Topical Notes by Chapter for Cambridge IGCSE

Physics 0972

1st edition, for examination until 2025

Chapter 1 : Motion, Forces And Energy

Physical quantities and measurement techniques

Rulers and measuring cylinders are for length and volume

measuring a variety of time intervals using clocks and digital timer

Average Value : $\frac{\text{sum of all values}}{\text{number of values}}$

Period of oscillation = time taken / number of swings

SCALAR

- quantities that only have magnitude
- distance is also scalar as it has no direction
- Eg speed, time, mass, energy, and temperature

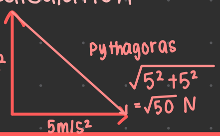
VECTORS

- quantities that have both magnitude and direction
- Velocity is also vector because it is necessary to mention both its speed and the direction.
- Eg: force, weight, acceleration, momentum, electric field strength and gravitational field strength.

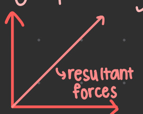
the resultant force of two vectors at right angles

Calculation

find angle using SOH, CAH, TOA



graphically



draw on graph, draw resultant vector, measure length for force and use a protractor for angle

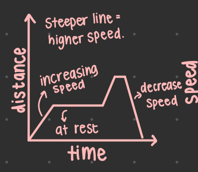
motion

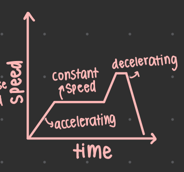
Speed is distance travelled per unit time

Velocity is Speed in a given direction

Average Speed = $\frac{\text{total distance travelled}}{\text{total time taken}}$

Acceleration is change in velocity per unit time $a = \frac{\Delta v}{\Delta t}$





- * Speed = gradient of distance-time
- * acceleration = gradient of speed-time
- * distance travelled = area under the speed-time graph.
- * deceleration is negative acceleration and use this in calculations

Acceleration of free fall g for an object near to the surface of the earth is approximately constant and is approx constant and is 9.8m/s²

Falling object w/o air resistance

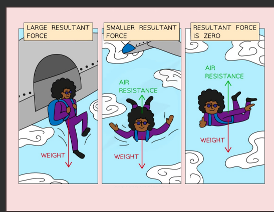
object falls with same acceleration, Speed of falling object increases at a steady rate

Falling object with air resistance

In uniform gravitational field, objects experience weight and friction.

The force of air resistance increases with speed of falling object.

initially the upward air resistance isn't high meaning there is unbalanced forces as air resistance increases, its enough to balance downward force, when air resistance = weight of object, forces are balanced. the object now falls at constant speed called Terminal Velocity.



mass and weight

Mass : a measure of the quantity of matter in an object at rest relative to the observer.

Weight : a gravitational force on an object that has mass.

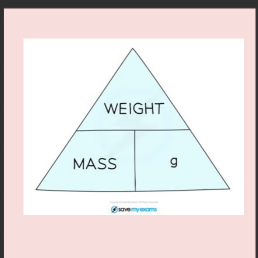
Weight is the effect of a gravitational field strength on mass.

Weight = mass × Gravitational field strength.

$W = mg$, $g = \frac{W}{m}$, $m = \frac{W}{g}$

Gravitational field strength is force per unit mass : This is equivalent to acceleration of free fall.

Weights (and mass) can be compared using a balance.



Mass	Weight
The amount of matter in a body.	Due to pull of gravity on the body
Has only magnitude.	Has both magnitude and direction
Measured in (kg).	Measured in Newton (N).
It remains constant regardless of place or location.	Changes from place to place.

density

Density is mass per unit volume

$\rho = \frac{m}{V}$ where ρ = density, m = mass, V = volume

How to determine density in Solids.

Regular solid

- * measure length, width, height & multiply to find volume.
- * place object on balance to find its mass.
- * $\rho = \frac{m}{V}$

irregular solid

- place object into a measuring cup till it is submerged in water, the increase in water volume is the volume.
- Place object on a balance to find mass
- $\rho = \frac{m}{V}$

Which Object Floats?

any object with a density lower than that of liquid will float above the liquid.

If liquid doesn't mix, does it float?

lower density liquids float on denser liquids if not mixed.

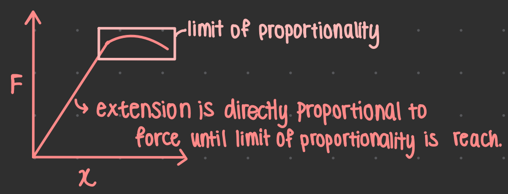
Chapter 1 : Motion, Forces And Energy

Forces

Forces may produce changes in the size and shape of an object.

the spring constant as force per unit extension

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



Limit of proportionality is the point beyond which the extension of an elastic object is no longer directly proportional to the force applied to it.

Resultant force of two forces that act in straight line in the same way is found by just adding them together.

F = ma
the force & the acceleration are in the same direction.

an object either remains at rest or continues in a straight line at constantly speed unless acted on by a resultant force.

A resultant force may change the velocity of an object by changing direction of motion or speed.

Motion in a circular path due to a force perpendicular to the motion as:

* Speed increases as force increases, with mass & radius constant
* radius decrease if force increases, with mass & speed constant
* an increased mass required an increased force to keep speed and radius constant.

Solid friction as the force between two surfaces that may impede motion and produce heating. Friction (drag) acts on an object moving through a liquid and also gas (e.g. air resistance)

Turning Effects of forces

the moment of a forces is a measure of its turning effect.
Eg: Door hinges, a seesaw & unscrewing a nut.

Moment = force × perpendicular distance from the pivot

Principle of moments is when a body is balanced the total clockwise moment about a point equals the total anticlockwise moment about the same point.

When there is no resultant force, and no resultant moment, an object is in equilibrium.

A simple experiment to demonstrate there is no resultant moment on object in equilibrium involves taking an object like a beam & replacing the support with supports with newton (force) meters. the beam will be in equilibrium if both sides exert same force.

Momentum

Momentum = Mass × Velocity
Impulse = force × time
$F\Delta t = \Delta(mv)$

Principal of conservation of momentum states that if two objects collide, total momentum before and after collision remains same if there is no external forces

Resultant force is the change in momentum per unit time.

$F = \frac{\Delta p}{\Delta t}$

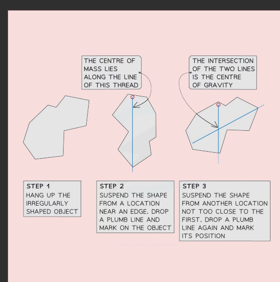
Centre of gravity of an object is the point at which the weight of the object may be considered to act.

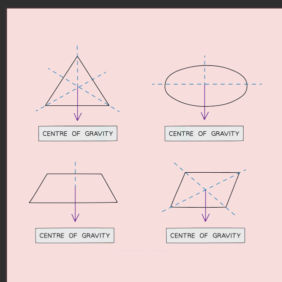
To find the centre of gravity of an irregulary shaped plane lamina :

① Hang up the irregularly shaped object

② Suspend shape from location near an edge. Drop a plumb line and mark on the object

③ Suspend the shape from another location & drop a plumb line & mark the position, the place where lines intersect is the centre of gravity.





The position of centre of gravity of an object affects its stability, the lower the centre, the more stable the object

Chapter 1 : Motion, Forces And Energy

energy, work and power

Energy

Energy may be stored as kinectic, gravitational potential, Chemical, elastic (strain), Nuclear, electrostatic and internal (thermal).

Energy transfer

- energy is transferred between stores during events & processes. Eg:

Transfer by forces (mechanical work done)

– when force acts on object eg: pulling, Pushing, strecning, etc.

Transfer by Electrical currents (electric work done)

– when charge (current) moves through a Potential difference

Transfer by heating

– when energy is transffered from hot object to a colder one.

Transfer by electromagnetic, sound & other waves.

– Energy transferred by electromagnetic waves eg: light.

