O Level + IGCSE (Quick Revision)

By: Kashif Iqbal

Scalar: A physical quantity that can be represented by magnitude only.

Examples: distance, time, speed, work energy, power

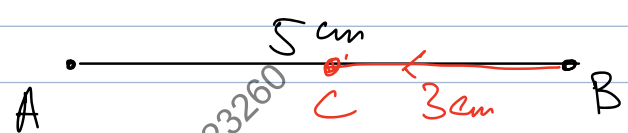
Vector: A physical quantity that can be represented by magnitude and direction.

Examples: displacement, force, velocity, acceleration, momentum,

Distance: Length of path between two points.

Displacement: Shortest (straight) path between two points.

Example:



A → B = 5 cm, B to C = 3 cm

distance = 8 cm, displacement = (5 − 3) = 2 cm

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Speed: Distance travelled per unit time

- SI unit : ms^{-1}
- $\text{Speed} = \frac{\text{distance}}{\text{time}}$
- Speed is a Scalar Quantity

Velocity: Rate of change of displacement

- SI unit : ms^{-1}
- $\text{velocity} = \frac{\text{displacement}}{\text{time}}$
- velocity is a vector quantity

Acceleration: "Rate of change of velocity"

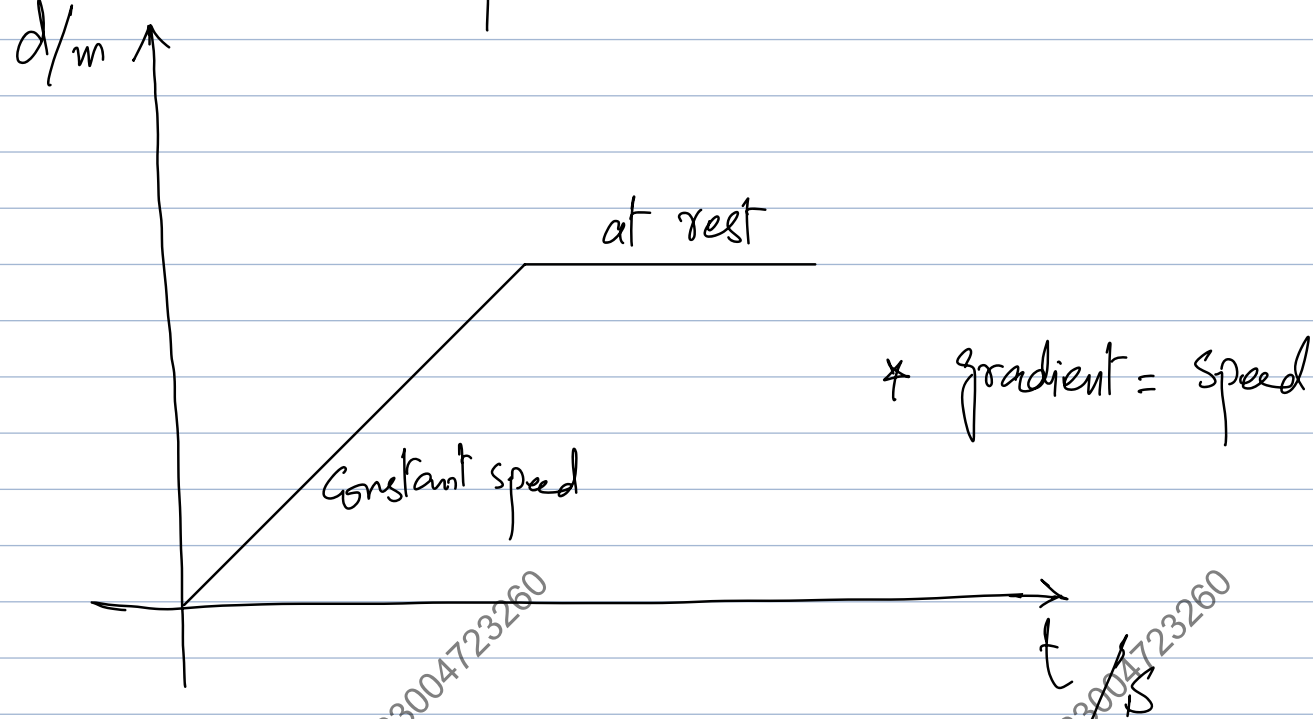
OR "change in velocity per unit time"

- SI unit : ms^{-2}
- $a = \frac{v - u}{t}$
- acceleration is a vector quantity

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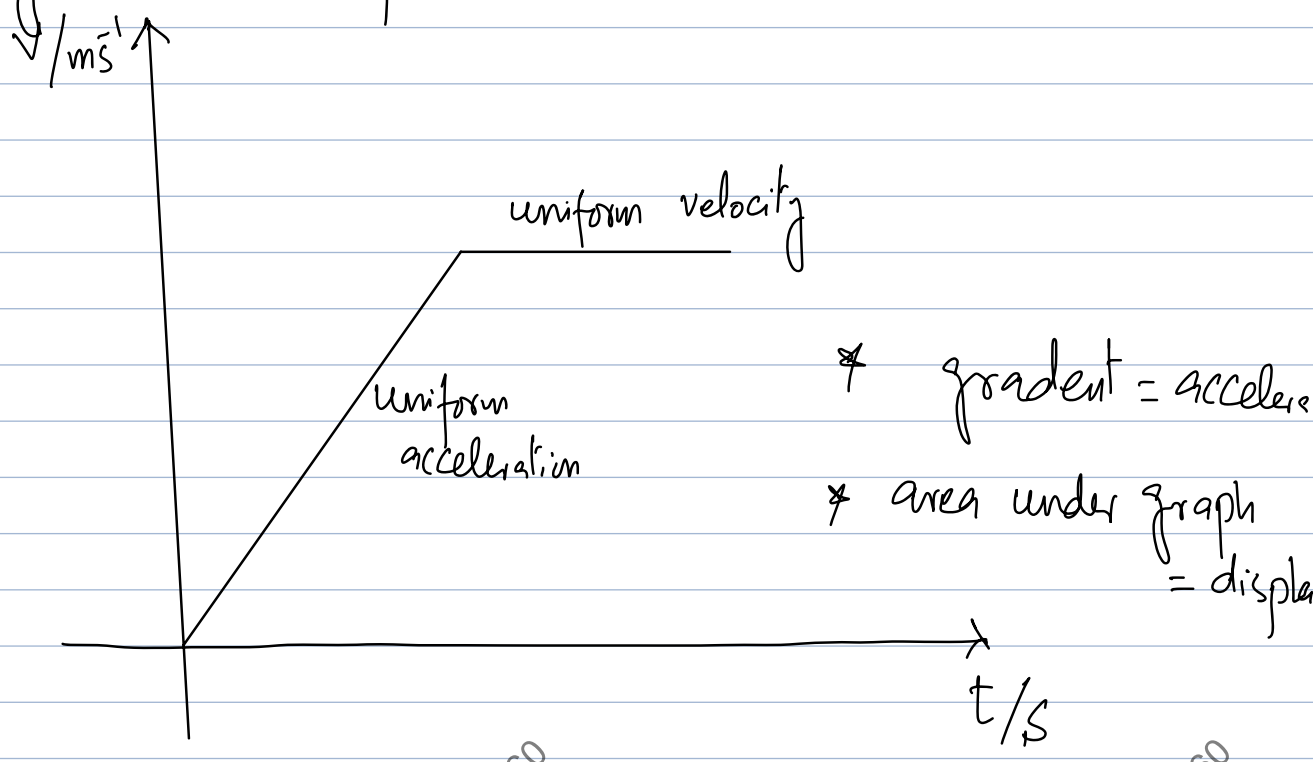
Graphs of Motion

- Distance – Time Graph



* gradient = Speed

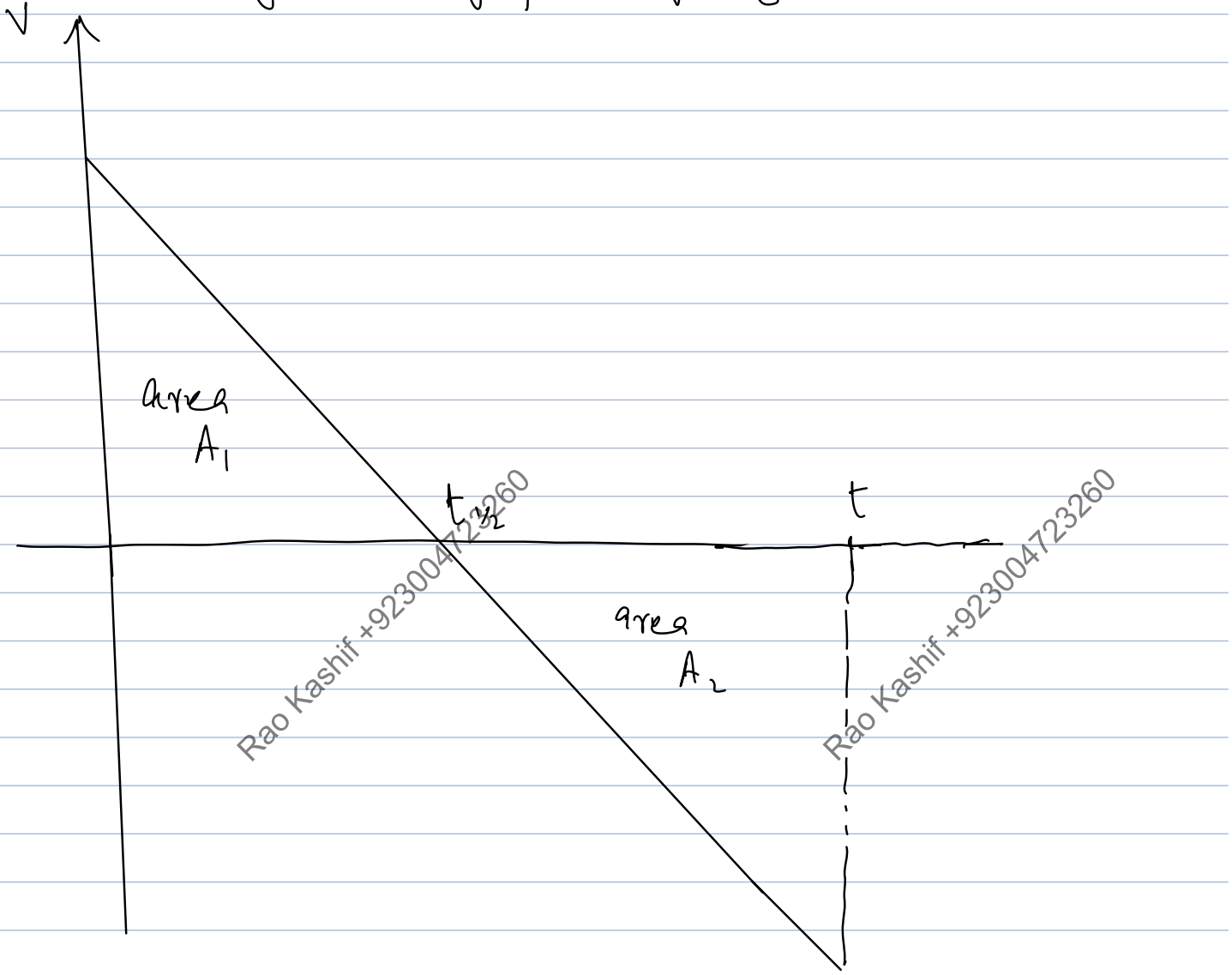
- Velocity – Time Graph



* gradient = acceleration
* area under graph = displacement

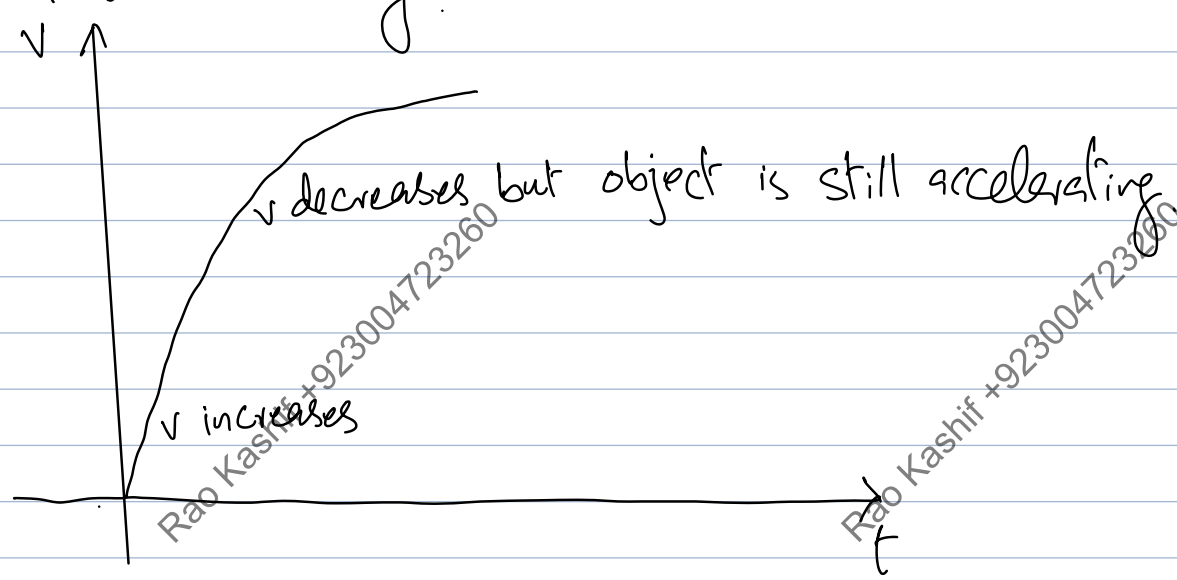
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* If a stone is thrown vertically upwards, it reaches highest point and returns back at same point, sketch its velocity time graph (ignoring air resistance)



displacement = $A_1 - A_2$

* of object falls in air under gravity and reaches terminal velocity.



