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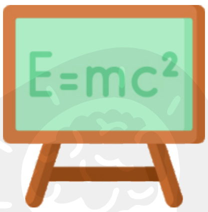


PHYSICS

1 CHAPTER Force

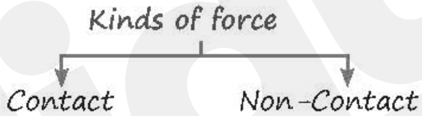
Force

A force is that physical cause which change (or tends to change) either the size or shape or the state of rest or motion of the body.

S.I. unit = Newton (N)

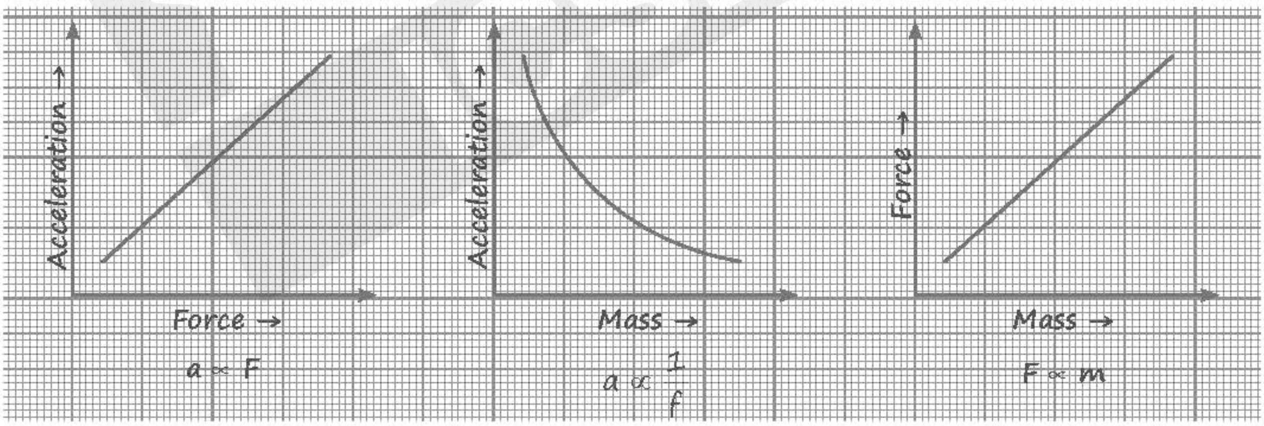
CGS unit = dyne

$1N = 10^5$ dynet



Newtons Laws of Motion

FIRST LAW	SECOND LAW	THIRD LAW
A body continues to be in its state of rest or of uniform motion is a straight line unless an external force is applied on it.	The rate of change of momentum of a body is directly proportional to the force applied on it and this change in momentum takes place in the direction of applied force.	To every action there is alway an equal and opposite reaction.
This law is also called "LAW OF INERTIA"	$F \propto \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}$ $F = ma$	$\overrightarrow{F_{12}} = -\overrightarrow{F_{21}}$



Momentum

The momentum of a body in linear motion is the product of the mass of the body and its velocity.

$$p = mv$$

It is vector quantify.

S.I. unit = kg m s^{-1}

C.G.S. unit = g cm s^{-1}

Equations of Motion

(i) $v = u + at$

(ii) $s = ut + \frac{1}{2}at^2$

(iii) $v^2 = u^2 + 2as$

Moment of Force

The turning effect produced by a force on a rigid body about a point, pivot or fulcrum is called moment of force.

S.I unit ⇒ Nm

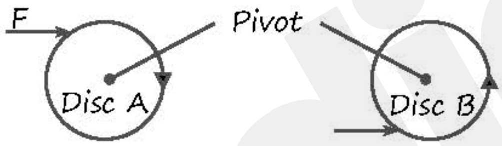
C.G.S unit ⇒ Dyne cm

1Nm = 10^7 Dyne cm

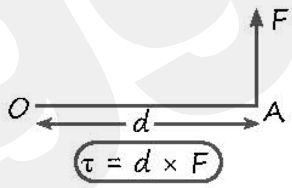
1kgf m = 9.8 N m

1gf cm = 980 dyne cm

Clockwise Moment   Anti Clockwise Moment



Negative   Positive



Equilibrium of Bodies

When a number of force acting an a body produce no change in its state of rest or of motion the body is said to be in equilibrium.

