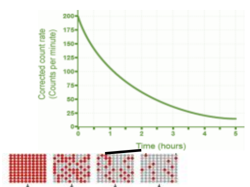
$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

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

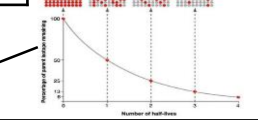
$^{99}_{43}Tc \rightarrow {}^{99}_{43}Tc + \gamma$

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

Contamination	*Unwanted presence of radioactive atoms*
Irradiation	*Person is in exposed to radioactive source*



Half life	*The time taken to lose half of its initial radioactivity*



Sievert	*Unit measuring dose of radiation*
Background	*Constant low level environmental radiation, e.g. from nuclear testing, nuclear power, waste*

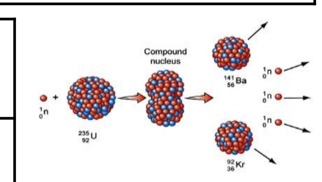
Uses	*Different isotopes have different half lives*	Short half-lives used in high doses, long half lives used in low doses.
Tracers	*Used within body*	Isotope with short half life injected, allowed to circulate and collect in damaged areas. PET scanner used to detect emitting radiation. Must be beta or gamma as alpha does not penetrate the body.
Radiation therapy	*Used to treat illnesses e.g. cancer*	Cancer cells killed by gamma rays. High dose used to kill cells. Damage to healthy cells prevented by focussed gamma ray gun.

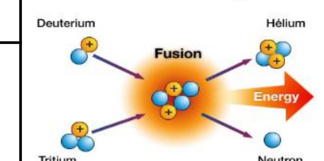
Nuclear fission and fusion

Fuel rods	Made of U-238, 'enriched' with U-235 (3%). Long and thin to allow neutrons to escape, hitting nuclei.
Control rods	Made of Boron. Controls the rate of reaction. Boron absorbs excess neutrons.
Concrete	Neutrons hazardous to humans – thick concreate shield protects workers.

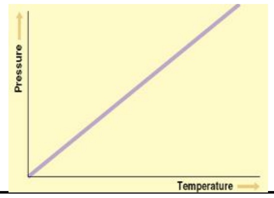
PHYSICS ONLY: Nuclear energy

Nuclear fission	*One large unstable nucleus splits to make two smaller nuclei*	Neutron hits U-235 nucleus, nucleus absorbs neutron, splits emitting two or three neutrons and two smaller nuclei. Process also releases energy.	Process repeats, chain reaction formed. Used in nuclear power stations
Nuclear fusion	*Two small nuclei join to make one larger nucleus*	Difficult to do on Earth – huge amounts of pressure and temperature needed.	Occurs in stars





OCR P6 Matter – models and explanations



Kinetic theory of gases

- 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.

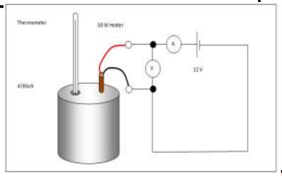
Particle model

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

$P = m \div V$

Density = mass ÷ volume.

Density	*Mass of a substance in a given volume*



	Units
Density	*Kilograms per metre cubed (kg/m^3)*
Mass	*Kilograms (kg)*
Volume	*Metres cubed (m^3)*
Energy needed	*Joules (J)*
Specific latent heat	*Joule per kilogram (J/kg)*
Change in thermal energy	*Joules (J)*
Specific heat capacity	*Joule per kilogram degrees Celsius (J/kg°C)*
Temperature change	*Degrees Celsius (°C)*
Pressure	*Pascals (Pa)*

Pressure

PHYSICS ONLY: when you do work the temperature increases e.g. pump air quickly into a ball, the air gets hot because as the piston in the pump moves the particles bounce off increasing kinetic energy, which causes a temperature rise.

- Reducing the volume of a fixed mass of gas increases the pressure.
- Halving the volume doubles the pressure.

PV = constant.

$P_1V_1 = P_2V_2$

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.

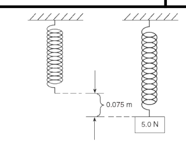
$\Delta E = m \times c \times \Delta\theta$

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.

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

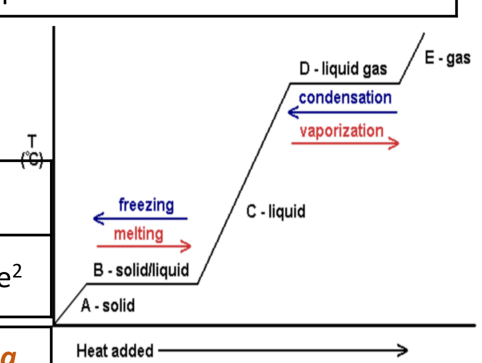
Energy needed = mass **X** specific latent heat.

$\Delta E = m \times L$



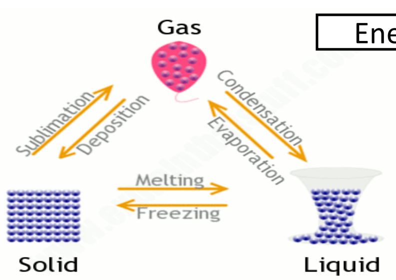
Stretching a spring
Force = spring constant X extension, F = k X e
EPE = ½ X spring constant X (extension)^2, EPE = ½ ke^2

Elastic Potential energy (EPE)	*Energy stored in a stretched spring*



Change of state

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.