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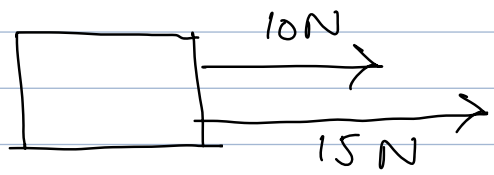
Force: "Force is a push or pull on an object with mass causing a change in velocity". OR "Rate of change of momentum"

- SI unit: Newton (N)
- Force is a vector quantity

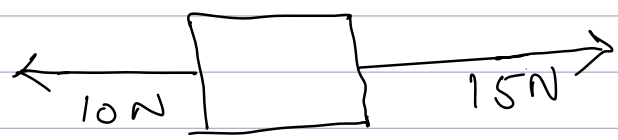
Contact Forces: Friction, air resistance

Non-Contact Forces: gravity, electrostatic force, magnetic force.

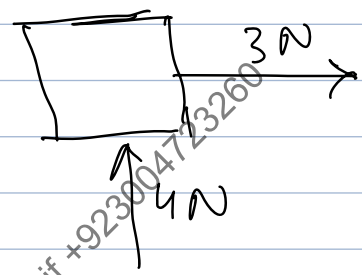
Net force (resultant force)



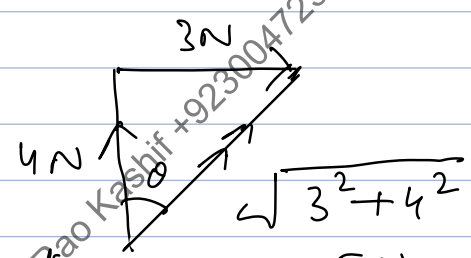
, net force = 25N



, net force = 5N



; net force = 5N



* θ can be found by using trigonometry

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Newton's Laws of Motion

First Law: An object continues its state of rest or of uniform motion unless a net force acts on it.

Second Law: "Net force is equal to product of mass and acceleration"

OR

" Net force produces acceleration which varies directly with the applied (net) force and inversely with the mass of object"

$$F = ma$$

Third Law: " For every action force there is equal and opposite reaction force"

OR

" If an object A exerts force F on object B, then object B will exert force $-F$ on object A"

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Friction: A force that resists the motion when one object slides over another

Mass: The amount of matter occupied by an object.

- SI unit: kg
- it is Scalar quantity
- mass remains same every where
- measured by beam balance / Top-pan balance

Inertia: The property of a body to resist any change in its current state

- Inertia relates with the mass of body

Weight: The gravitational pull that attracts every object towards the centre of Earth.

- SI unit: Newton (N)
- it is vector quantity
- it varies directly with the force of gravity

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Density : "Mass per unit volume"

. density = $\frac{\text{mass}}{\text{volume}}$

. SI unit : $kg\ m^{-3}$

. density is directly proportional to mass (if volume is constant) and inversely proportional to volume of object (if mass is constant).

* Density of an irregular shaped object can be found by using measuring cylinder filled with water. ↑ top-pan balance

Momentum : "The quality of motion due to mass and velocity"

OR

" The product of mass and velocity"

$P = mv$; $P \rightarrow$ momentum

$m \rightarrow$ mass

$v \rightarrow$ velocity

SI unit → $kg\ ms^{-1}$ or Ns

. momentum is vector quantity

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Force and momentum

Impulse : Change in momentum is known as impulse

Impulse = final momentum − initial momentum

$= mv - mu$

however, if object reverses direction

Impulse $= mv + mu$

$$\text{Force} = \frac{mv - mu}{t}$$ (if direction remains same)

$$\text{Force} = \frac{mv + mu}{t}$$ (if object reverses direction)

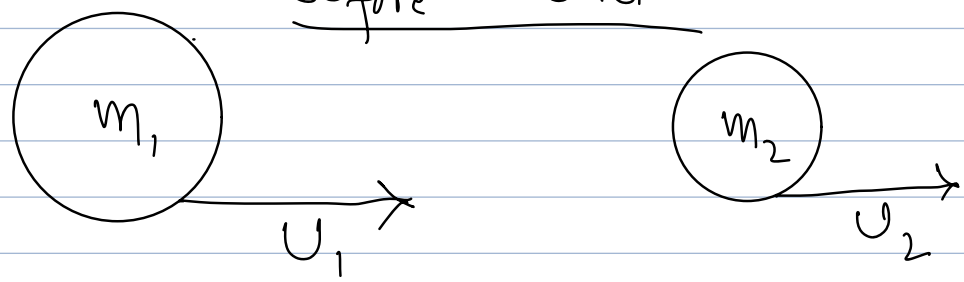
Law of Conservation of Momentum

" Total momentum of an isolated System remains Conserved "

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before Collision



Total momentum = $m_1 U_1 + m_2 U_2$

after Collision

Total momentum = $m_1 v_1 + m_2 v_2$

by law of Conservation of momentum

$$m_1 U_1 + m_2 U_2 = m_1 v_1 + m_2 v_2$$

Note: If objects have opposite direction before and/or after Collision, The plus (+) Sign will Change to minus (−) according to Situation

- If object stick together after Collision

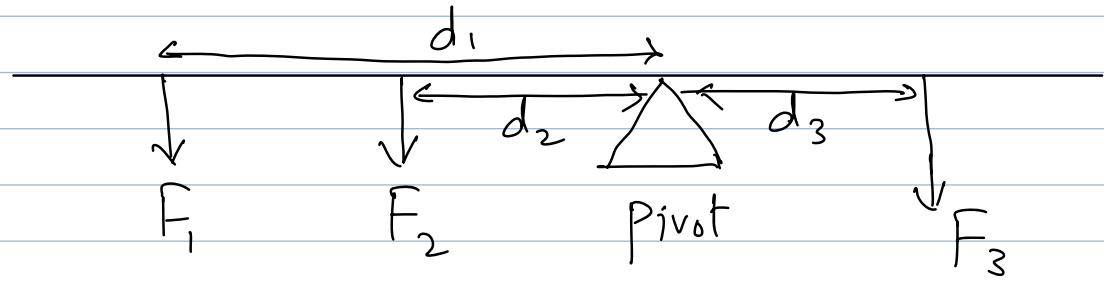
$$m_1 U_1 \pm m_2 U_2 = (m_1 + m_2) V$$

Moment: Turning effect of a force is called moment or torque.

Moment = Force x distance

Note: Force and distance must by perpendicular to each other

Principle of moments: A body is in equilibrium if total clock wise moment is equal to total anticlock wise moment.



$$F_1 d_1 + F_2 d_2 = F_3 d_3$$

Equilibrium: A body is in equilibrium if

(1) net force is zero

(2) net (total) moment is zero

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Work

Work is said to be done when a force causes an object to be displaced in the direction of force

$$\text{Work} = f \times d$$ (force & distance must be in the same direction)

: SI unit : N m or Joule (J)
. Work is a scalar quantity
. Work is a scalar quantity

Energy

The ability to do work

. SI unit : Joule

Forms of Energy

(1) Potential Energy

(2) Kinetic Energy

(3) Mechanical Energy

(4) Chemical Potential Energy

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(5) Thermal Energy

(6) Electrical Energy

(7) Nuclear Energy

- Kinetic Energy — Energy due to motion

$$K.E = \frac{1}{2} mv^2$$

- Potential Energy — Energy due to position (vertical height)

$$P.E = mgh$$

- Law of Conservation of Energy

Energy can neither be created nor be destroyed, it can convert from one form to another.

* Total input energy = useful output + Wasted energy

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Power

"Rate of doing work"

OR "Energy per unit time"

$$\text{Power} = \frac{\text{Work}}{\text{time}} \quad \text{or} \quad \frac{\text{Energy}}{\text{time}}$$

- SI unit : Js^{-1} or Watt (W)

Pressure

"Force per unit area is known as Pressure"

$$\text{Pressure} = \frac{\text{Force}}{\text{area}}$$

- SI unit → $N m^{-2}$ or Pascal (Pa)
- Pressure is a scalar quantity
- Pressure varies inversely with area

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Pressure in liquids

Pressure due to liquid at depth h is given by

$$P = \rho g h \quad ; \quad \rho \text{ is the density of object}$$

Pressure of Gas

- Gas pressure is caused by continuous collisions of gas molecules to the walls of container.
- During collision, molecules exert force on the area of the walls which creates pressure
- If the gas is heated, the frequency of collision will increase therefore, average pressure will increase, thus "pressure is directly proportional to temperature"

$$P \propto T, \quad \frac{P}{T} = \text{Constant}$$

- If the gas is compressed, the volume of gas decreases. Molecules will collide more frequently, Therefore "Pressure is inversely proportional to volume"

$$P \propto \frac{1}{V}$$

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$$P_1 V_1 = P_2 V_2$$

- Combining above two equations, we get

$$\frac{PV}{T} = \text{Constant}$$

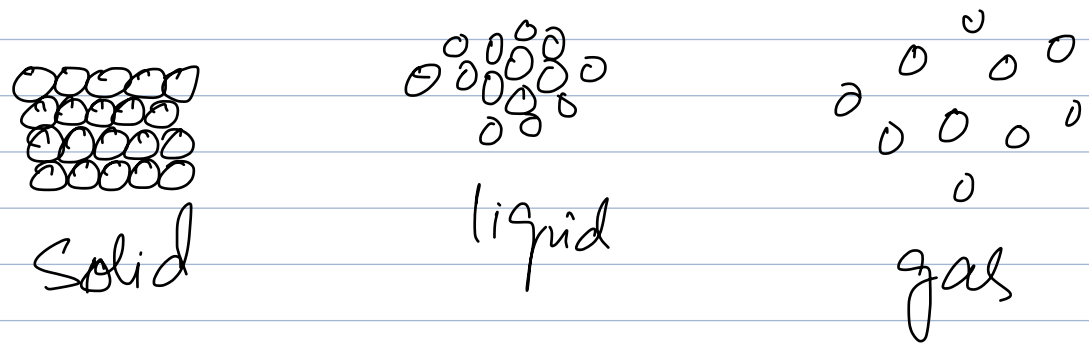
- A gas that obeys this law ($\frac{PV}{T} = \text{Const}$

Kinetic Particle Model

(1) matter is made up of particles called molecules

(2) molecules are in continuous motion

States of matter



Brownian Motion

Disordered (random) motion of gas molecules is called Brownian Motion

Heat Transfer

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Conduction

"Heat transfer by vibrating particles"

Conduction takes place faster in metals due to free electrons

Convection

" Heat transfer by actual movement of particles due to difference of pressure (Concentration)"

Radiation

" Heat transfer in the form of Electromagnetic Radiation"

Radiation depends upon:

(1) Color and texture of a Surface

(2) Surface Temperature

* Dull black Surface is good emitter and good absorber of radiations but poor reflector

* Shiny Silver Surface is good reflector but poor emitter or absorber of radiations

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* In general, dull surfaces are good absorbers and shiny surfaces are good reflectors.

Specific Heat Capacity

" Heat energy required to change the temperature per unit mass by 1°C "

$$c = \frac{Q}{m\Delta\theta}, \quad \text{SI unit: } J\,kg^{-1}\,C^{-1}$$

Latent Heat

Heat energy required to change the state of an object without changing its temperature.

Latent Heat of Fusion

Heat energy required to change an object from Solid to liquid without changing its temperature

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Latent Heat of vaporisation

Heat energy required to change a substance from liquid to gas without changing its temperature.