Kinectic Energy:

energy that object has as a result of its mass and speed.

$E_K = \frac{1}{2}mv^2$ m: mass, V: velocity, E_K: kinectic energy

Gravitational Potential Energy:

energy an object has due to its height in a gravitational field. Change in GPE =

$\Delta E_p = mg\Delta h$ m: mass, g: gravitational field strengnt, Δh: change in height

Principle of Conservation of energy.

– Energy can't be created or destroyed, it can only be transferred from one store to another.

SANKEY DIAGRAMS

- used to represent energy transfers
* flat end of arrow shows energy in
* Straight arrow shows useful energy out
* arrows bending away show waste energy

Total energy in = Useful energy out + wasted energy

Mechanical or Electrical work done is equal to the energy transfe red.

$W = Fd$ ↳ work = force × distance

$W = \Delta E$ ↳ work = change in energy (J)

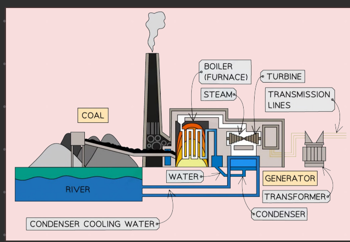
Energy Resources

useful energy may be obtained, or generated from:

- Chemical energy in fossil fuels & biofuels
- Water – energy in waves, tides & dams.
- Geothermal Resources
- Nuclear fuel (non-renewable)
- light from sun to generate power (solar cells)
- Infrared & other electromagnetic waves from the sun to heat water (solar panels) and be source of wind energy.

Energy Resource	Renewable?	Advantages	Disadvantages
Fossil fuels	No	Reliable. Can produce large amounts of energy at fairly short notice.	Produces significant greenhouse gases and pollution
Nuclear	No	Reliable. Produces no greenhouse gases or pollution. A large amount of energy is produced from a small amount of fuel.	Produces dangerous radioactive waste that can take thousands of years to decay
Bio-fuels	Yes	The CO_2 produced while burning the fuel is balanced by the CO_2 absorbed whilst producing it.	Can take up a lot of land and consume resources that are needed for food production
Wind	Yes	Produces no greenhouse gases or pollution. Land can still be used for farming.	Not reliable. Turbines can be noisy and ugly. Not everywhere is suitable
Hydroelectric	Yes	Reliable and can produce large amount of energy at short notice. Produces no pollution of greenhouse gases.	Can involve flooding large area, destroying important wildlife habitats
Tidal	Yes	The tides are very predictable, and a large amount of energy can be produced at regular intervals.	Very few suitable locations. Can cause environmental harm to estuaries and disrupt shipping
Geothermal	Yes	Reliable. Geothermal stations are usually small.	Can result in the release of harmful gases from underground. Not many places are suitable
Solar	Yes	Produces no greenhouse gases or pollution. Good for producing energy in remote places.	Not reliable (only works when sunny). Solar farms can use up lots of farmland.

steam generator to produce electricity



Radiation from the Sun is the main source of energy for all our energy Resources except geothermal, nuclear & tidal. Energy is released by nuclear fusion in the sun.

Research is being done to investigate how energy released by nuclear fusion can be used to produce electric energy on large scale.

the ratio of useful energy / Power output from system to total energy / Power input

$$\text{Efficiency } (\%) = \frac{(\text{useful energy output})}{(\text{total energy input})} \times 100$$

$$\text{Efficiency } (\%) = \frac{(\text{useful power output})}{(\text{total power input})} \times 100$$

Power is Work done per unit time and Energy transferred per unit time.

(a) $P = \frac{W}{t}$

(b) $P = \frac{\Delta E}{t}$

Pressure

Pressure is force per unit area.

$P = \frac{F}{A}$

In real life, pressure is seen in any force exerted

- Push a door
- Standing on floor
- nail / thumb pin

Pressure unit is Pascals (Pa)

Pressure in liquid is exerted from all directions

Force acts at 90° to the Surface of Object

the formula for pressure in liquid is:

$\Delta p = \rho g \Delta h$

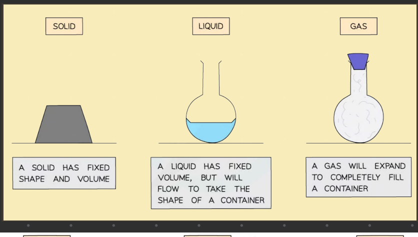
where ρ – liquid density

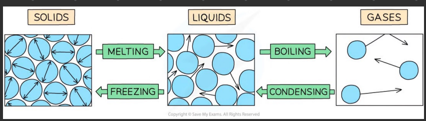
g – gravitational field

Δh – change in height

Chapter 2 : Thermal Physics

Kinetic particle model of matter





State	Solid	Liquid	Gas
Density	High	Medium	Low
Arrangement of particles	Regular pattern	Randomly arranged	Randomly arranged
Movement of particles	Vibrate around a fixed position	Move around each other	Move quickly in all directions
Energy of particles	Low energy	Greater energy	Highest energy
2D diagram			

The absolute zero

Particles move due to energy from the surrounding temperature but at some point there is a temperature where particles no longer move. This is the absolute zero (-273°C)

Pressure is caused by the collision of gas particles onto the walls of its container, forces exerted by particles colliding with surfaces

$P = \frac{F}{A}$ ↳ force per unit area.

Brownian motion is the random movement of of particles in a liquid /gas produced by large numbers of collisions with smaller particles.

Brownian motion can only be seen under microscope and even then you can only see particles like smoke but not the smaller atoms & molecules.

The light, fast-moving atoms and molecules collide with larger microscopic particles.

Gases and Absolute temperature

- Kelvin temperature scale begins at absolute zero
- 0K is equal to -273°C
- 1K increase is same as 1°C increase

It is impossible for temperature to be lower than 0K, it can never be negative

kelvin to °C converting:

$T(\text{in K}) = \theta(\text{in °C}) + 273$

Change in temperature (increase) will cause pressure to increase.

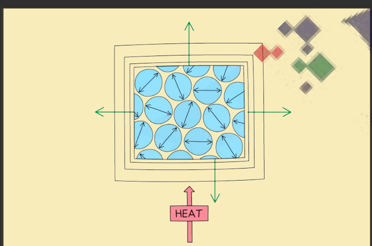
Change in volume (increase) will cause pressure to increase.

$P_1 V_1 = P_2 V_2$

Thermal properties and temperature

Thermal Expansion

- when materials are heated, they expand
- the space taken up by molecules increase
- the molecules themself don't increase in size.



Everyday Application and Consequences of thermal expansion

- Thermometers rely on the expansion of liquid to measure temperature.
- Bimetallic strip that bends up when heated & closes the circuit.

Consequences of expansion:

- metal railway tracks, road surfaces and bridges so gaps are built in.

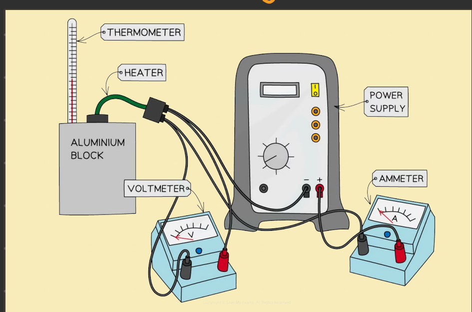
A rise in temperature of an object increases its internal energy

the rise in temperature of an object cause increase in average kinectic energies of all particles in the object.

Specific heat capacity is the energy required per unit mass per unit temperature

$C = \frac{\Delta E}{m \Delta \theta}$ ↱ change in energy ↳ mass × change in temp

Experiment to measure specific heat capacity



Melting: when solid turns to liquid

Boiling: when vapour pressure = liquid pressure no internal temperatur rise

Ice melts at 0°C & water boils at 100°C

* Boiling happens throughout liquid at a set temperature but evaporation happens only at the surface and at any temperature.