Kind of Equilibrium
- Static Equilibrium
- Dynamic Equilibrium

Conditions for Equilibrium

(i) The resultant of all the forces acting an a body should be 0.

(ii) Algebraic sum of moments acting on a body should be 0.

Principle of Moments

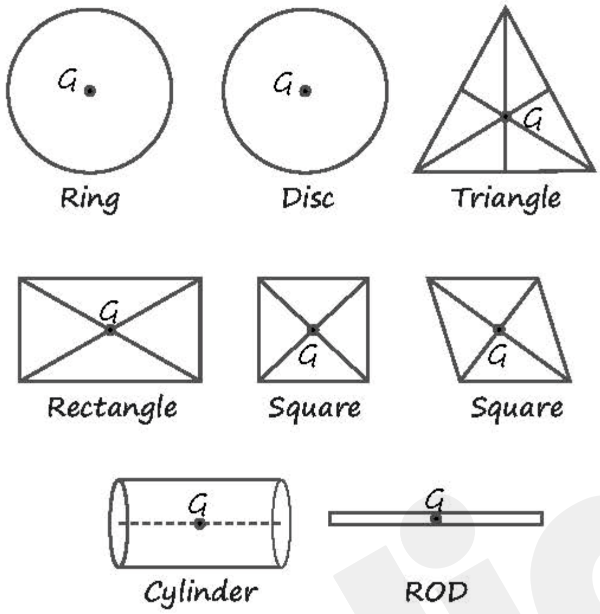
According to principle of moments in equilibrium.

Sum of anticlockwise moment = Sum of clockwise moment

Centre of Gravity

The centre of gravity (C.G.) of a body is the point about which the algebraic sum of moments of weights of all the particles constituting the body is zero.

The entire weight of the body can be considered to act at this point.

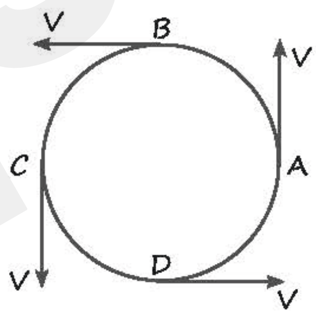


Uniform Circular Motion

When a particle moves with constant speed in a circular path, its motion is said to be the uniform circular motion.

It is accelerated motion.

Centripetal Force	Centrifugal Force
A force that acts towards the center of circle, keeping object moving in circular path.	A force that acts away from center of a circle.
It is a real force.	It doesn't really exist.



Formula sheet

1. Momentum (p)

   $p = mv$

   p-momentum, m-mass, v-velocity

2. Force (F)

   $F = ma$

   F-force, m-mass, a-acceleration

3. Equations of motion

   u-initial velocity

   v-final velocity

   t-time

   a-acceleration

s-distance of travelled

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

4. Moment of force (τ)

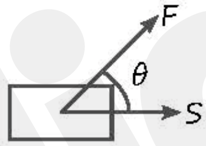
$$\tau = d \times F$$

d-perpendicular distance, F-force from pivot

2 CHAPTER Work, Energy and Power

Work

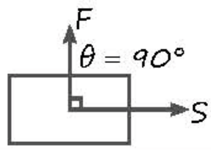
Work is said to be done only when the force applied on a body makes the body move.
It is scalar quantity
F – applied force
s – displacement
θ – between force and displacement



$W = FS\cos\theta$

S.I. unit = joule(J)
C.G.S. unit = erg
$1J = 10^7$ erg
$1kJ = 10^3$ J, $1MJ = 10^6$ J, $1GJ = 10^9$ J

Different Cases of Work Done

W → Positive	W → Negative	W → Zero
 $\theta = 0°$	$\theta = 180°$ 	

Power

The rate of doing work is called power. It is a scalar quantity.

$$\text{Power } P = \frac{\text{Work done } W}{\text{Time taken } t}$$

$$P = \frac{W}{t}$$

$$P = \frac{F \times s}{t} = F \times v$$

F → force v → Average speed
S.I. unit = watt (W)
C.G.S. unit = erg s^{-1}
$1W = 10^7$ erg s^{-1}
1 H.P. = 746W = 0.746 kW

Energy

The energy of a body is its capacity to do work.