Specific Latent Heat of Fusion

Heat energy required to change an object per unit mass from solid to liquid without changing its temperature

Specific Latent Heat of vaporisation

Heat energy required to change the state per unit mass from liquid to gas without changing its temperature.

$$l = \frac{Q}{m}$$

$l \rightarrow$ Specific latent heat

$Q \rightarrow$ heat energy (Latent heat)

$m \rightarrow$ mass

- SI unit : $J\,kg^{-1}$

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- Difference between boiling and evaporation.

Boiling	Evaporation
• heating process	• Cooling process
• takes place throughout the liquid	• takes place at surface only
• occurs at a specific temperature	• occurs at all temperatures

Waves

Wave Motion

A disturbance in a medium which causes the particles of medium oscillate

Transverse Waves

Particles of medium oscillate perpendicular to the direction of energy transfer

Longitudinal Waves

Particles of medium oscillate parallel to the direction of Energy Transfer.

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Wavelength

Distance of one Crest and one trough. (Distance from a Centre of Compression to next Centre of Compression)

Amplitude

Maximum displacement from rest position

Time Period

Time taken by one wave to pass through a point

Frequency

Number of waves passing through a point in 1 Sec.

$$f = \frac{1}{T}$$

Wave equation

$$V = f\lambda$$

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Reflection of Waves

Waves incident on the boundary of a medium reflects back such that angle of incidence is equal to angle of reflection

Refraction

Wave enters from deep to shallow: wavelength and speed decreases, frequency remains same.

Diffraction

Spreading of a wave around the edges of an obstacle.

Wave front

The geometrical orientation of a wave obtained by joining all in-phase points.

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Electromagnetic Waves

Waves that can travel without medium.

Properties of EM Waves

(1) In vacuum, all EM waves travel at the same speed ($3.0 \times 10^8 ms^{-1}$)

(2) EM waves consist of fluctuations in electric and magnetic fields

(3) EM waves carry no charge

(4) EM waves obey laws of reflection, refraction and diffraction

(5) Wave equation ($v = f\lambda$) is applicable to EM waves as well.

Electromagnetic Spectrum

Gamma rays | X rays | Ultraviolet | Visible light | Infrared | Microwaves | Radiowaves

→ decreasing frequency (increasing wavelength)

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Uses of EM Waves

Infrared

- Our bodies detect infrared radiations
- it is emitted by hot object
- Used in thermal imaging cameras
- Used in finding victims of Earthquake
- remote control

Ultraviolet

- Cause Sun tan
- produce vitamins in skin using Sunlight
- Too long exposure is harmful
- Used in fluorescent paints and detergents
- Used in security markings like invisible signatures
- Used in water treatment plants to kill bacteria
- long exposure can cause cancer and eye problems

Radio Waves

- high wavelength waves used for aerial communication to spread signals over a vast area
- Astronomers use radio telescopes to pick radio signals from other stars and galaxies

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to get information about the universe

Micro Waves

- used for international communication via Satellite
- wireless applications such as bluetooth
- used for cooking as they cause water molecules in the food to vibrate vigorously

X-rays

- In medical, used to detect broken, dislocated bones
- High dose X-rays can be used to kill cancer cells
- Security machines at airports but they are very low dose X-rays
- In engineering, X-rays are used to inspect welded joints and detect cracks in metals

Gamma rays

- These are more penetrating and

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dangerous than X-rays
- Used to diagnose and treat cancer
- Used to detect cracks and flaws in metals

Sound

- Sound waves are longitudinal in nature
- Speed of sound is slower in gases ($300-400\ ms^{-1}$), faster in liquids ($1000-1500\ ms^{-1}$) and fastest in solids (few thousand ms^{-1})
- Sound does not travel through vacuum (bell jar experiment can be explained)

Echo of Sound = Reflection of Sound is known as echo"

Loudness of Sound = Amplitude of Sound is loudness"

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Pitch of Sound = Frequency of Sound"

: Higher frequency, higher pitch

- Human audible range: 20 Hz — 20 kHz

Ultrasound: Sound waves of frequency greater than 20 kHz.

Uses of ultrasound

(1) Pre-natal Scanning: ultrasounds are transmitted through the body, the reflected pulse can be detected.

(2) Cleaning jewellary

(3) depth of Sea bed

Light

- Light travels in a straight line

Reflection of Light

Light waves incident on the boundary of a medium bounce back such that angle of incidence is equal to angle of reflection.

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Laws of Reflection

(1) angle of incidence is equal to angle of reflection

(2) incident ray, reflected ray and normal to the point of incidence, all lie on the same plane.

Types of Reflection

(1) Regular reflection: reflection of smooth surface

(2) Irregular reflection: reflection of rough surface.

Properties of image in a plane mirror

(1) Same size

(2) Same distance

(3) upright

(4) left – right inverted

(5) virtual

Refraction of Light

Bending of light when it enters from one medium to another.

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- The speed of light slows down when it enters from rare to dense medium

Laws of Refraction

(1) incident ray, refracted ray, and normal to the point of incident, all lie on the same plane

(2) refractive index $n = \frac{\sin i}{\sin r}$ (light enters from rare to dense medium)

$n = \frac{\sin r}{\sin i}$ (dense to rare medium)

Total Internal Reflection

It occurs when light ray travelling from dense to rare medium totally reflects back into the same medium

Critical Angle: The angle of incidence for which angle of refraction is

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90° is called Critical Angle.

* When angle of incidence is greater than critical angle, total internal reflection occurs.

Uses of Total Internal Reflection

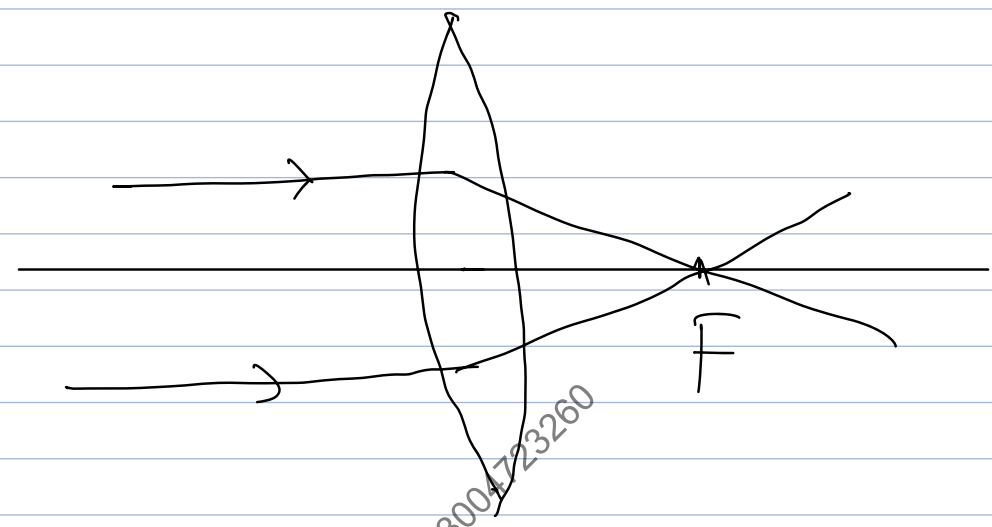
(1) optical fibre : Thin glass wires used for communication (less expensive)

(2) Periscope

Types of Lenses

(1) Converging Lense

It converges all parallel rays at a single point called focal point

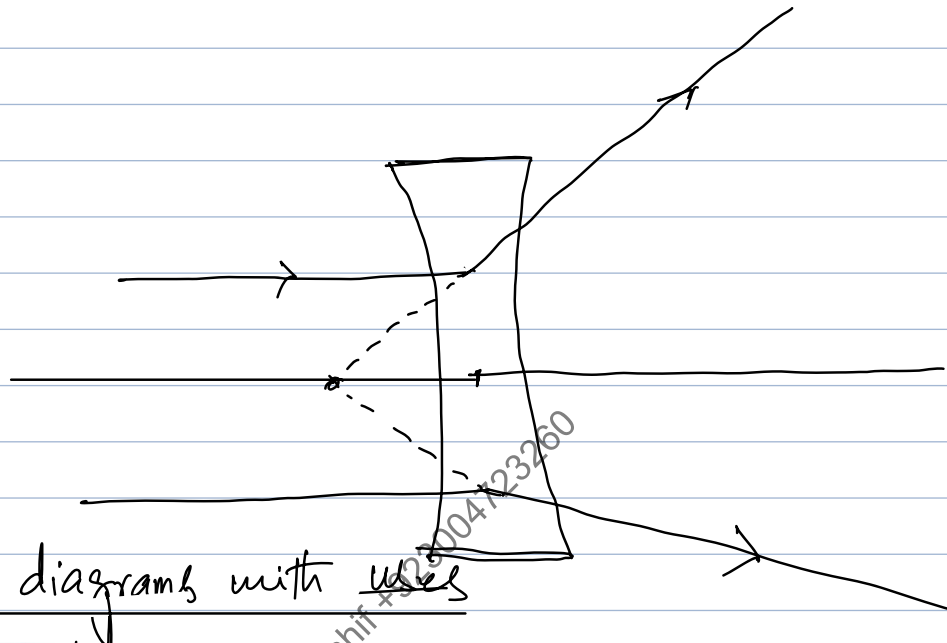


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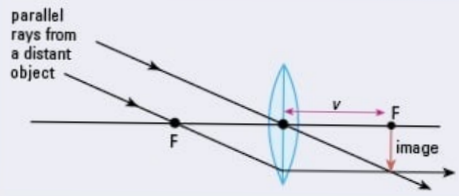
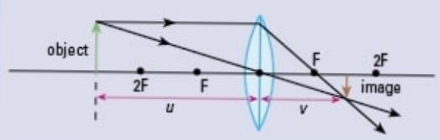
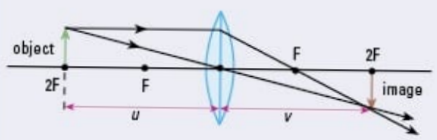
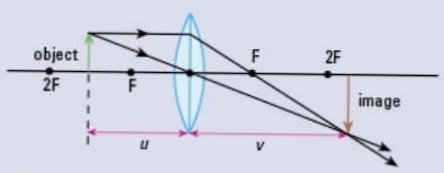
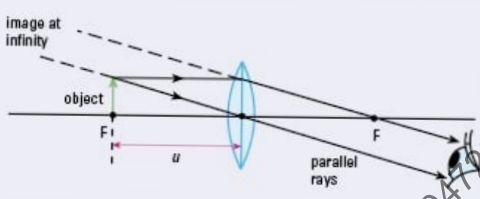
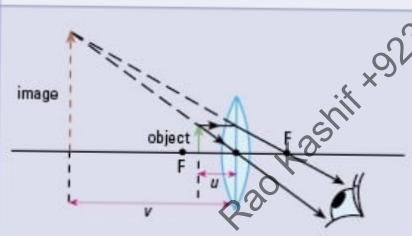
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(2) Diverging Lenses