Condensation - particle lose KE & come closer and become slower
↳ gas → liquid

Solidification - particles lose more KE, barely move and only vibrate in fixed position.
↳ liquid → solid

Evaporation: the escape of more energetic particles from surface of the liquid.

* Higher temperature = more evaporation
* Higher surface area = more evaporation
* Higher air movement = more evaporation

Evaporation causes cooling of a liquid

- particles at surface of liquid gain energy and change into vapour so all high energy (high temp) particles vapourise leaving behind the low energy cool particles

Chapter 2 : Thermal Physics

transfer of thermal energy

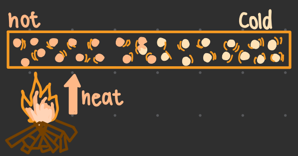
conduction

Thermal conduction occurs when 2 Solids of different temperatures come in contact with one another, thermal energy is transferred from hot to cold Object.

Metals are best conductors because of the high number of free-moving electrons. Atoms need to vibrate & Collide to pass the energy.

Conduction is bad in liquids & gas due to the particles being further away. the vibration can't be passed.

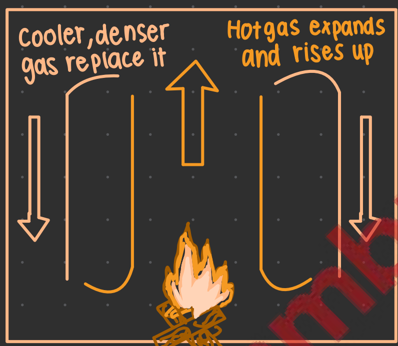
Conductors tend to be metal, Better conductors have delocalized electrons to transfer energy



convection

Convection is main mode for heat to travel through liquids & gases.
- Convection can't happen in Solids

★ When a liquid /gas is heated, this makes the hot liquid/ gas than the surroundings so the liquid/ gas rises, the cooler liquid/ gas will Sink and take its Place & repeat the Process, this is called a convection current.



radiation

thermal radiation is infrared radiation and all Objects emit this radiation and this radiation doesn't require a medium

For an object to be at constant temperature it needs to transfer energy away from the object at the same rate that it recieves energy

Different surfaces radiate & reflect heat differently eg:

if object recieves energy at a rate higher than loss, object temperature will increase. (vice versa)

Greenhouse Effect

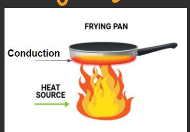
The temperature of earth is controlled by incoming and emitted radiation.

Infrared from the sun is:
- Reflected back to space.
- Absorbed by the earth atmosphere /surface.
- Emitted from earth atmos/surface to space.

Radiated heat is directly proportional to the surface area and temperature of the object.

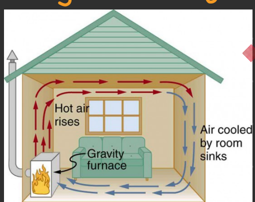
consequences of thermal energy

- Heating objects with kitchen pans

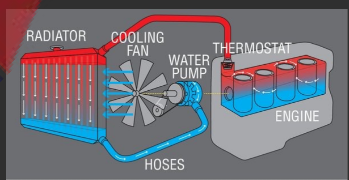


- A fire burning wood / coal

- Heating a room by convection

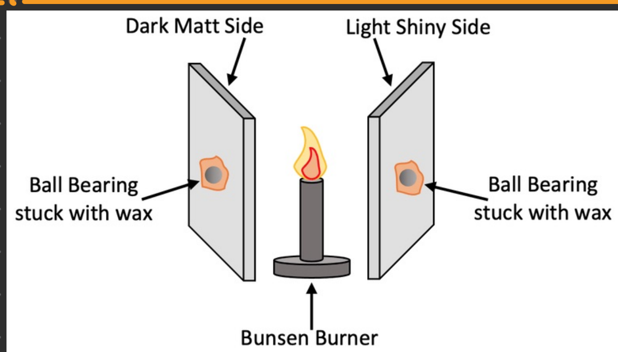


- A radiator in a car



extra notes :

experiments to distinguish good & bad absorbers and emitters

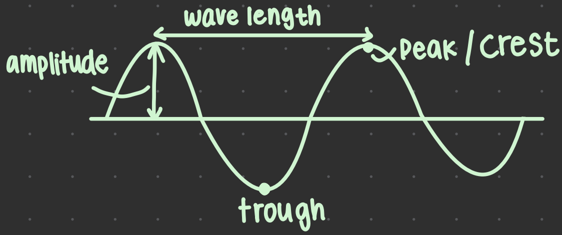


Chapter 3 : Waves

general properties of waves

A wave transfers energy without transferring matter.

Wave motions are oscillations & vibrations
Eg: ropes, strings, and water waves

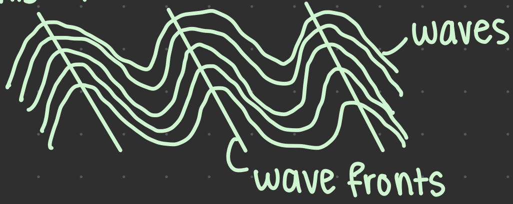


Frequency: number of waves passing a point per sec measured in Hertz (Hz).

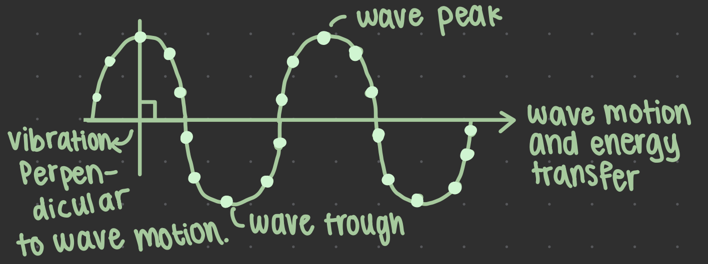
wave speed: distanced travelled by wave per second.

$V = f\lambda$ frequency x wave length (λ) 'lambda'

wave fronts: imaginary surface corresponding points of waves that vibrate in unison.

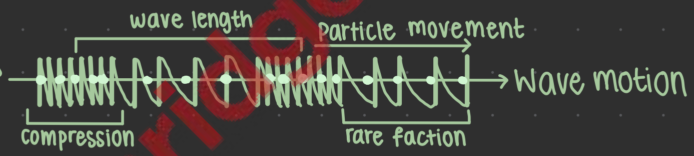


TRANSVERSE WAVES



- Wave vibration is perpendicular to wave propagation.
- Electromagnetic radiation, water waves, seismic (S) secondary waves can be modelled as transverse.

LONGITUDINAL WAVE



- Wave vibration is parallel to the wave propagation.
- Sound, and seismic (P) primary waves can be modelled as longitudinal waves.

reflection

wave hits boundary between two media & doesn't pass through and stays in original medium.
angle of incidence = angle of reflection

refraction

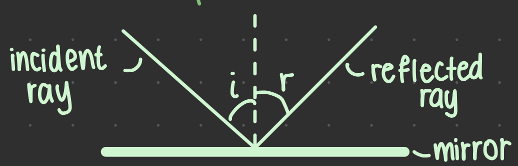
A wave passes a boundary between two transparent media and undergoes change in speed.
a wave refracts and undergoes change in wave length and direction.
if wave slows down, waves bunch up & λ decrease.
if wave speeds up, waves spread out & λ increases.

diffraction

When waves pass a narrow gap, the waves spread out, this is called diffraction.
if gap is smaller, diffraction is more prominent

using a ripple tank

- Reflection at a plane surface



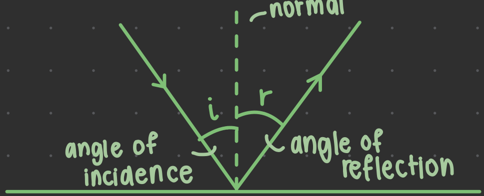
- Refraction due to a change of speed caused by change in depth

extra notes :

Chapter 3 : Waves

Light

Reflection of Light



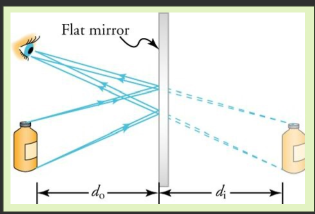
Normal : line that is perpendicular to plane (at 90°)

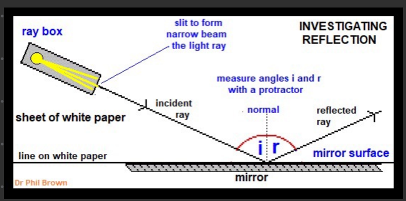
Angle of incidence : angle of wave approaching plane

Angle of reflection : angle of wave leaving plane.