S.I. unit = joule (J)

C.G.S. unit = erg

Bigger unit of energy kilowatt hour (kWh)

$1kWh = 3.6 \times 10^6 J = 3.6\ MJ$

Heat energy is usually measured in calorie.

1J = 0.24 calories, 1 calorie = 4.18 J

The energy of atomic particles is measured in electron volt (eV).

$1eV = 1.6 \times 10^{-19} J$

WORK	ENERGY	POWER
It is equal to product of force & displacement in direction of force.	Capacity to do work.	The rate of doing work.
Does not depend on time.	Does not depend on time.	Depends on time.
S.I. unit → joule	S.I. unit → joule	S.I. unit → watt

Different forms of Energy

Mechanical Energy – The energy possessed by a body due to its state of rest or of motion is caused mechanical energy. It is in two forms:

(i) Kinetic energy

(ii) Potential energy

Kinetic energy – Energy possessed by a body by virtue of its state of motion.

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

k → kinetic energy

m → mass

v → velocity

There are 3 forms of K.E.

1. Translational K.E.
2. Rotational K.E.
3. Vibrational K.E.

Relation between K.E. & momentum

$$p = \sqrt{2mk} \quad \text{or} \quad K = \frac{p^2}{2m}$$

Work energy theorem – The work done by a force on moving body is equal to the increase in its kinetic energy.

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Potential energy- Energy possessed by a body by virtue of its specific position (or changed configuration) is called potential energy.

It is usually denoted by symbol U.

It is mainly of two types-

(i) Gravitational P.E.

(ii) Elastic P.E.

+ Gravitational P.E. is the amount of work done in raising a body from ground to a point at height h, against gravity.

$u = mgh$

m - mass of object, g - acceleration clue to gravity h - height through which object is raised

h - height through which object is raised

1. **Solar energy**- energy radiated by Sun.
2. **Heat energy**- energy released on burning coal, oil, wood, gas.
3. **Light energy**- energy in presence of which other objects are seen.
4. **Chemical energy**- Energy possessed by fossil fuels.
5. **Hydro energy**- Energy of fast moving water.
6. **Electrical energy**- Energy possessed by charged body due to movement of free electrons.
7. **Nuclear energy**- Energy released due to process of nuclear fusion or fusion.

Energy Conversion

(i) Mechanical → electrical = Electric generator (dynamo)

(ii) Electrical → mechanical = fan, washing machine, mixer

(iii) Electrical → heat = heater, oven, geyser, toaster

(iv) heat → electrical = thermocouple

(v) electrical → sound = loudspeaker

(vi) sound → electrical = microphone

(vii) light → chemical = photosynthesis

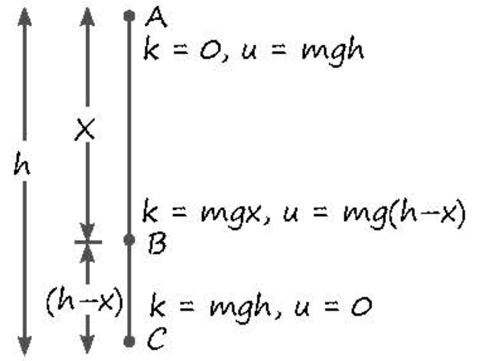
(viii) light → electrical = photoelectric cell

Energy Sources

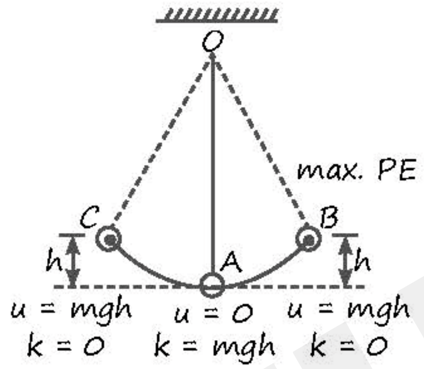
Renewable or non conventional source	Non-Renewable or conventional source
A natural source providing us energy continuously is called renewable source of energy.	These are the sources from which energy cannot be continuously obtained over a long period of time.
These sources can be regenerated.	These sources cannot be regenerated.
E.g. Sun, wind, flowing water, tides, Oceans, geothermal spots, nuclear fuel.	E.g. - Coal, petroleum, natural gas

Law of Conservation of Energy

Energy can neither be created nor can it be destroyed. It only changes from one form to another.