. Diverges all parallel rays. If's Principle focus is virtual

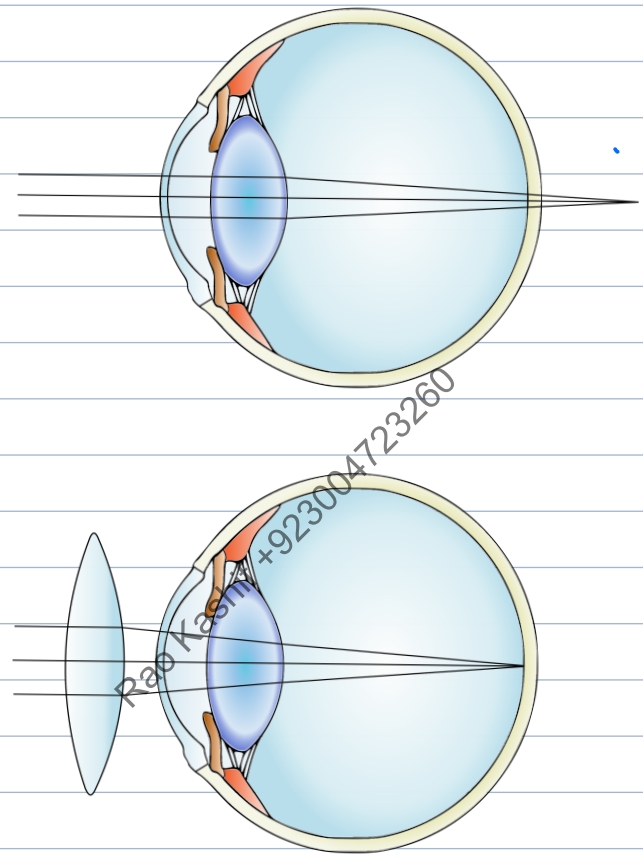


Important ray diagrams with uses

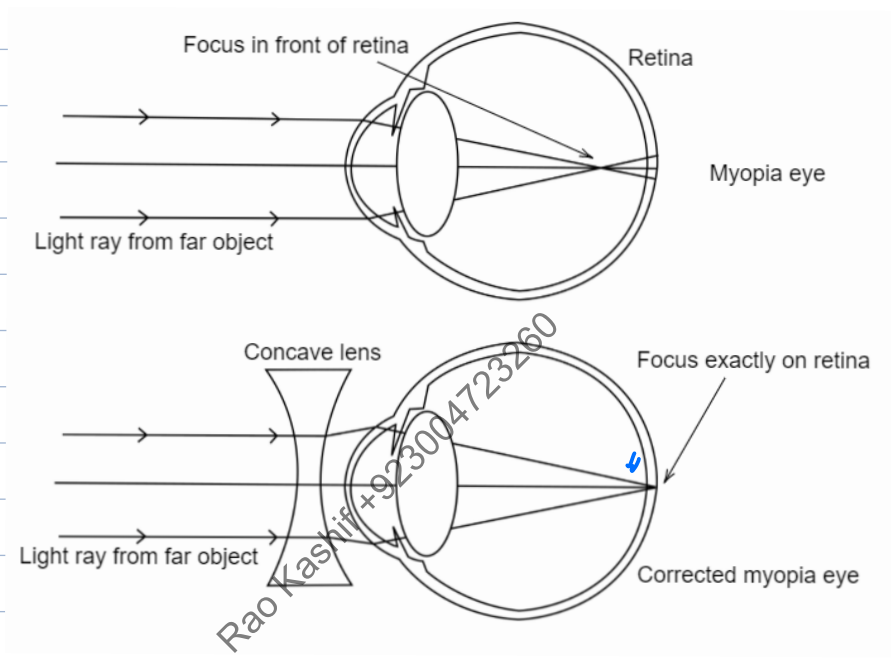
Object distance (u)	Ray diagram	Type of image	Image distance (v)	Uses
$u = \infty$		- inverted - real - diminished	$v = f$ - opposite side of the lens	- object lens of a telescope
$u > 2f$		- inverted - real - diminished	$f < v < 2f$ - opposite side of the lens	- camera - eye
$u = 2f$		- inverted - real - same size	$v = 2f$ - opposite side of the lens	- photocopier making same-sized copy
$f < u < 2f$		- inverted - real - magnified	$v > 2f$ - opposite side of the lens	- projector - photograph enlarger
$u = f$		- upright - virtual - magnified	- image at infinity - same side of the lens	- to produce a parallel beam of light, e.g. a spotlight
$u < f$		- upright - virtual - magnified	- image is behind the object - same side of the lens	- magnifying glass

Defects of Visim

(1) **Far Sightedness**: Inability to see nearby objects clearly. (Converging lense is used)



(2) **Near Sightedness**: Inability to see distant objects clearly. (Diverging lense is used)



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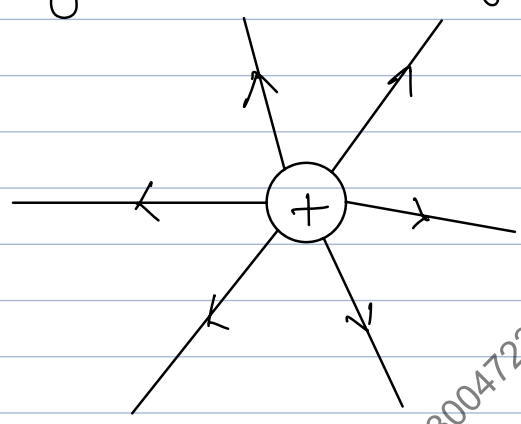
Electrostatics

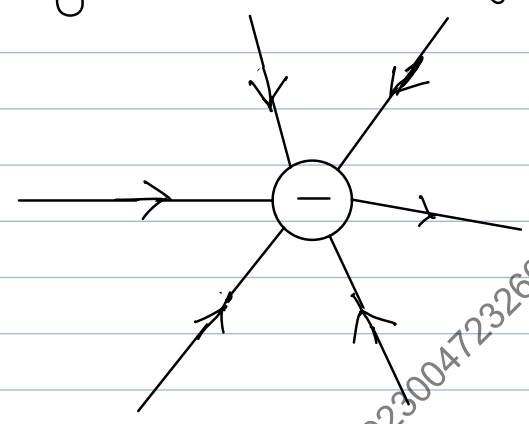
" Study of charges at rest is known as electrostatics"

- Insulators can be charged by rubbing (friction)
  " The object that gains electrons becomes negatively charged while the object that loses electrons becomes positively charged"

- Conductors can be charged by Electrostatic Induction: bringing a charged object near an uncharged Conductor.

- Electric Field: "The region of space around a charge in which its electrostatic force (attraction or repulsion) can be experienced by other charge"





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Electric Current

Rate of flow of Charge through a cross-sectional area

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

- SI unit of current: Ampere (A) or Coulomb per second (Cs^{-1})
- SI unit of charge: Coulomb (C)
- SI unit of time: second (s)

Conventional Current

Current flowing from positive to negative terminal of battery

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Current Electricity

Electric Current: "Rate of flow of charge through a cross-sectional area"

$$I = \frac{Q}{t} \quad ; \quad Q \longrightarrow \text{Charge (Coulomb)}, \quad t \longrightarrow \text{time (Seconds)}$$

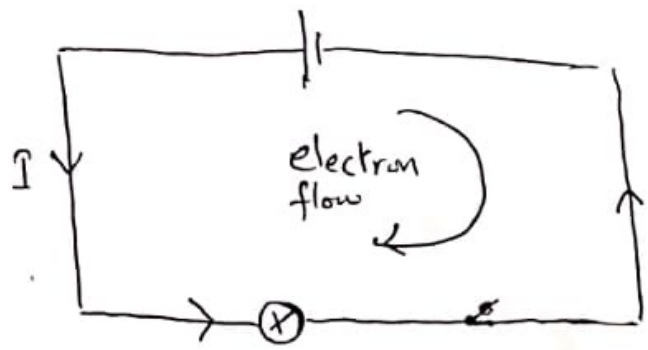
- SI unit → Ampere (A) or $C\,S^{-1}$

Example: If 5 μC charge flows through a part of wire in 3 mS. What will be amount of electric current?

Sol:

$$I = \frac{Q}{t} = \frac{5 \times 10^{-6}\,C}{3 \times 10^{-3}\,S} = 1.7\,mA$$

Conventional Current: "The current that flows from positive to negative terminal of battery" (It is assumed due to flow of positive charges.



Measurement of Current: We use ammeter (A) to measure the current. It is connected in Series with the part of circuit whose current is to be measured.

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Electromotive force (e.m.f)

" It is work done by the battery in driving unit charge around a Complete Circuit"

$$E = \frac{W}{Q}$$

SI unit ⟶ Volt(V) or JC^{-1}

Potential Difference (p.d.)

" P.d. across a circuit Component is work done in order to drive a unit charge a through that Component"

$$V = \frac{W}{Q}$$

SI unit ⟶ Volt(V) or JC^{-1}.

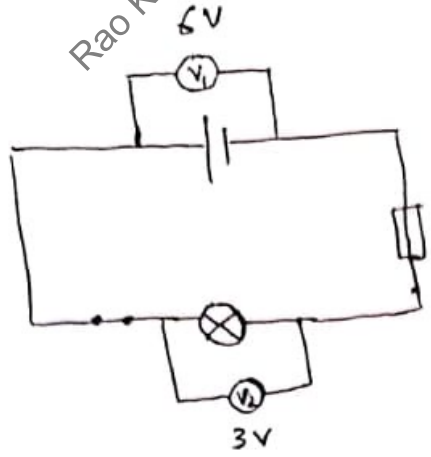
Despite having same formula and SI unit, there are some significant differences between e.m.f and p.d

- e.m.f is referred to the voltage of battery and potential difference is of individual circuit Component.
- e.m.f is energy converted from non-electric to electric form where potential difference is refers to energy from electric to non-electric form.

→ We use voltmeter to measure potential difference or e.m.f.

→ Voltmeter is always Connected in parallel across battery or Circuit-Component

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In this diagram $V_1 = 6V$ is e.m.f and $V_2 = 3V$ is potential difference.

Ohm's Law

"Current passing through a conductor is directly proportional to the potential difference across it, Provided that physical conditions remains constant

$$V \propto I$$

or $$V = IR$$

The constant of proportionality R is the resistance.

"It is the property of a conductor due to which it resists the flow of electric current"

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

It is ratio of potential difference to electric current. unit of resistance is ohm (Ω)

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Resistor

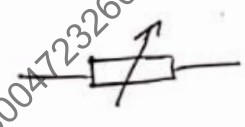
It is used to create resistance. We use resistors to control the flow of electric current.

There are two types of resistors:

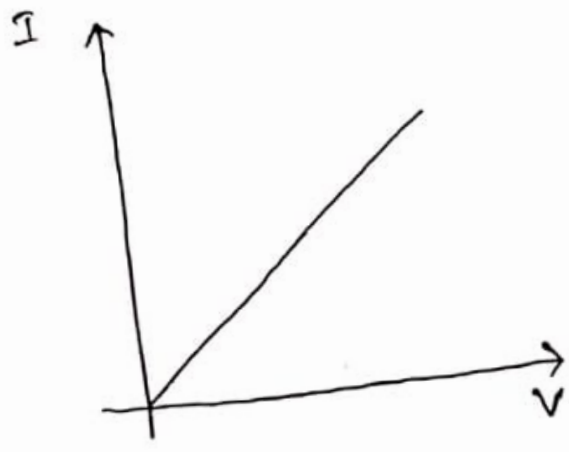
Fixed Resistor: = Resistor with constant resistance"

Symbol: 

Variable Resistor: = Resistor ~~with~~ whose resistance can be changed". It is also called rheostat

Symbol: 

Ohmic Conductors = The conductors that obey Ohm's Law" (resistance remains constant over a wide range of p.d. and current).



" Gradient of this graph is constant i.e

$\frac{1}{R}$ = Constant

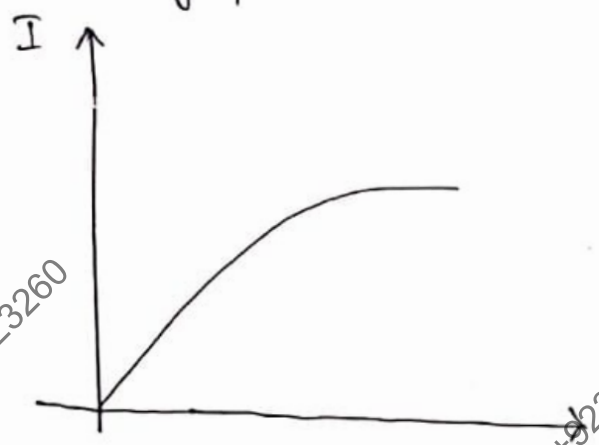
This means R = Constant"

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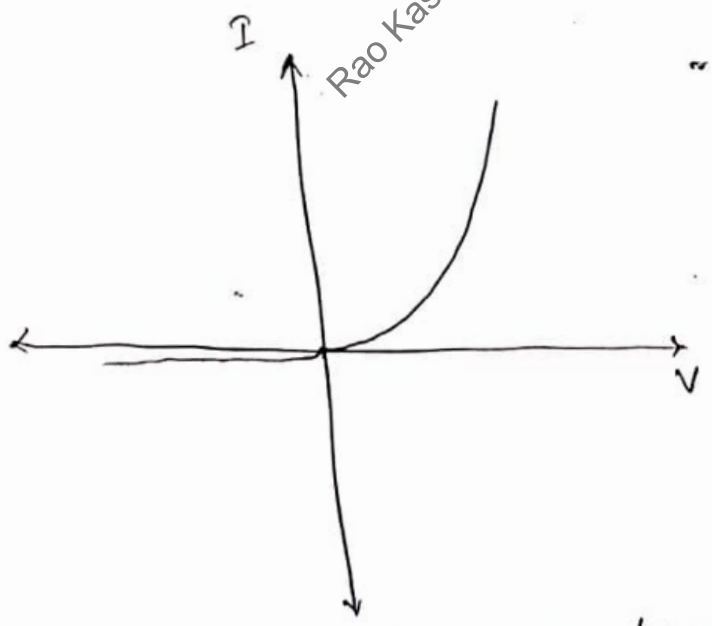
Non-ohmic Conductors

For most of electrical devices we use in our daily life, the resistance does not remain constant as it it greatly affected by temperature and other physical conditions. These devices do not obey ohm's Law and we call them Non-ohmic Conductors.

I-V graph is not straight line.