*Angle of incidence = Angle of reflection

A virtual image is formed by the divergence of rays from the image, and can't be projected onto a piece of paper (rays don't go thru image)

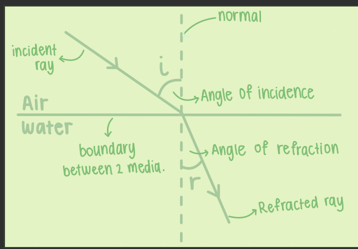




Safety:
- ray box can burn
- Don't look into light
- keep liquid away from items

Control variables : distance of ray box, wavelength, width

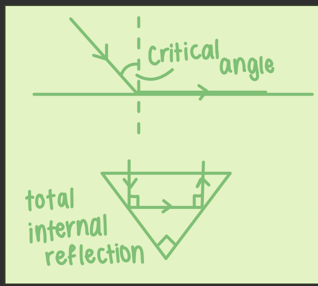
Refraction of Light



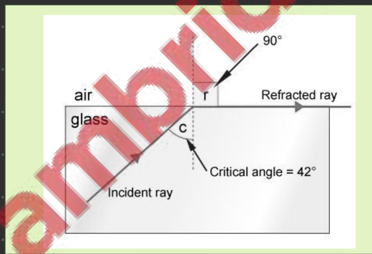
Refractive index, n, is the ratio of speeds of a wave in two different regions.

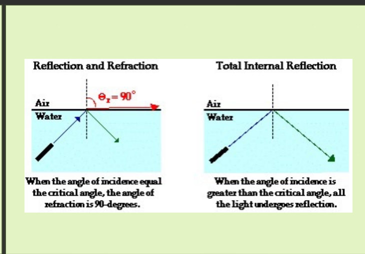
$n = \frac{\sin(i)}{\sin(r)}$ $n = \frac{1}{\sin(c)}$ } Critical angle

Critical angle : the angle of incidence at which the angle of refraction is 90° degrees.



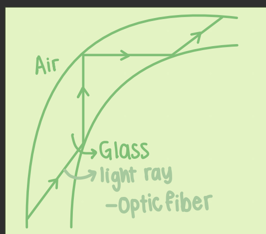
Total internal reflection : when the angle of incidence is greater than critical angle.

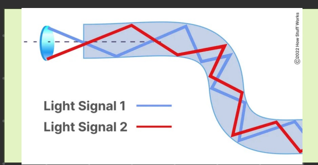




Optical fibres

- technology that transmits info as light pulses along glass/plastic fiber
- used by telecommunication to transmit telephone signals, internet & cable TV signals.





Lenses can be used to:
- single lens for magnifying
- use converging & diverging lens to correct long/short sightedness

Thin Lenses

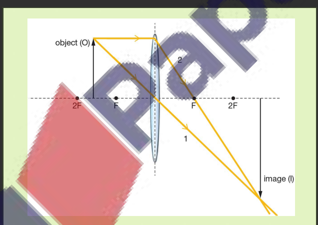
Principal axis : line passing thru lens centre

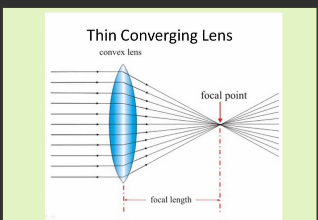
Principal focus : point at which rays of light intersect with principal axis

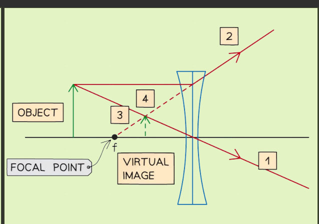
Focal length : distance between centre & focal point

Converging lenses: Parallel rays are brought to a focus called principal focus / focus point. - convex

Diverging lenses: Parallel light rays are made to diverge (spread out) from a point. - concave







Real image : image formed when rays converge & project on screen.

Virtual image : image formed when light rays meet behind lens

Converging lens real image   Converging lens virtual image

Dispersion of Light

The dispersion of light occurs when white light is refracted by a glass prism. the light splits to form a spectrum of 7 colours. this is because each colour has different wavelength & frequency.

Red Orange Yellow Green Blue Indigo Violet

(longest wavelength, lowest frequency) ... Shortest wavelength & highest frequency

A ray of single colour / wavelength is called monochromatic

Chapter 3 : Waves

electromagnetic spectrum

Electromagnetic spectrums have specific order based on wave length or frequencies :

highest wave length & lowest frequency
- radio waves : radio, TV transmissions, astronomy, RFID
- microwaves : Satellite, TV, mobile, microwave ovens, phones
- infrared : electric grills, short range communication, thermal img
- visible light : vision, photography, illumination.
- ultraviolet : Security marking, detecting fake bank notes, sterilize
- X-rays : medical scanning, Security scanners
- Gamma Rays : Sterilizing food & medical equipment, cancer detection & treatment.

lowest wavelength & highest frequency

All electromagnetic waves travel at the same high speed which is 3.0×10^8 m/s and it approx same in air.

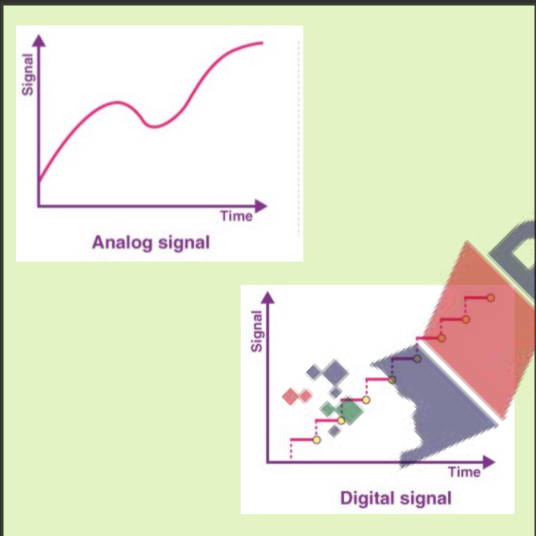
Digital signal : Signal represented by binary numbers
Analogue signal : representation of direct copy of original source
Sound can be transmitted as both analogue & digital signals.

Harmful effects of electromagnetic waves :

Microwaves : internal heating of body cells
Infrared : Skin burns
Ultraviolet : damage to surface cells & eyes – Cancer
X-rays & Gamma Rays : mutation & damage to cells.

Many important communication systems rely on electromagnetic radiation including :
- Mobile phones & wireless internet – microwaves used because they penetrate walls & require short ariel.
- Bluetooth – uses low energy radio waves or microwaves as they pass through walls but signal is weakened by doing so.
- optic fibres – (visible light / infrared) used for cable TV & high speed broadband, visible light carries high rates of data.

Communication with artificial satellites is mainly by microwaves :
- Some satellites phones use low orbit artificial satellites
- Some satellite phones & direct broadcast satellites use geostationary satellites



extra notes :

Sound

Sound is produced by vibrating sources!
Sound waves are of longitudinal nature

compression rarefaction

The approximate range of frequency audible to humans is 20 Hz – 20 000 Hz.