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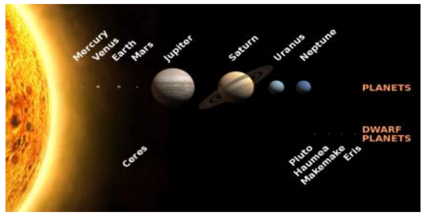
Milky Way our galaxy.

Planet	*A large body orbiting the Sun*
Moon	*A natural satellite orbiting a planet*
Dwarf planet	*A body large enough to have its own gravity which caused a spherical shape*
Solar system	*Any object orbiting the Sun due to gravity*
Galaxy	*Collection of billions of stars*
Universe	*Collection of galaxies*



Comets, asteroids, satellites.

Other objects.

OCR P6 Matter – models and explanations Space – PHYSICS ONLY

Solar system

Effect of gravity.

Gravity causes moons to orbit planets, planets to orbit the Sun, stars to orbit galaxy centres.

Force of gravity changes the moon's direction not its speed.

Gravity pulls objects towards the ground.

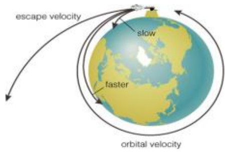
Orbital motions

Speed of Orbit.

Too fast = disappears into Space.

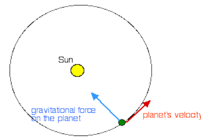
Correct speed = steady orbit around Earth.

Too slow = falls to Earth.



HIGHER: Circular orbits.

To calculate speed of Orbit: distance object moves in 1 orbit, Distance = 2∏r, then average speed = distance ÷ time.



Planets close to the Sun, gravity pull is strong. Planets move quickly.

Planets further away from the Sun, gravity pull is weaker. So speed of planet is slower.

HIGHER:

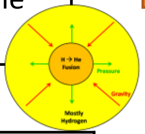
Velocity = a vector.

A planet's velocity changes but speed remains constant.

Due to the Sun's gravity, planets accelerate towards the Sun and so changes direction.

The life cycle of a star.

Nebula	*A cloud of cold hydrogen gas and dust*	Cloud collapses due to gravity, particles move very fast colliding with each other, kinetic energy transfers into internal energy and the temperature increases.
Protostar	*The large ball of gas contracts to form a star*	High temperature causes Hydrogen nuclei to collide and nuclear fusion begins. A star is 'born'.
Main sequence	*Stable period of star*	Gravity tries to collapse the star but enormous pressure of fusion energy expands and balances the inward force.



Stars the same size as our Sun.

Red giant	*A large star that fuses Helium into heavier elements*	Hydrogen runs out, star becomes unstable, pressure inside drops causing star to collapse. Atoms now closer together results in atoms fusing and temperature increases. This increase in temperature causes the core to swell.
White dwarf	*Star collapses*	Nuclear fuel runs out, fusion stops, dense very hot core.
Black dwarf	*Cold dark star*	White dwarf cools down.

Stars larger than our Sun.

Red super giant	*Star swells greatly*	Nuclear fuel begins to run out and star swells (more matter = bigger size).
Supernova	*Gigantic explosion due to run away fusion reactions*	Rapid collapse, heats to very high temperatures causing run away nuclear reactions, star explodes, flinging remnants out into space. Large gravitational forces collapse the core into a tiny space. Remains of supernova form heavier elements (Iron and above)
Neutron star	*Very dense star*	Made out of neutrons.

OR if collapse is into a really tiny space.

Black hole	*No light escapes*	Gravitational forces so strong everything is pulled in.

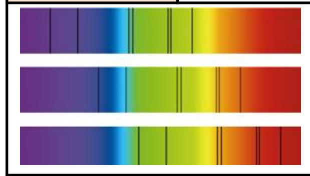
Red shift

When ambulances go past the sound changes from a high pitch to a low pitch.

Frequency of sound wave decreases, wavelength increases.

Understanding models.

Red-shift	*The observed increase in wavelength of light from most distance galaxies. Light moves towards the red end of the spectrum.*
Hubble (1929)	*He studied light from distant galaxies; found as frequency decreases, wavelength increases.*



Light from star in our galaxy.

Light from star in nearby galaxy.

Light from star in distant galaxy.

Galaxies are moving away from us in all directions.

Light from distant galaxies is red-shifted, so galaxy is moving away from us.

Galaxies further away have bigger red-shift so are moving faster away.

The Big Bang	*Universe began 13.8 billion years ago*
All matter and space expanded violently from a single point.	Red—shift provides evidence for expansion.

Aristotle (ancient Greek)	*Earth at the centre, other heavenly bodies move around the Earth.*
Copernicus (1473 - 1543)	*Sun at the centre, other heavenly bodies move around the Sun.*
Galileo (1610)	*Made a telescope, looked at Jupiter, found four moons rotating around planet.*

Planets and moons moved at different speeds to stars = reason for different positions.