"I-V graph of a filament lamp. It gains more heat energy and resistance increases"



"I-V graph of a diode. It is used to allow one-way flow of current. It is used as rectifier (a device converts A.C. to D.C.)"

* Diode a is either reverse biased or forward biased. When it is forward, large current will flow which means resistance will be low. When it is reverse, almost no current flows which means it will have high resistance when reverse biased.

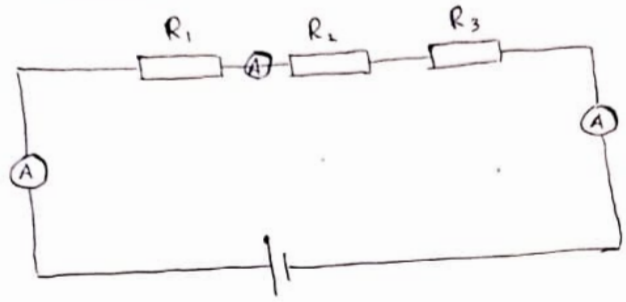


(forward biased)

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Combinations of resistors

Series Combination



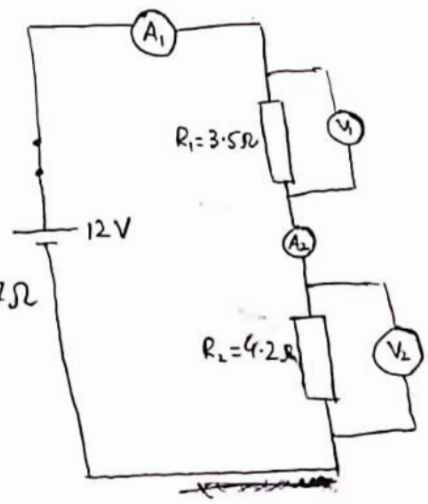
Properties

- all resistors are connected side by side with a single wire
- Current flowing through each resistor is same
- Potential difference divides. Higher the resistance, higher the voltage. $V = V_1 + V_2 + V_3$
- Combined resistance in series combination:

$$R = R_1 + R_2 + R_3 + \cdots$$

Example

The diagram shows a circuit, Calculate value of A_1, A_2 and V_1, V_2



Solution

Combined resistance:

$R = 3.5 + 4.2 = 7.7\Omega$

$$I = \frac{V}{R} = \frac{12}{7.7} = 1.6\ A$$

Since current is same in series combination; So $A_1 = A_2 = 1.6A$

Now

$V_1 = IR_1$

$= 1.6 \times 3.5$

$= 5.6\ V$

$V_2 = IR_2$

$= 1.6 \times 4.2$

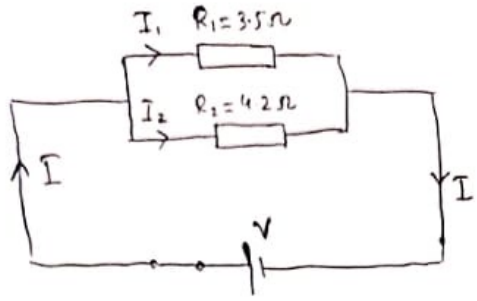
$V_2 = 6.7\ V$

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Parallel Combination



Properties

- Potential difference across each resistor is same and equal to e.m.f of battery $V = V_1 = V_2 = V_3$
- Current divides, larger the resistor, smaller the current

$$I = I_1 + I_2 + I_3$$

- Combined resistance in parallel combination:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \rightarrow \text{General formula}$$

However, for two resistors in parallel; R_1 and R_2, we can use:

$$R = \frac{\text{Product}}{\text{Sum}} = \frac{R_1 R_2}{R_1 + R_2}$$

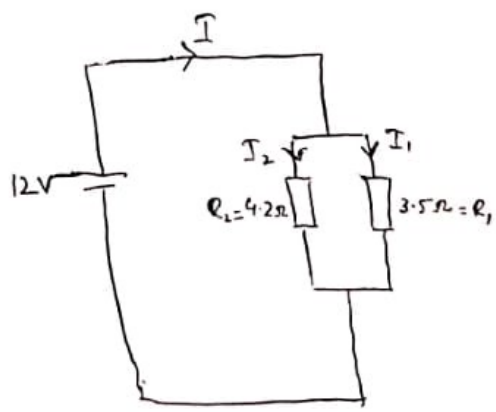
Example:

$$R = \frac{3.5 \times 4.2}{3.5 + 4.2} = 1.9\,\Omega$$

$$I = \frac{V}{R} = \frac{12}{1.9} = 6.3A$$

$$I_1 = \frac{V}{R_1} = \frac{12}{3.5} = 3.43A$$

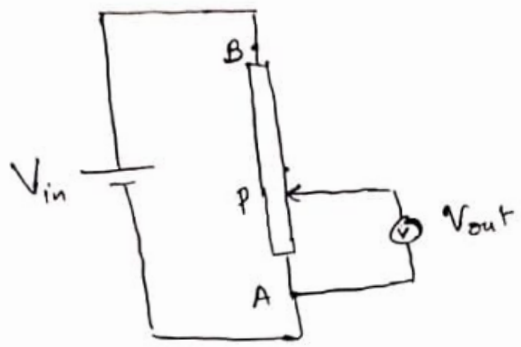
$$I_2 = \frac{V}{R_2} = \frac{12}{4.2} = 2.85A$$



Potentiometer

It is a potential divider having a large resistor with three terminals

Symbol · 



$$V_{out} = \frac{V_{in} \times R_{PA}}{R_{AP} + R_{PB}}$$

. Note that if resistance R_2 (connected to V_{out}) increases output voltage will increase.

Thermistor

A device whose resistance decreases as temperature increases

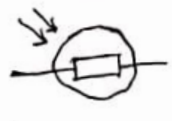
. used in fire alarm

. Symbol 

Light Dependent Resistor (LDR)

A device whose resistance decreases as light intensity increases

. used in street lamps

. Symbol 

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Sources of electrical Energy

- **Solar Power**

  Advantages: High efficiency in daylight, renewable, clean energy

  Disadvantages: Low efficiency at night or in cloud cover, high cost, requires large land area for installation

- **Hydroelectric Power**

  Advantages: Highly efficient, easily managable as water can be controlled, renewable, clean energy

  Disadvantages: Dams require large land, disrupt ecosystem, Silt in large dams

- **Wind Power**

  Advantages: Highly effective in windy areas, renewable, clean energy

  Disadvantages: costly, land occupied, harms birds

- **Nuclear Power**: Highly efficient,

  Disadvantages: Harmful nuclear waste, costly, contaminates water
  Non-renewable

- **Fossil Feuls**

  Advantages: available all round the globe

  Disadvantages: Non-renewable, pollution

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Dangers of Electricity

- Damaged Insulation
- overheating of cables
- Damp environment

Safety Devices

- **Circuit Breaker**: It Contains electromagnet, turns off when current exceeds the limit and saves appliances
- **Fuse**: It consists of a wire that blows off (breaks) when large current flows. Its disadvantage is that it it to be replaced. Fuse limit should be slightly above desired amount of current.
  - It should be connected to live wire
- **Switches**: It is used to turn on and off the circuit. It should be connected to live wire.
  - **Live Wire**: The wire which Supplies Current
  - **Neutral Wire**: It provides return path of current
  - **Earth Wire**: used to Earth the current if live wire touches the device/appliance

Three pin-plug: It Contains live, neutral and earth wire

Double Insulation: It insulates the wires internally, and it saves the casing.

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Electric Power

Power is generally defined as "rate of doing work"

electric power formulae:

$$P = IV$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

electrical energy formulae:

$$E = IVt$$

$$E = I^2Rt$$

$$E = \frac{V^2}{R}t$$

Electrical Energy as kilo-watt-hour (kWh)

$$1\ kWh = 1000\ W \times 1\ hr$$

$$= 1000 \times 3600\ Sec$$

$$= 3.6 \times 10^6\ Watt \times sec \qquad \because Watt \times Sec = Joule$$

$$= 3.6 \times 10^6\ J$$

or $\boxed{1\ kWh = 3.6\ MJ}$ $\quad \because M(Omega) = 10^6$

- One unit of electricity is 1 kWh.
- Cost of electricity is calculated by calculating amount of energy in kWh multiplied by cost of one-unit

Examples:

$1500\ W = 1.5\ kW$

$800\ W = 0.8\ kW$

$1000\ W = 1\ kW$

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Magnetism

* Magnetic Materials

  - Iron
  - Steel
  - Nickle
  - Cobalt

* Methods of magnetising a magnet

  - Stroking Method
  - electrical method: passing D.C. Supply Through a Conductor.

* De-magnetising a magnet

  - Hammering in East-West direction
  - Heating (placing in boiling water).
  - Passing A.C. Supply, place in East West direction

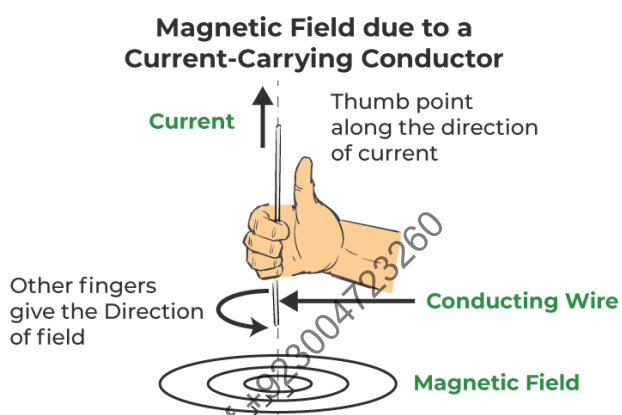
* North pole of a Compass needle points away from North Pole.

* We can use plotting Compass to Trace a magnetic field

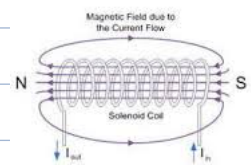
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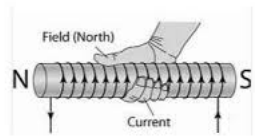
Electromagnetism

* Magnetic field of a straight current carrying wire is in circular form. Circles are closer near the wire and farther away from wire. (Right hand rule)



* Right hand grip rule is used to determine the poles of a current carrying Solenoid. (Curl fingers in current direction, thumb will indicate North Pole)





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Electromagnetic Induction

Faraday's Law of Electromagnetic Induction

"Induced e.m.f is directly proportional to rate of change of magnetic flux"

* Magnetic flux means magnetic field Lines

* When a magnet is moved rapidly towards and away from a coil, an e.m.f is induced due to rate of change of flux. Induced e.m.f can be increased by increasing:

(1) Number of turns of coil

(2) Strength of magnetic field (use strong magnets)

(3) Speed of magnet / coil

* Lenz's Law

"Induced e.m.f is produced in a direction such that is always opposes its cause"

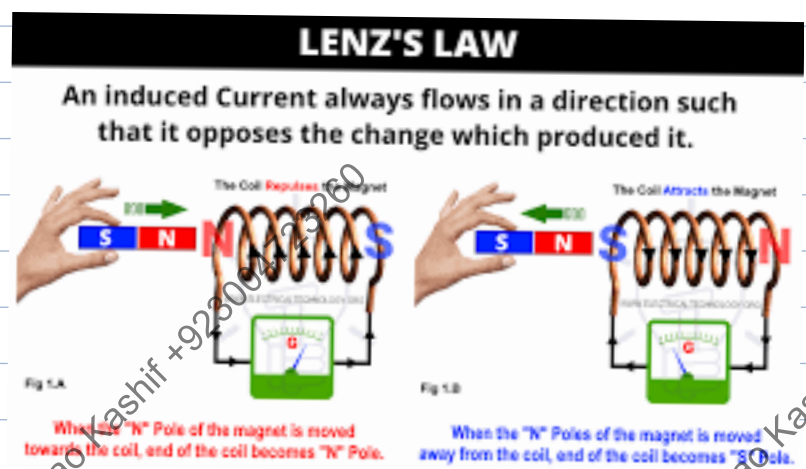
- If magnet moves towards the coil, they have like poles so repel. If magnet

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moves away from coil, they have unlike poles so coil is attracted towards magnet.

* This e.m.f, hence current keeps on reversing direction. Therefore, it is Alternating Current (A.C.)