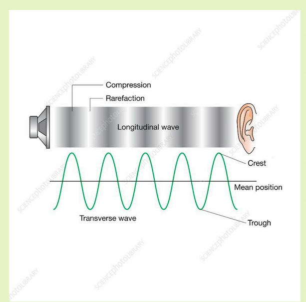
A medium is needed to transmit sound waves (vibrating particles so medium is needed).

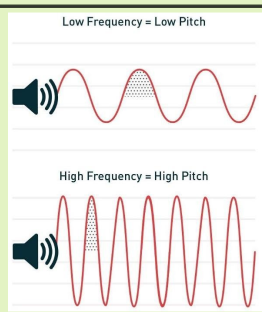
The speed of sound in air is approx 330-350 m/s
In general, sound travels faster in solids than liquid and gas, faster in liquids than gas.

Echoes are a reflection of sound waves.

Ultra sound is a sound with a frequency higher than 20 kHz. It is used in non-destructive testing of material, medical scanning of soft tissue & Sonar.

$$\text{Average Speed} = \frac{\text{distance moved}}{\text{Time taken}}$$





Frequency is related to pitch
high pitch ⟶ high frequency
low pitch ⟶ low frequency
Amplitude is related to volume
high amplitude ⟶ high volume
low amplitude ⟶ low volume

Chapter 4 : Electricity & Magnetism

simple phenomena of magnetism

the two ends of a magnet are called poles : North & south poles.

The like poles Repel (Push each other apart)
The unlike poles attract (move towards each other)

Magnetic materials : experience force when in a magnetic field, attracted to magnet when unmagnetised Can be magnetised to form a magnet
Only a magnet can repel another magnet (test)
Non-magnetic materials : do not experience a force when placed in a magnetic field.

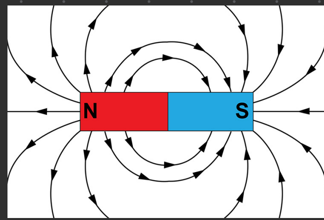
Permanent Magnets :
Compass – always points north due to earth's south pole
School lab experiment – Permanent magnets for demo
Toys
Fridge Magnets – Stick magnet to back of charm.

Uses of electromagnets (temporary magnet) :
MRI Scanners – Used to produce diagnostics of organs
Speakers & Earphones – to sense /send sound waves
Recyling – used to seperate & Recycle metal from rubbish.

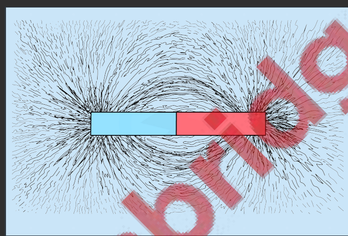
A magnetic field is a region in which a magnetic pole which experiences a force

Pattern & direction of magnetic field around a bar magnet :

* the closer the lines are in the field, the stronger the magnetic field.



the direction of magnetic field always goes from north to South, Magnetic field lines can be plotted by the iron filling method :



- Place magnet below paper
- Spread iron fillings around paper
- let the fillings settle on the field lines

– Place magnet on paper & draw dot at corner of magnet & Place plotting compass near dot, Place another where the Previous points & repeat.

electric circuits

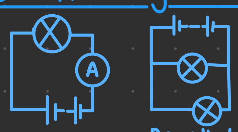
Circuit diagrams

- Cells
- Light-emitting diode
- batteries
- Power supplies — DC, AC
- Generators
- Potential dividers
- Switches
- Resistors — fixed, variable
- heaters
- thermistors
- Light-dependant Resistor
- Lamps
- diode
- Motors
- Ammeters
- Voltmeters
- magnetising Coils
- transformers
- fuses
- Relays

Current at any point in a series Circuit is the same.

- The sum of the currents entering a junction in a parallel circuit is equal to the sum of current leaving.
- total P.d. across the components in a series circuit is equal to the sum of the individual P.d.s across component
- P.d. across an arrangement of Parallel resistances is the same as P.d across one branch in the arrangement of Parallel resistance.

Constructing Series & parallel



Combined e.m.f Series = Sum of all sources
Combined resistance series = $R_1 + R_2 + R_3$...

For a parallel circuit, the current from the source is larger than the current in each branch
The sum of the currents into junction is the same as the sum of currents exiting the junction.

Combined resistance of two resistors in parallel is less than that of either resistor by itself

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

The advantage of connecting lamps in parallel is that you are able to switch on/off seperate lights, even if one lamp is broken, the rest will work.

The P.d across a conductor increases as it's resistance increases for constant Current.

a variable P.d. works with 2 resistors,
The input voltage is applied across resistors & output is taken across on of the resistors : $\frac{R_1}{R_2} = \frac{V_1}{V_2}$

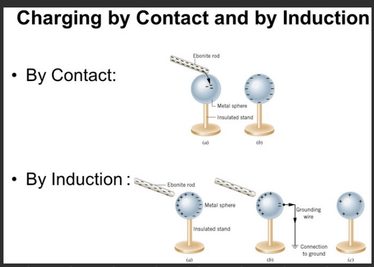
Chapter 4 : Electricity & Magnetism

electrical quantities

there are positive & Negative charges, charge is measured in coulombs

- Like charges repel, opposite charges attract.
- An electric field is a region in which electric charge experiences a force.

*Experiment to show production of electrostatic charges:



The direction of an electric field at a point is the direction of the force on a positive charge at that point.

Charging of solids by friction involves only a transfer of negative charge (electrons).

Electric current is related to the flow of charge.

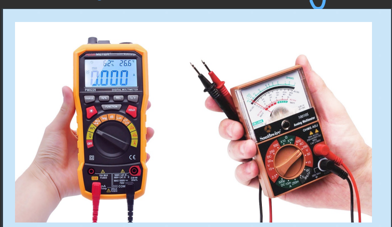
Electric current is charge passing a point per unit time

$I = \frac{Q}{t}$

I - current
Q - charge
t - time

Use of ammeters is to measure current.
Use of voltmeters is to measure volts.

Analogue — Digital

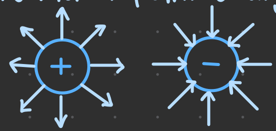


Electrical conduction in metals happens by allowing free electrons to move between atoms.

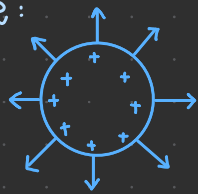
Conventional current is from positive to negative and that the flow of free electrons is from negative to positive.

Simple electric field patterns, Direction of field:

around a point charge.



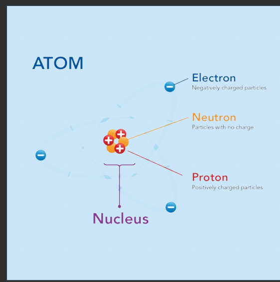
around a charged conducting sphere:



between two oppositely charged parallel conducting plates:

Electrical Conductor and Insulators:

Electron model:



Direct Current: when current flows in one constant directio (batteries / solar cells)

Alternating Current: when current periodically inverts its direction. (electrical appliances & home sockets)

Electromotive force (e.m.f) is the electrical work done by a source in a moving unit charge around circuit.

measured in: (volts) $E = \frac{W}{Q}$ $\frac{\text{work}}{\text{charge}}$

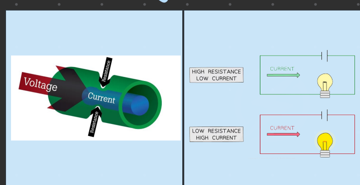
Potential difference (p.d.) as the work done by a unit charge passing through a component

measured in: (volts) $V = \frac{W}{Q}$ $\frac{\text{work done}}{\text{charge}}$

Resistance is how difficult it is for current to pass a component, measured in Ohms(Ω).

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

- Resistance is directly proportional to length
- Resistance is inversely proportional to cross sectional area.