Free fall of body



motion of simple pendulum

Formula Sheet

(i) Work(w)

$$W - FS\cos\theta$$

(ii) Power(p)

$$P = \frac{W}{t} \qquad P = F \times V$$

p → power, w → work, t → time f → force, v → avg. speed

(iii) Kinetic energy (K)

$$K = \frac{1}{2}mv^2 \qquad K = \frac{p^2}{2m}$$

K – K.E., m → mass, v → velocity, p → momentum

(iv) Gravitation P.E. (U)

$$U = mgh$$

m → mass, g → acceleration due to gravity, h → height

(v) Work energy theorem.

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

3
CHAPTER

Machine

Machine

It is a device by which we can either overcome a large resistive force (or load) at some point by applying a small force (or effort) at a convenient point and in a desired direction or by which we can obtain a gain in speed.

Uses of Machine

Multiply force

To change direction of the force

To increase or decrease speed

Terms Related to Machine

(i) **Load:** The resistive or opposing force to be overcome, by machine.

(ii) **Effort:** The force applied on machine to overcome load.

(iii) **Mechanical advantage (M.A.):** Ratio of the load (L) to the effort (E)

$$\text{M.A.} = \frac{\text{Load}(L)}{\text{Effort}(E)}$$

It has no unit

M.A. > 1 ⇒ force multiplier

M.A. < 1 ⇒ gains speed

M.A. = 1 ⇒ change in direction of effort.

(iv) **Velocity Ratio (V.R.):** Ratio of distance moved by effort (d_E) to the distance moved by load (d_L).

$$\text{V.R.} = \frac{\text{Velocity of effort } (V_E)}{\text{Velocity of load } (V_L)}$$

$$\text{V.R.} = \frac{V_E}{V_L} = \frac{d_E}{d_L}$$

It has no unit

V.R. < 1 ⇒ gains speed

V.R. > 1 ⇒ force multiplier

V.R. = 1 ⇒ changes direction of effort

(v) **Work Input Winput:** The work done on the machine by the effort.

(vi) **Work Output Woutput:** The work done by machine on the load.

(vii) **Efficiency (η):** It is the ratio of work done on load by machine to the work done on machine by effort.

$$\text{Efficiency}(\eta) = \frac{\text{Work output}}{\text{Work input}}$$

It can be expressed in percentage, it has no unit.

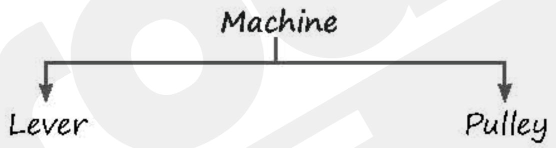
$$\eta = \frac{W_{output}}{W_{input}} \times 100$$

Ideal Machine

An ideal machine is that in which there is no loss of energy in any manner. The efficiency of ideal machine is 100%.

Relation Between η, M.A. and V.R.

$$\eta = \frac{M.A.}{V.R.}$$



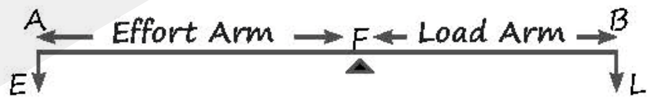
Levers

A lever is a rigid straight (or bent) bar which is capable of turning about a fixed axis.

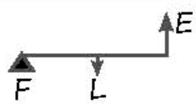
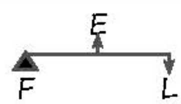
According to principle of lever,

Movement of load about fulcrum = Movement of effort about fulcrum

L × d, = E × ι



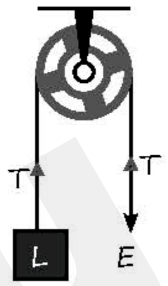
Kinds of Levers

Class I	Class II	Class III
		
M.A. = 1, M.A. < 1, M.A. > 1	M.A. > 1	M.A. < 1
V.R. = 1, V.R. < 1, V.R. > 1	V.R. > 1	V.R. < 1

E.g., A pair of scissors, handle of water pump, a catapult, nodding of human head	E.g., Bottle opener, wheel barrow, paper cutter, raising weight of human body on toes.	E.g., Sugar tongs, foot treadle, spade lifting load, forearm used for lifting a load.