Important diagram ↘



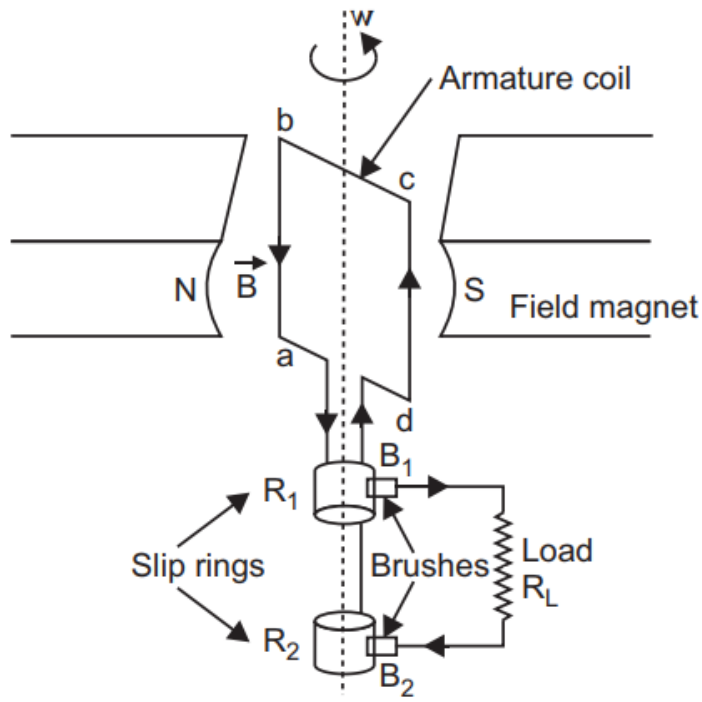
A.C. Generator

Converts mechanical energy to electrical energy

- Parts of A.C. Generator
  - Armature
  - Slip rings
  - Carbon brushes

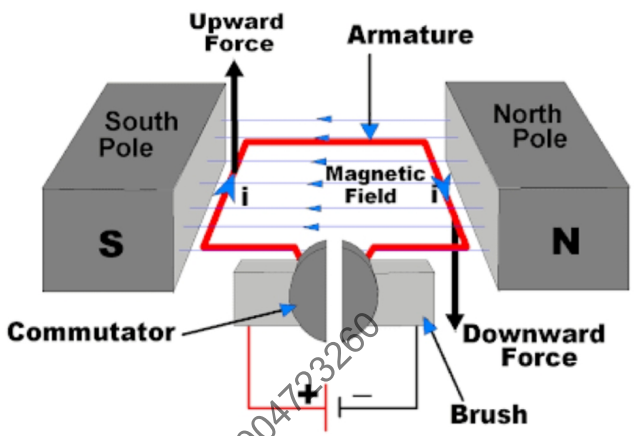
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D. C. Motor

Converts electrical energy to mechanical energy. It has split rings. It takes D.C. input and the coil rotates



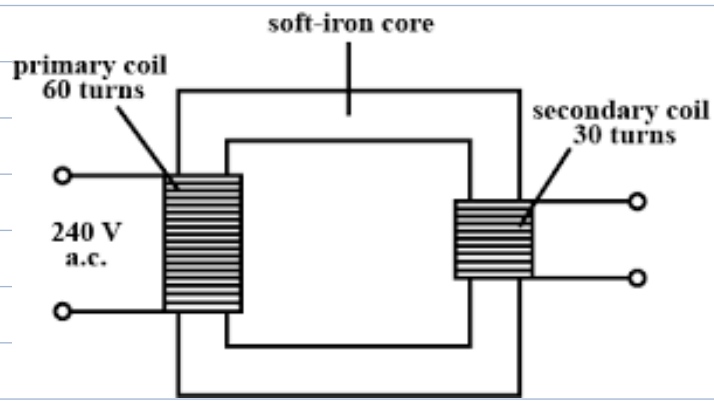
Transformer: used to step up/down A.C. input

Consists of two Coils: Primary and Secondary. Number of turns is directly proportional to voltage. In a step-up transformer, primary coil has more number of turns and vice versa

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

$$\text{Power}_{(\text{input})} = \text{Power}_{(\text{output})}$$

$$I_p V_p = I_s V_s$$



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Nuclear Physics

Radioactivity: The process by which an unstable nucleus decays by emitting radiations until it becomes stable.

Radioactivity is:

Spontaneous: A nucleus that decays is neither effected by its neighbouring nuclei nor by atmospheric conditions.

Random: Can not be predicted.

- Three types of radiations:

  Alpha - α

  Beta - β

  Gamma - γ

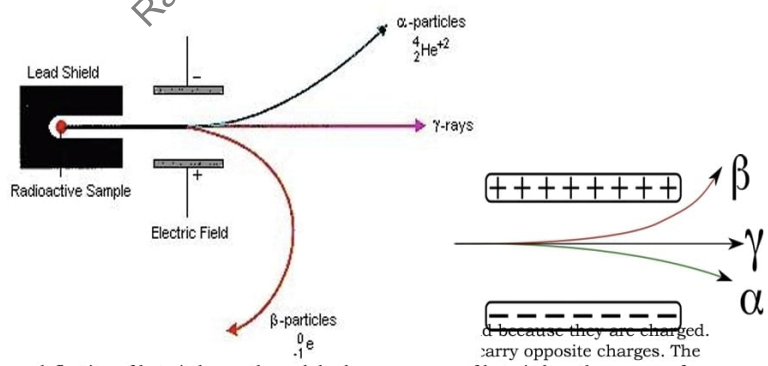
* Alpha and Beta are particles while Gamma are electromagnetic radiations.

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Characteristics of alpha beta and gamma

Characteristic	Alpha	Beta	Gamma
Nature	Helium nuclei or $^{4}_{2}He$ 2 p and 2 n	Electrons, $^{0}_{-1}e$	Electromagnetic radiation.
Mass	4	1/2000	0
Charge	+2e	-e	Neutral
Speed	Slow	Fast	Speed of light
Ionizing ability	High	Medium	Low
Penetrating power	Low	Medium	High
Stopped by	A few cm of air or a piece of paper	A few mm of aluminum foil	A few cm of lead
Deflected by electric and magnetic fields	Yes	Yes	No

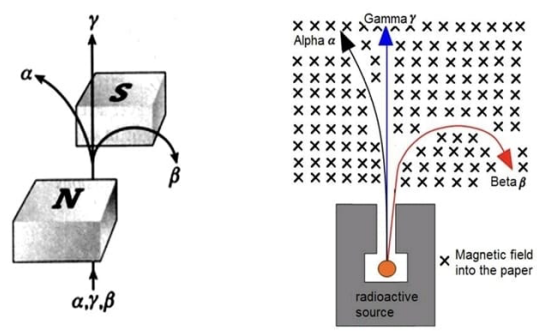
Interaction with electric field



d because they are charged. carry opposite charges. The deflection of beta is larger than alpha because mass of beta is less than mass of alpha.

- Gamma rays are not deflected because they do not carry any charge.

Interaction with magnetic field



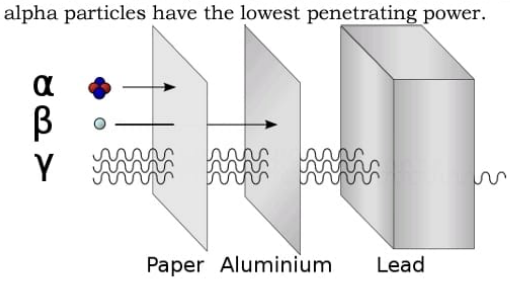
- Alpha particles and beta particles are also deflected when they pass through a magnetic field while gamma rays are unaffected.
- The direction of the deflection of alpha particles in the magnetic field can be found using Fleming's left-hand rule.

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Penetrating power

- The penetrating effect of alpha, beta and gamma radiation depends on their ionizing power.
- Radiation which has a stronger ionizing power will have a lower penetrating effect.
- The radiation emission loses some of its energy each time an ion pair is produced.
- Alpha particles lose energy very quick as they move through a medium. After a short distance in the medium, the alpha particles would have lost almost all energy. So alpha particles have the lowest penetrating power.

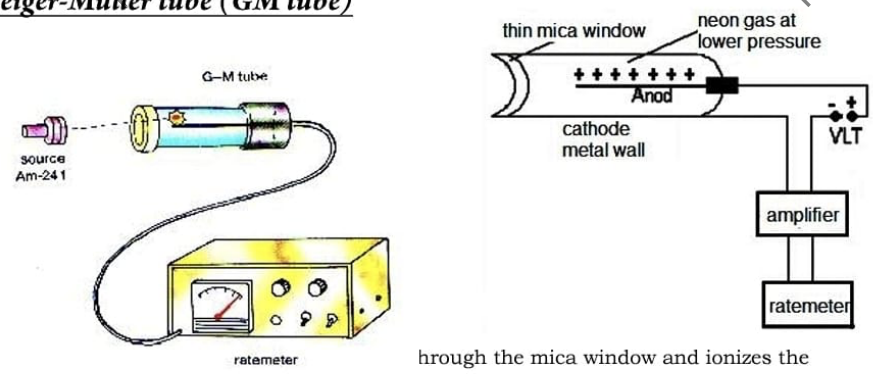


- Alpha particles can be stopped by paper; beta particles can penetrate through paper but can be stopped by thin metal (aluminum). Gamma rays can go through paper and metal sheet and can only be stopped by thick lead or concrete.

Detectors for radioactive emissions

Radioactive emissions can be detected with the help of Geiger-Muller tube (GM tube), gold leaf electroscope, cloud chamber and spark counter.

Geiger-Muller tube (GM tube)



hrough the mica window and ionizes the neon gas.

- The electrons and positive ions are attracted towards the anode and cathode respectively.
- When electrons are collected by the anode, a pulse of current is produces.
- The pulses of current are counted by a scaler or rate meter.
- The scaler gives the number of counts over a certain period of time that is counts per minute / counts per second.
- Initially the GM tube is switched on without the presence of any radioactive substance. The reading displayed by the rate meter is known as the background count rates.
- When the GM tube is used to detect radioactive emission, the background count rate is subtracted from the count rate obtained.

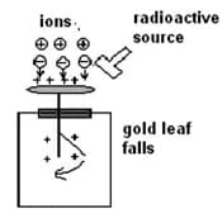
Notes:

Background radiation gives reading to the GM tube even though there is no radioactive source.

Background radiation is always present due to natural radioactivity in the ground, bricks or buildings and cosmic radiation.

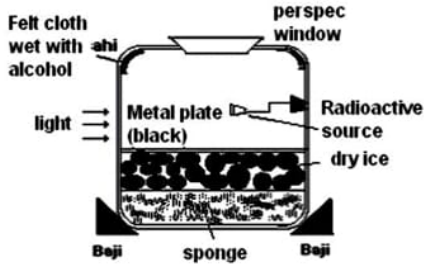
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Gold leaf electroscope

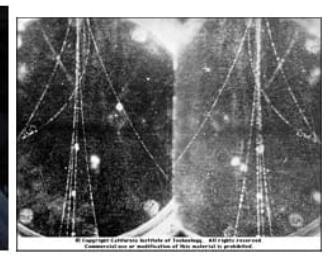


- When an electroscope is charged, the gold leaf sticks out, because the charges on the gold repel the charges on the metal stalk.
- When a radioactive source comes near, the air is ionized and starts to conduct electricity.
- This means the charge can 'leak' away, the electroscope discharges and the gold leaf falls.

Cloud Chamber







- It shows the path traveled by the ionizing radiation in air.
- The radioactive produces ions in the air that is saturated with alcohol vapor.
- The alcohol vapor condenses on the ions to make the tracks of the radiation visible. Alpha particles are best for this because it ionization power is high.

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Background radiation

The radioactive radiation present around the environment because of radioactive materials in the environment.

Background radiation can be produced by natural sources

- The Rocks of the Earth (radon gas)
- Cosmic radiation from space
- Radioactive gas within our atmosphere

Background radiation can also be produced from man-made sources

- Nuclear reactors
- Nuclear waste
- Fall out from nuclear weapon testing
- Uses of radioactive materials in Medicine
- Uses of radioactive materials in Industry

Radioactive decay

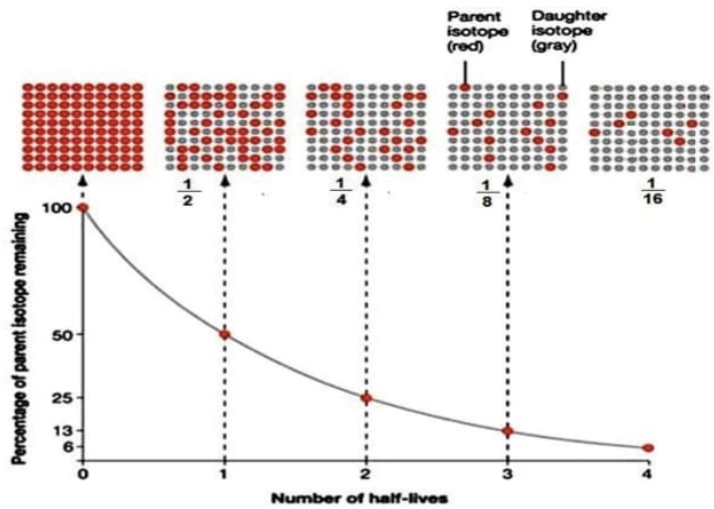
Radioactive decay is a self-disintegrating process which an unstable nucleus emits nuclear radiation like alpha beta or gamma so as to become stable.