Chapter 4 : Electricity & Magnetism

electrical quantities Continued...

Electric circuits transfer energy from a source of electrical energy, such as an electrical cell or mains supply, to the circuit components & then to surroundings

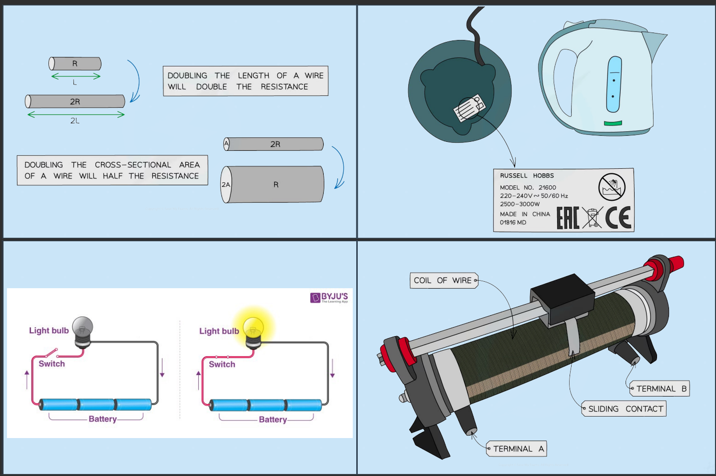
$P = IV$

electrical power = Current x Voltage

$E = IVt$

electrical energy = Current x voltage x time

Kilowatt per hour (kWh) is equal to the energy Converted by a 1kW device for one hour.



electrical Safety.

Hazards of:

- damaged insulation : electrocution
- overheating Cables : burns & short circuit
- damp conditions : electrocution, short circuit
- excess Current from plug overload : fires, short circuit

A mains circuit Consists of a live wire (line wire), a neutral wire and an earth wire and a Switch should always be connected to live wire so when it's switched off no current flows through appliance to prevent electrocution and overloading.

a fuse is a thin wire that heats up & melts when an excess current flows through it, fuse has a rating and this is the maximum current that can flow through it without melting the wire.

$\text{Current} = \frac{\text{Power}}{\text{Voltage}}$ Choose a rating higher than current.

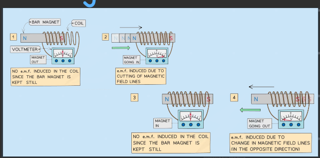
the outer case of an electrical appliance must be non-Conducting or earthed to prevent electric Shocks

A fuse without an earth wire protects the circuit and the cabling for a double-insulated appliance.

electromagnetic effects

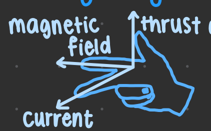
A conductor moving across a magnetic field or changing magnetic field linking with conductor Can induce an e.m.f on conductor.

The direction of an e.m.f opposes the change causing it.



Experiment to demonstrate the electromagnetic induction

Fleming's Right hand rule:

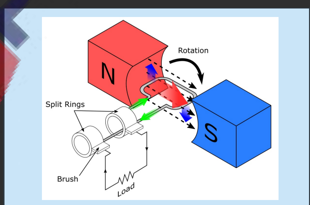


-used to find direction of induced current when a conductor moves in field.

Factors affecting magnitude of induced e.m.f:

- Speed of wire, coil or magnet movement
- number of turns on the coils of wire
- the Size of Coils (larger coil = larger P.d.)
- Strength of magnetic field.

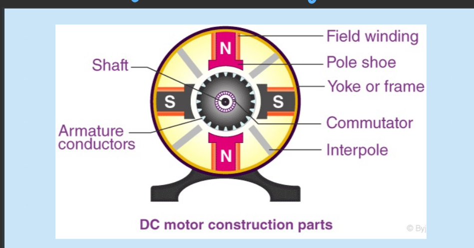
Alternating Current generator:



Direct Current motor

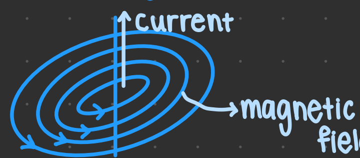
A current-Carrying coil in a magnetic field may experience a turning effect and that the turning effect is increased by increasing:

- the number of turns on the coil
- the Current
- the strength of the magnetic field

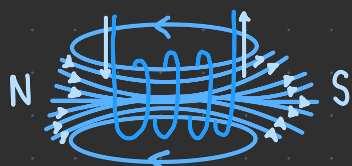


Magnetic effect of a current

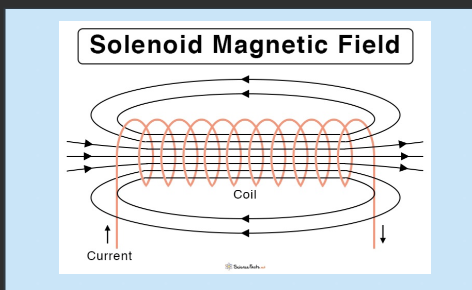
Current in Straight wires:



Current in Solenoids:



The magnetic field created by the Solenoid is much Stronger than that Created by a Straight wire or a flat Circular Coil.



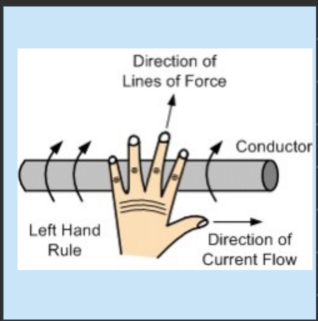
Chapter 4 : Electricity & Magnetism

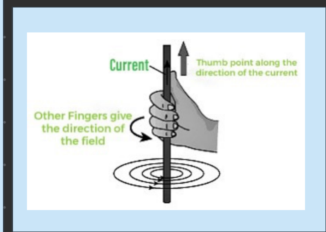
electromagnetic effects Continued...

Electromagnets are used in relays. A relay is a device that uses a low current circuit to switch a high current circuit on or off.

- When the switch in the low current circuit is closed, it turns the electromagnet on which attracts iron armature.
- armature pivots & closes the switch contacts in the high current circuit.
- When low current opens, electromagnet stops pulling the armature and the high current circuit is broken again.

Effect on the magnetic field around straight wires and solenoid of changing the magnitude & direction of the current.





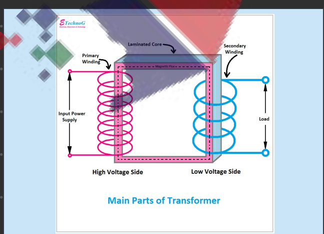
A current carrying conductor will only experience a force if current is perpendicular to direction of magnetic field lines. If the current or direction of field is reversed, the N & S poles are also reserved.

TRANSFORMER EFFICIENCY

if a transformer is 100% efficient,

$V_p \times I_p = V_s \times I_s$

where
V is voltage (Volts)
I is current (Amps)



or... $P_s = V_p \times I_p$

P_s is output power produced in secondary coil (Watts).

High Voltage Transmissions

- Used to increase P.d before transmitted to national grid
- Used to lower high voltage electricity used in power lines
- Used in adapters to lower mains voltage.

Advantages

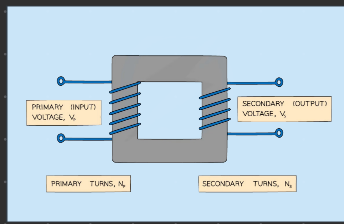
- reduce energy loss – less current, less heat in wires

Energy loss = I^2R or $E = P \times t$

TRANSFORMERS

A transformer is an electrical device that can increase or decrease the potential difference of alternating currents
– This can be done using the generator effect

A basic transformer consists of:
- Primary coil
- Secondary coil
- Soft iron core



Operation of a transformer

- alternating current is supplied to the primary coil.
- the current is continually changing direction
  - Producing a changing magnetic field around primary coil.
- the iron core is easily magnetised, so the field passes through it
  - So now theres a changing field inside secondary coil
  - changing field cuts through secondary coil & induces a potential.
- Since the magnetic field is changing, the P.d. induced will be alternating.
  - alternating P.d is same frequency as current to primary coil
- Secondary coil is part of complete circuit & cause AC flow.