Pulley: It is a wheel on an axle that is designed to support movement and change the direction of a cable or belt along its circumference. A set of pulleys assembled so that they rotate independently on the same axle to form a block is called pulley system.

Single Fixed Pulley: A pulley which has its axis of rotation fixed in position.



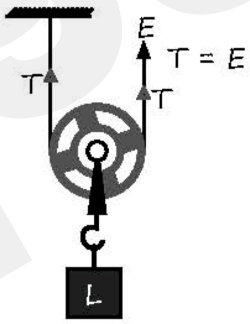
$$M.A. = \frac{Load}{Effort} = \frac{T}{T} = 1$$

$$V.R. = \frac{d_E}{d_L} = \frac{d}{d} = 1$$

$$\eta = \frac{M.A.}{V.R.} = 1 \text{ or } 100\%$$

with the use of single fixed pulley effort can be applied in more convenient direction.

Single Movable Pulley: A pulley whose axis of rotation is not fixed.



$$M.A. = \frac{Load}{Effort} = \frac{2T}{T} = 2$$

$$V.R. = \frac{d_E}{d_L} = \frac{2d}{d} = 2$$

$$\eta = \frac{M.A.}{V.R.} = \frac{2}{2} = 1 \text{ or } 100\%$$

It is used as force multiplier

Combination of pulleys

(1) using one fixed pulley and other movable pulleys:

M.A. = 2^n

V.R. = 2^n

$n \Rightarrow$ number of movable pulleys

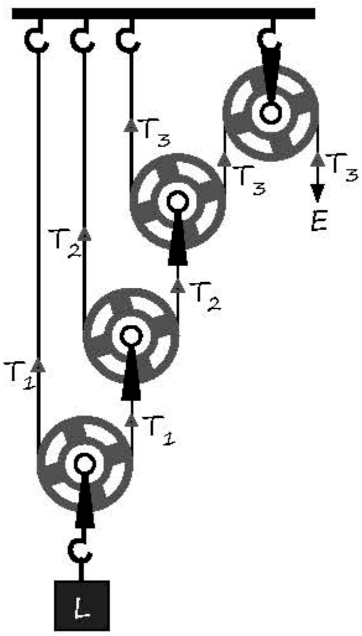
(2) Using several pulleys in two blocks (block and tackle system)

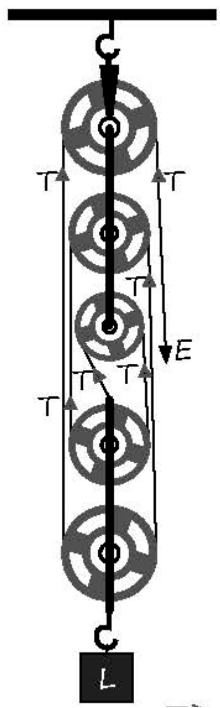
$$M.A. = \frac{Load}{Effort} = \frac{nT}{T} = n$$

$$V.R = \frac{d_E}{d_L} = \frac{nd}{d} = n$$

$$\text{Efficiency } \eta = \frac{M.A.}{V.R.} = \frac{n}{n} = 1 \text{ or } 100\%$$

n = total number of pulleys





Effect of weight of pulleys on M.A., V.R. and η

$$M.A. = \frac{L}{E} = \frac{nE - W}{E} = n - \frac{W}{E}$$

$n \Rightarrow$ no. of pulleys, $w \Rightarrow$ weight of lower block (total)