- When a radioactive nucleus decays, its nucleus breaks up, emits an alpha particle or beta particle and energy, and forms a new atom of a different element.
- A parent nuclide X changes into a daughter nuclide Y.

Half –life

The half-life $T_{1/2}$ of a radioactive substance is the time for half of the radioactive nuclei to decay.

All radioactive substances decay with the same pattern, as shown in the graphs below.



The graph shows that amount of substance decrease rapidly at first and then more and more slowly. We cannot say when the last atom will decay. Different radioactive substances decay at different rates some much faster than others.

Worked Examples

Question 1: The count-rate from a radioactive source falls from 400 to 50 in 3.0 minutes.

What is the half-life?

Ans : 1minutes

Question 2: The half-life of a radioisotope is 2400 years. The activity of a sample is 720 counts / s.

How long will it take for the activity to fall to 90 counts / s?

Ans: 7200 years

Question 3: The half-life of a radioactive material is 24 years.

The activity of a sample falls to a fraction of its initial value after 72 years.

What is the fraction?

Ans: 1/8

Question 4: A radioactive isotope has a half-life of 6000 years.

How much time passes before the rate of emission from a sample of this isotope falls to 1/16 of its original value?

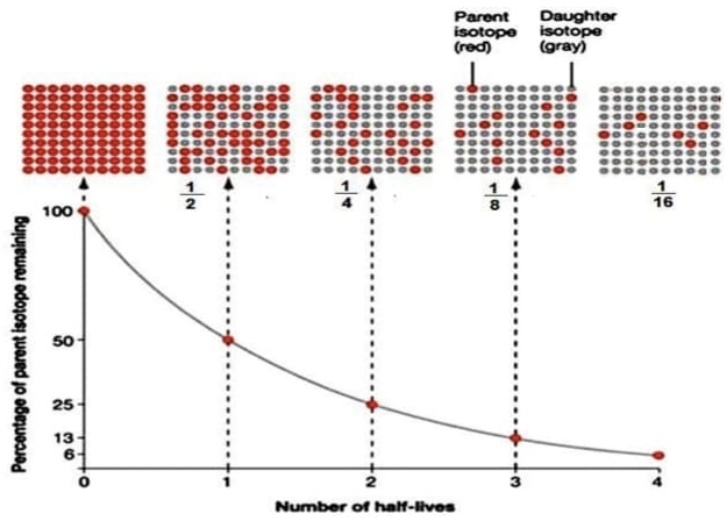
Ans : 2400 years

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Half –life

The half-life $T_{1/2}$ of a radioactive substance is the time for half of the radioactive nuclei to decay.

All radioactive substances decay with the same pattern, as shown in the graphs below.



The graph shows that amount of substance decrease rapidly at first and then more and more slowly. We cannot say when the last atom will decay. Different radioactive substances decay at different rates some much faster than others.

Worked Examples

Question 1: The count-rate from a radioactive source falls from 400 to 50 in 3.0 minutes.

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Ans : 1minutes

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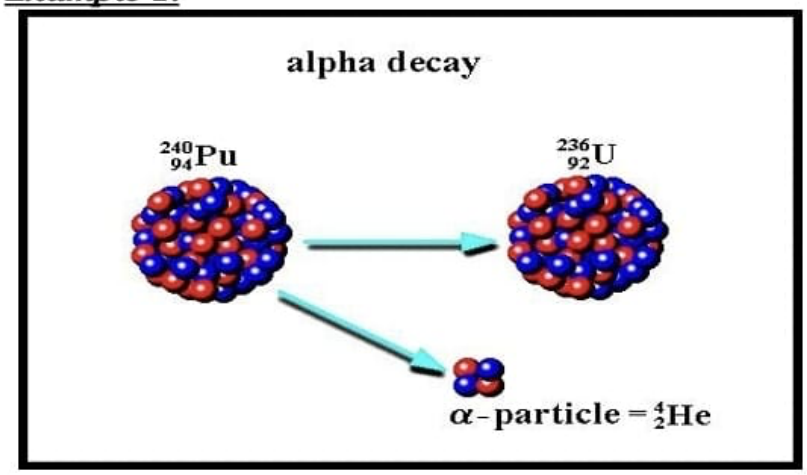
Ans : 2400 years

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Alpha decay

When a nucleus emits alpha particle, the atomic number decreases by 2 units and it mass number decreases by 4 units. And huge amount of energy is released.

Example 1:



$$^{240}_{94}Pu \longrightarrow {}^{236}_{92}U + {}^{4}_{2}He + \text{Energy}$$

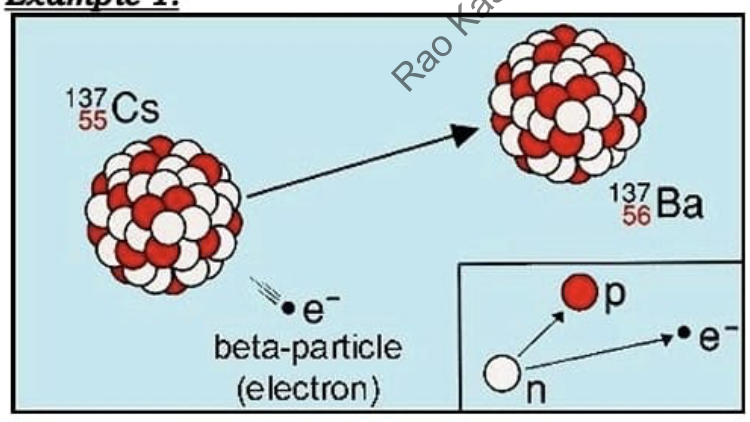
Example 2: $^{230}_{90}Th \rightarrow {}^{226}_{88} + {}^{4}_{2}He$ **+ energy**

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

Beta decay

When a nucleus emits a beta particle, the mass number does not change but the atomic number increases by 1. And huge amount of energy will be released.

Example 1:



$$^{137}_{55}Cs \longrightarrow {}^{137}_{56}Ba + {}^{0}_{-1}e + \text{Energy}$$

Example 2: $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$ **+ energy**

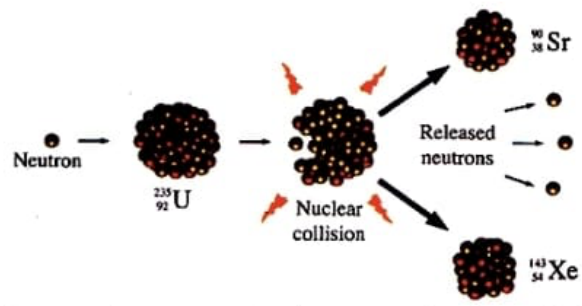
$$^{209}_{82}Pb \rightarrow {}^{209}_{83}Bi + {}^{0}_{-1}e \text{ + energy}$$

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Nuclear fission

Nuclear fission is the splitting of a heavy nucleus into two lighter nuclei, when the nucleus of an atom is bombarded with a neutron.



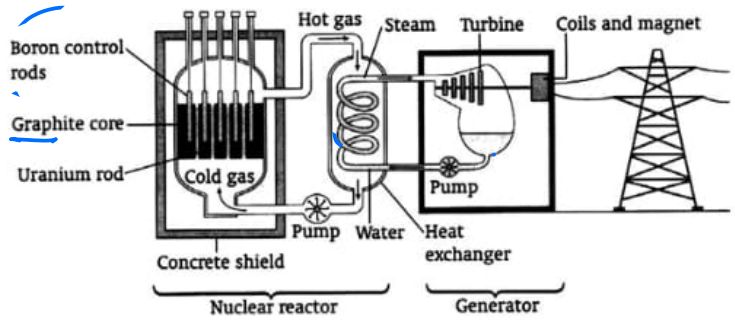
The energy of the neutron causes the target nucleus to split into two (or more) nuclei that are lighter than the parent nucleus, releasing a large amount of energy during the process.

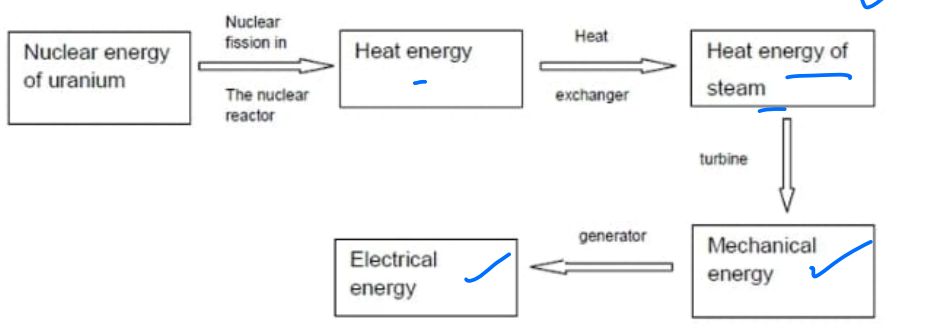
- A neutron hitting a uranium-235 nucleus, causing it to split producing strontium-90, xenon-143 and three neutrons + energy.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{143}_{54}Xe + ^{90}_{38}Sr + 3\,^{1}_{0}n + energy$$

Use of nuclear fission

Electricity can be generated from the energy released by fission reactions. A nuclear power station consists of a nuclear reactor and a generator.





Nuclear fusion

Nuclear fusion is the combining of two lighter nuclei to form a heavier nucleus, releasing a vast amount of energy during the process.

Nuclear fusion is believed to be the process by which energy is released by the Sun. When two hydrogen-2 nuclei moving at high speeds collide, they can join together to produce heavier nucleus. A large amount of energy is released.
A hydrogen bomb uses the principle of nuclear fusion for its design.

Carbon dating

Radioactive substances decay at a rate we can determine, we can use them to discover how old objects and animals are. The best-known example of this is radiocarbon dating.

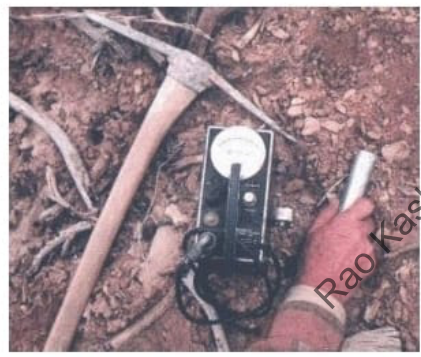
All living things contain carbon. Plant gets this from atmospheric carbon-dioxide, which they use in photosynthesis. Plant-eating animals get it from the plants they eat to build their bodies. Meat eating animals get it from their prey. Most carbon is carbon – 12 ($^{12}_{6}C$), which is not radioactive. A tiny fraction is radioactive carbon – 14 ($^{14}_{6}C$), with a half-life of 5370 years. (It emits beta radiation)

The idea of radiocarbon dating is this. When a living organism dies, the carbon – 14 in its body decays. As time passes, the amount remaining decreases. If we can measure the amount remaining, we can work out when the organism was alive.

There are two ways to measure the amount of carbon – 14 present in an object.

- By measuring the activity of the sample using a detector such as a Geiger counter.
- By counting the number of carbon – 14 atoms using a mass spectrometer.