Primary coil – first coil
Secondary coil – second coil

Step up transformer increases P.d of power source
Step up has more turns on secondary coil than primary.
Step down transformer decreases P.d. of power source
Step down has less turns on secondary than primary coil.

TRANSFORMER CALCULATIONS

Output potential difference (voltage) depends on:
- Number of turns on N_p & N_s
- input potential difference.

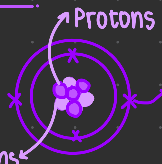
$$\frac{\text{P.d at Primary coil}}{\text{P.d at secondary coil}} = \frac{\text{Number of turns on Primary coil}}{\text{Number of turns on secondary coil}}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Chapter 5 : Nuclear Physics

the nuclear model of the atom

The atom



Scattering Alpha (α) particles by a thin sheet of metal supports nuclear model of the atom as it proves:
- small nucleus surrounded by empty space
- nucleus contains most of atom's mass
- nucleus is positively charged

Atoms may form positive ions by loosing electrons or form negative ions by gaining electrons.

The nucleus is composed of neutrons and protons.

Relative charge of the
electrons is −1
protons is +1
neutrons is 0

Proton number (atomic number) Z
nucleon number (mass number) A
-to find number of neutrons, A minus Z.

Charge of nucleus is given by the number of its protons (Z)
Mass number = total nucleon number

Nuclide notation = $^{A}_{Z}X$

Isotope is two or more species of atom with same atomic number (Z) but different atomic mass (A)
An element may have more than 1 isotope.

Nuclear Fission

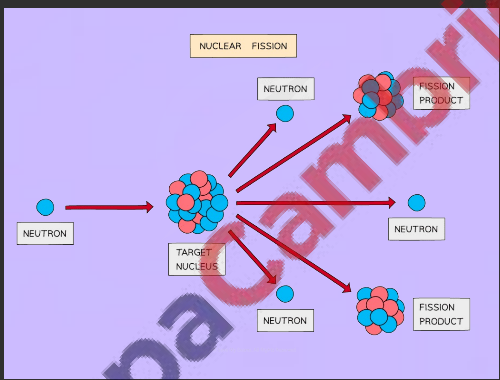
nuclear fission is the splitting of a large unstable nucleus into two smaller nuclei

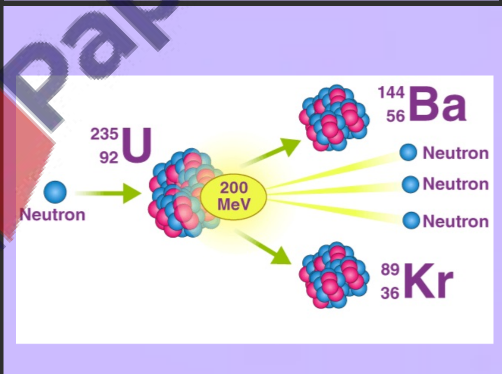
Products of fission move away very quickly
- nuclear potential energy to kinectic energy
- mass of products is less than original nucleus. this is cause remaining mass is converted into energy that is released.

Nuclide equation for fission:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + 3^{1}_{0}n + energy$$

neutron
unstable uranium atom
unstable isotope of krypton
unstable isotope of barium





Nuclear Fusion

nuclear fusion is when two light nuclei join to form a heavier nucleus
This process requires high temperatures to maintain this is why nuclear fusion is hard to reproduce.

energy produced during nuclear fusion comes from a small amount of particles mass being converted into energy

$E = m \times c^2$

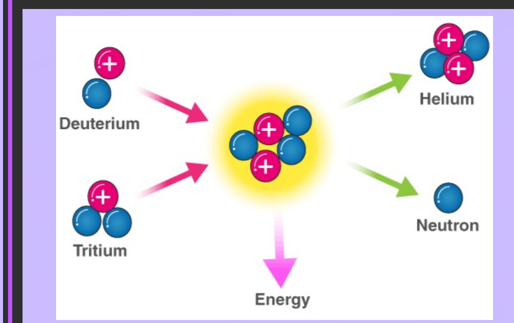
E - energy released in fusion (Joules)
m - mass converted to energy in kg
c - speed of light m/s

mass of product is less than the mass of the two original nuclei
- this is because remaining mass has been converted into energy

Nuclide equation for fusion:

$$^{2}_{1}H + ^{1}_{1}H \rightarrow ^{3}_{2}H + energy$$

$^{2}_{1}H$ - deuterium (hydrogen isotope)
$^{1}_{1}H$ - hydrogen
$^{3}_{2}He$ - Helium



extra notes :

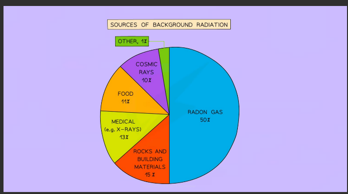
Chapter 5 : Nuclear Physics

Radioactivity

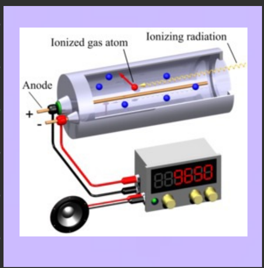
detection of radioactivity

Background Radiation is found in small quantities all around us and originates from natural sources.

Sources that contribute to background radiation:
- Radon gas (in the air)
- Rocks and buildings
- food and drink
- Cosmic Rays



ionising nuclear radiation can be measured using a dectector connected to a counter.



- Count rate is measured in Counts/second or Counts/minute.
- background radiation count rate is minused from each measurement so the actual Count rate is calculated.

three types of nuclear emission

The emission of radiation from a nucleus is spontaneous and random in direction.

The three types of emissions from the nucleus are:

#1: Alpha (α) Particles (deflected by magnetic field)
- 2 protons & 2 neutrons (eg: He Nucleus) - Positive charge
- highly ionising due to double positive charge & large mass
- ionising range of 3-5 cm.
- Penetration low, can't penetrate too far thru matter

#2: Beta (β) Particles (deflected by magnetic field)
- Fast moving electrons
- Moderate ionising power, range about 1m.
- Penetration stopped by few mm of aluminium.

#3: Gamma (γ) radiation (not deflected.)
- Electromagnetic waves
- Low ionisation power, infinite range.
- Penetration reduced by few mm of lead.

— greater the charge of radiation, the more ionising it is
— higher the kinetic energy, the more ionising it is.

radioactive decay

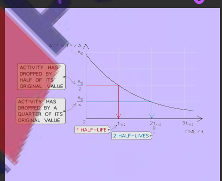
Radioactive decay is the change in an unstable nucleus that can result in the emission of α particles or β particles and/or γ-radiation, these changes are spontaneous and random.

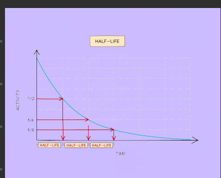
Isotopes of an element may be radio-active due to an excess of neutrons in the nucleus and/or the nucleus being too heavy.

During α-decay or β-decay, the nucleus changes to that of a different element.
During Alpha decay, a completely new element is formed in the Process atomic number decreases by 2, mass number decreases by 4.
During beta decay, neutron changes to Proton & electron. new element is formed.
neutron → proton + electron
During gamma decay, no change but lots of energy emitted, no mass or charge.

half-life

Half life of isotope is the time taken for half the nuclei of that isotope in Sample to decay.





The type of radiation & half-life of isotope determine which isotope is used for:
- household fire (smoke) alarms
- irradiating food to kill bacteria
- Object sterilization with gamma
- measuring object thickness
- diagnosis & Cancer treament (gamma)

Decay Equations

$^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$ (alpha)

$^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta$ (beta)

$^{A}_{Z}X \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$ (gamma)

Safety precautions

the effects of ionising nuclear radiations on living things are cell death, mutations and getting cancer.

Radioactive material is safely stored in lead lined boxes, & kept at safe distance from people. You must use tongs to keep away & avoid direct contact. the radio-active material is used to diagnose, radiation medication & radiopharmac-euticals.

Disposing radioactive waste is done by burying it underground.

Safety precautions for all ionising radiations are reducing exposure time increasing distance between source & living tissue & using shielding to absorb radiation.

Chapter 6 : Space Physics

earth and the solar system

The earth is a planet that rotates on its axis, which is tilted, once in approximately 24 hours. we can observe this by the periodic cycle of day & night, the sun & moon dont move, earth spins.

The earth orbits the sun once every approximately 365 days, this can be seen when sun is furthest up in sky it is summer & when sun is lower down its winter.

The average orbital speed is

$$v = \frac{2\pi r}{t}$$

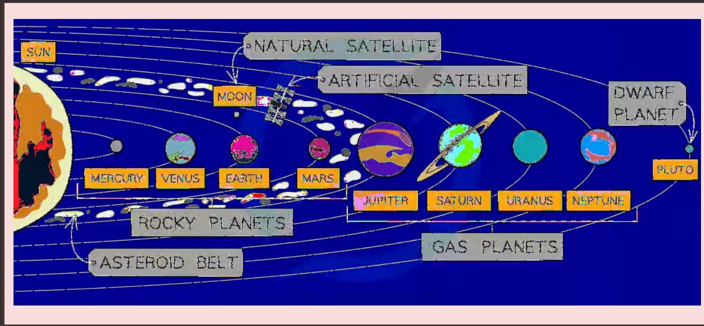
where r is average radius of orbit
T is orbital period

It takes one month for moon to orbit earth and at different times only parts of the moon reflect light while other parts are blocked by earth, hence why we see moon Phases.

The Solar system contains:

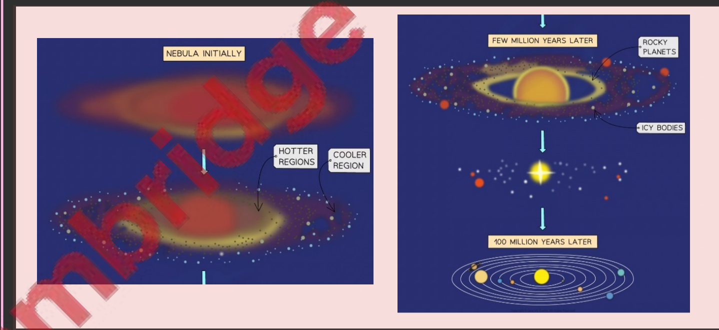
* One star (the sun)
* the eight Planets : Mercury, Venus, Earth, Mars, Jupiter, Saturn, Neptune, and Uranus
* Minor Planets that orbit the sun : Dwarf Planets like Pluto, and asteroids in the asteroid belt.
* Moons that orbit the planets
* Smaller Solar System bodies like comets and natural Satellites.

Note : Minor planets & Comets have elliptical orbits meaning oval shaped orbit, and the sun is not at the centre of the elliptical orbit, except when orbit is extremely circle.



In comparison to the planets, the 4 closest to the sun are rocky and small planets, the 4 furthest from the sun are gaseous and large

Accretion model.



The strength of gravitational field at the surface of a planet depends on the mass of Planet, and around a Planet the strength decreases as the distance from planet increases.

The time taken for light to travel between objects is found by taking speed of light to be : 3×10^8 m/s

The sun contains most of the mass in our solar system so it has the strongest gravitational field strenght so all planets orbit the sun.

the strength of the sun's gravitational field decreases and that the orbital speeds of the planet decrease as distance from sun increases

an object in an elliptical orbit travels faster when closer to the sun and this is because it loses gravitational potential energy & gain kinetic energy as it gets closer to the sun and it causes the object to speed up & this speed increase causes the slingshot effect where its flung back into space & orbit slows

extra notes :

Chapter 6 : Space Physics

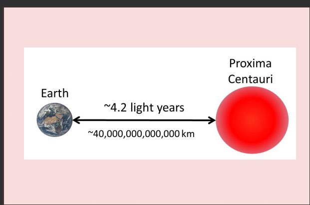
Stars and the Universe

The Sun is a star of medium size consisting of mostly hydrogen and helium, it radiates most of its energy in the infrared, visible & ultraviolet regions of the electromagnetic spectrum.

Stars are powered by nuclear reactions that release energy and in stable stars the nuclear reactions involve the fusion of hydrogen into helium.

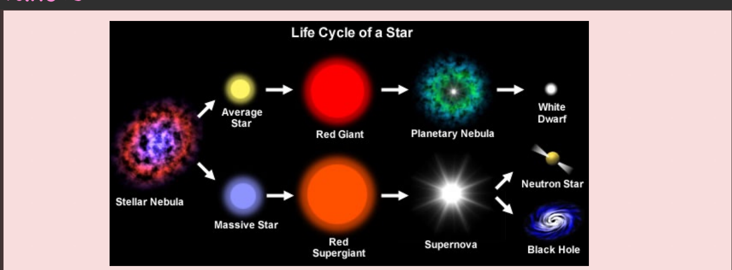
Galaxies are made up of many billions of stars
The sun is a star in the galaxy called the milky way
Other stars that make up the milky way are much further away from earth than the sun.
Astronomical distances can be measured in light years, where one light year is distance travelled in (in vacuum) space by light in one year.

1 light year = 9.5×10^{15} m



The life cycle of a star

* a star is formed interstellar cloud of gas & dust that contain hydrogen
* a protostar is an interstellar cloud collapsing and increasing in temperature as a result of internal gravitational attraction
* Protostar becomes stable when inward force of gravitational attraction is balanced by outward force due to high internal temp.
* All stars eventually run out of hydrogen as fuel for the nuclear reaction.
* most stars expand to form red giants and more stars expand to form red supergiants when most hydrogen is converted to helium
* a red giant from a less massive star forms a planetary nebula with a white dwarf star at its centre.
* a red supergaint explodes as a supernova, forming a nebula containing hydrogen and new heavier elements, leaving behind a neutron star or black hole at its centre.
* the nebula from supernova may form new stars with orbiting planets



The Milky Way is one of many billions of galaxies making up the Universe and that the diameter of the Milky way is approximately 100 000 light years.

Redshift is an increase in the observed wavelength of electromagnetic radiation emitted from receding stars and galaxies.

The light emitted from distant galaxies appears redshifted in comparison with light emitted on the earth.

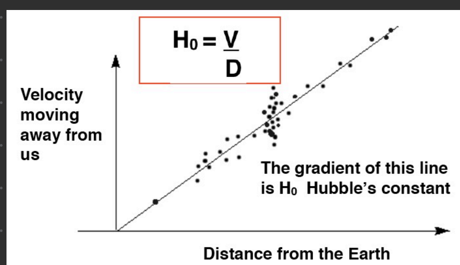
Redshift in the light from distant galaxies is evidence that the Universe is expanding and supports the Big Bang theory.

Microwave radiation of a specific frequency is observed at all points in space around us and is known as cosmic microwave background radiation (CMBR).

CMBR was produced slightly after the universe was formed and this radiation has expanded into microwave region of the electromagnetic spectrum as universe expanded.

Speed (v) at which the galaxy is moving away from the earth can be found from change in wave length of galaxy's starlight due to red shift.

the distance of a far galaxy (d) can be found using brightness of a super nova in that galaxy



The Hubble constant (H_0) is the speed at which the galaxy is moving away from the earth

$$H_0 = \frac{v}{d}$$

The current estimate for H_0 is 2.2×10^{-18} per sec

$\frac{d}{v} = \frac{1}{H_0}$ represents estimated age of universe & all matter in universe was present at a single point.