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Space Physics

Important Points

- Earth is a planet that revolves around the Sun
- orbit of Earth is not perfectly circular, it is elliptic
- Motion of Earth is both rotatory (spin) and Circular. It rotates around its own axis and moves around the Sun.
- Days and nights are caused by the spinning motion of Earth. The side of Earth facing the Sun experiences day time while other side experiences night
- Sun is a star that empowers the whole Solar System
- There are 8 planets in the Solar System: Mercury, Venus, Earth, Mars, Jupiter, Saturn Uranus, Neptune

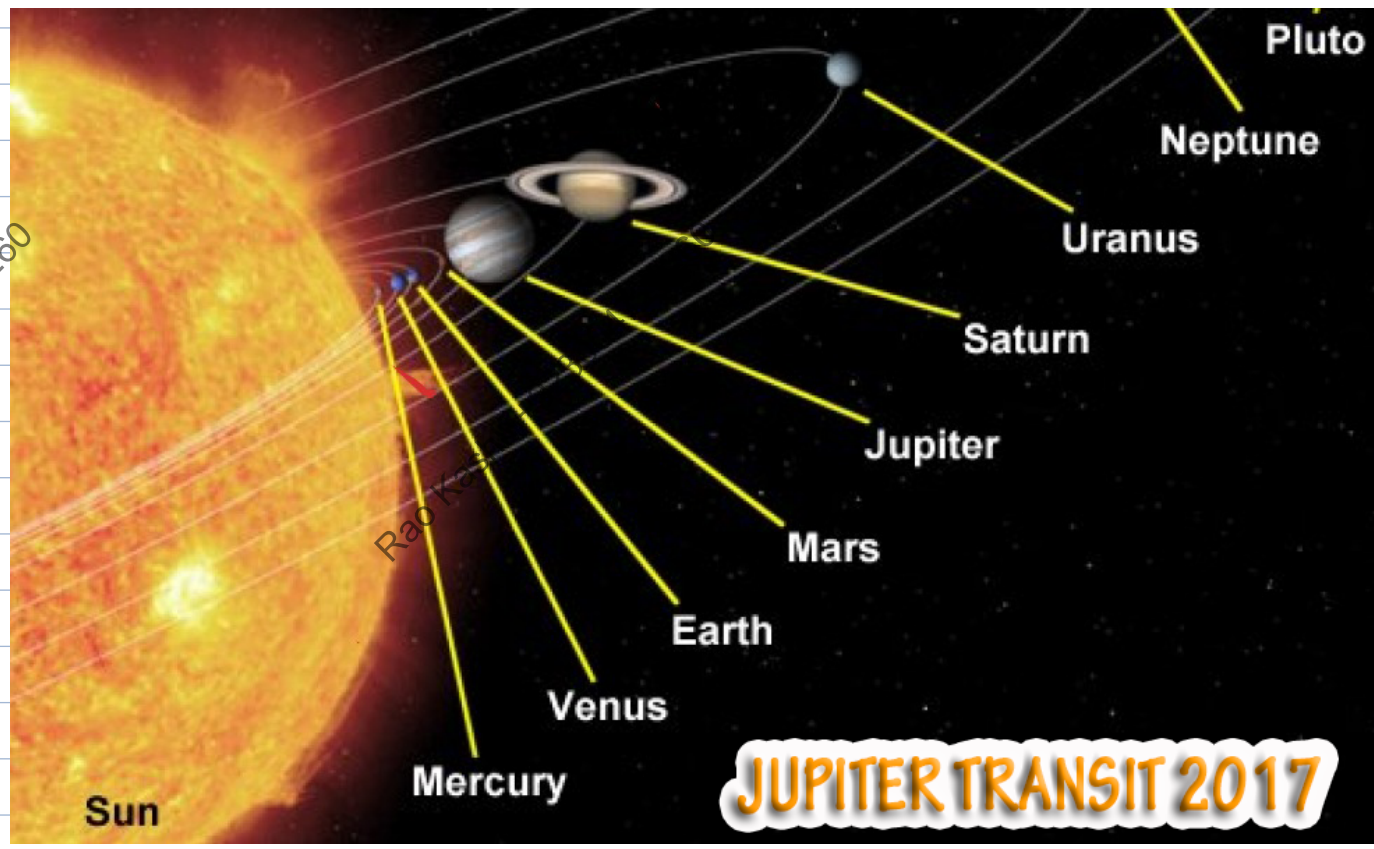
Note: These names are in a Sequence from Sun

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- Any object that revolves around a planet is called Satellite. Moon is a natural Satellite of the Earth.
- Moon revolves around Earth in a month approximately
- Earth takes 24 hours to spin about its own axis and one year (365 days) to Complete one orbit around the Sun.
- Out of eight planets in the Solar System, four are inner planets (Mercury, Venus, Earth and Mars). These are Small, Solid and rocky.
- Jupiter, Saturn, Uranus and Neptune are outer planets which are bigger in Size and are in gaseous sate.
- Inner and outer planets are separated by Asteroid Belt
- Asteroids are pieces of rocks of various Sizes and they orbit the Sun between the orbits of Mars and Jupiter.

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- Comets Consist of dust mixed in ice made from water and Methane. Their density is similar to outer planets and They orbit the Sun in highly elliptic orbits



- Our Sun was formed about 4.5 billion years ago as a result of gravitational forces of attraction pulling clouds of hydrogen and dust (called Nebula) together.
- gravitational field Strength of an object depends upon its mass. It is equal on the Surface of planet / Star

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- Sun is a medium size star which consists mostly of Hydrogen and Helium. The energy it emits is mostly infrared, visible and ultraviolet.
- Closest star to us is the Sun
- distance travelled by light in one year is known as light year.

Question

Convert one light year to meters (m)

Solution

Speed of light $= 3.0 \times 10^8 \, m s^{-1}$

time of one-year $= 365$ days

$= 365 \times 24 \times 60 \times 60$

$= 3.154 \times 10^7$ Sec

distance $=$ Speed $\times$ time

$= 3.0 \times 10^8 \times 3.154 \times 10^7$

$= 9.5 \times 10^{15}$ m

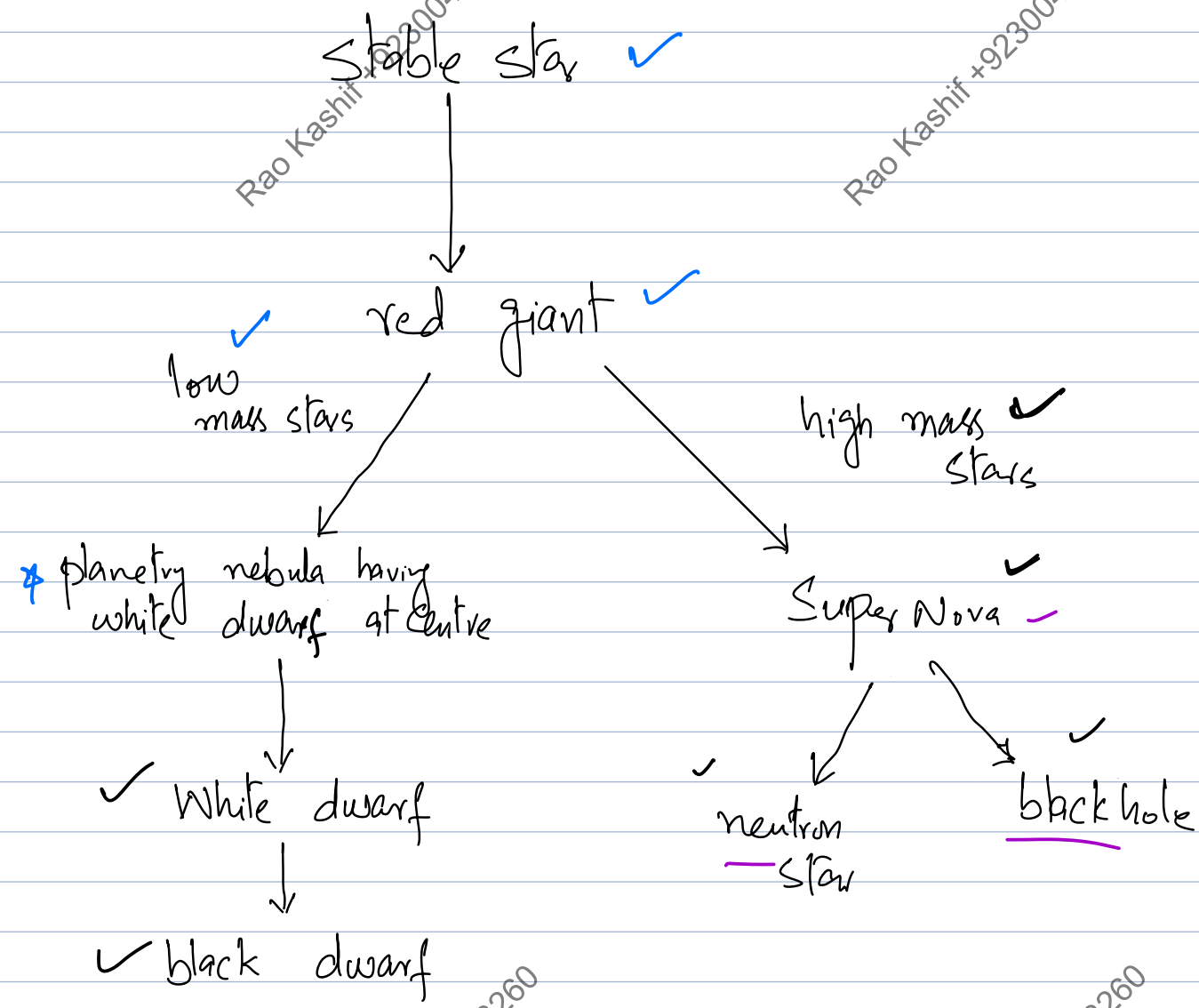
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- The nearest star outside Solar System is Alpha Centauri, 4.3 light years away
- A galaxy is a collection of stars. there can be billions of stars in a galaxy
- our Solar System is located in Milky Way galaxy
- Nearest galaxy to Miky way is Andromeda
- Origin of a Star: When interstellar cloud of dust and gas collapses under gravitational forces, a protostar is formed. Gravitational forces keep on increasing the mass of the star due to which its temperature rises. Gravitational Potential energy converts to kinetic Energy and protostar contracts further. When Core is hot enough, nuclear fusion starts and a star is born
- If a young star has very large mass, it forms a blue or white star. If it has smaller mass (like our Sun), its forms yellow or red dwarf.

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- In a stable star, (as is our Sun), the very strong force of gravity pulling it inwards are balanced by the expanding forces. During this time, most of the Hydrogen converts into Helium.

* Further stages are described as follows:



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- When further fusion stops in unstable and forces. This

dead or very

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in the Universe.

ars, the gravitational very strong. It times larger stars

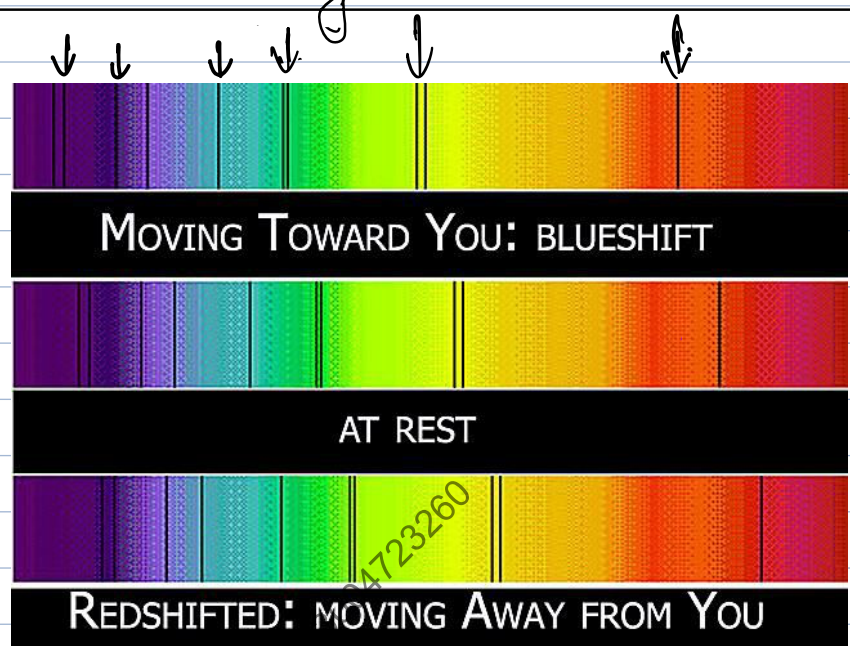
- states that our panding and this rate is ctly proportional to from The galaxies that are aways from us are moving aw a faster rate

- If a galaxy is moving away from us, the wavelengths of its spectrum appears to be redshifted

• If a galaxy is moving closer to us,

the wavelengths appear to be blue shifted

* Look carefully the black lines in this spectrum



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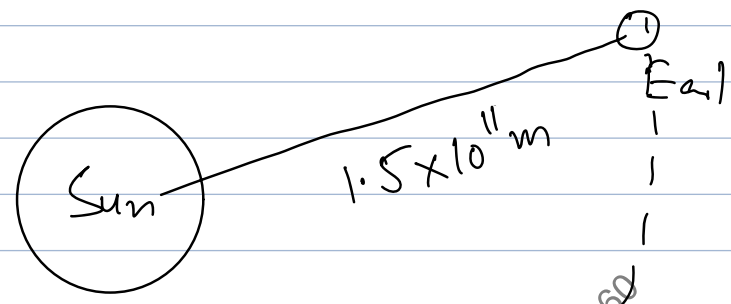
Question

Earth covers a round trip around the Sun in one years, Calculate its orbital speed.

Solution

* distance from Sun to Earth is radius of orbit

$r = 1.5 \times 10^{11}\ m$



distance of one orbit $= 2\pi r$

$= 2\pi (1.5 \times 10^{11})$

time $= 365$ days

$= 365 \times 24 \times 60 \times 60$ sec

$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{2\pi (1.5 \times 10^{11})}{365 \times 24 \times 60 \times 60}$$

$$= 2.99 \times 10^{3}\ m\ s^{-1}$$

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