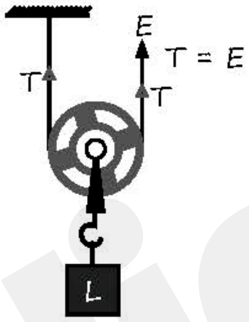
Formula Sheet

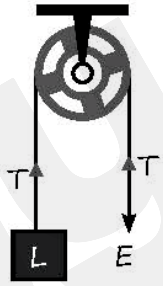
(1) Mechanical advantage:

$$M.A. = \frac{\text{Load}(L)}{\text{Effort}(E)}$$

(2) Velocity Ratio:

$$V.R. = \frac{\text{velocity of effort } (V_E)}{\text{velocity of load } (V_L)} = \frac{d_E}{d_L}$$





(3) Efficiency

$$\eta = \frac{W_{output}}{W_{input}}$$

$$\text{In\% } \eta = \frac{W_{output}}{W_{input}} \times 100$$

(4) $\eta = \dfrac{M.A.}{V.R.}$

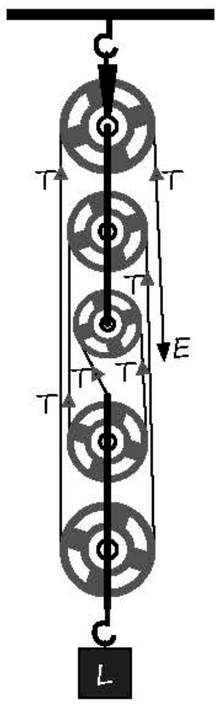
(5) Principle of Lever $\Rightarrow L \times d_L = E \times d_E$

(6) Kinds of Lever

- Class I: MA = 1, MA > 1, MA < 1

- Class II: MA > 1

- Class III: MA < 1



$$M.A. = \frac{\text{Load Arm}}{\text{Effort Arm}}$$

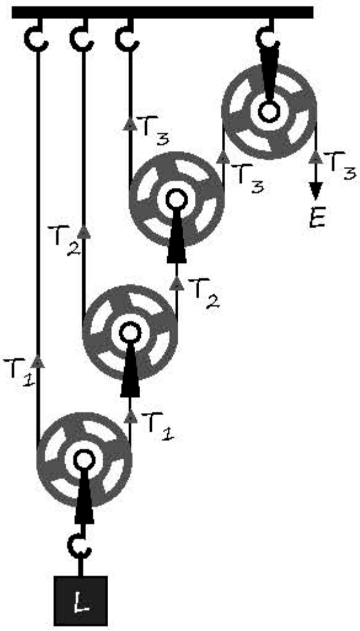
$$V.R. = \frac{d_E}{d_L}$$

(7) Single Fixed Pulley

M.A. = 1

V.R. = 1

η = 1 or 100%



(8) Single Movable Pulley

M.A. = 2

V.R. = 2

η = 1 or 100%

(9) Combination of pulleys

1 fixed & n movable pulleys

M.A. = 2^n

V.R. = 2^n

(10) Block and tackle system

n number of pulleys

M.A. = n

V.R. = n

If total weight of pulleys in lower back is W

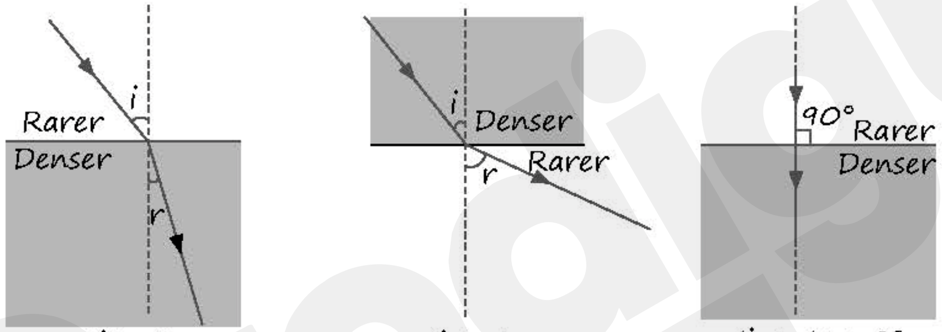
$$M.A. = n - \frac{W}{E}, \quad V.R. = n$$

$$\eta = 1 - \frac{W}{nE}$$

4 CHAPTER Refraction of Light at Plane Surface

Refraction of Light

The change in the direction of the path o light, when it passes from one transparent medium to another transparent medium is called refraction.



$\angle i > \angle r$ $\angle i < \angle r$ $\angle i = \angle r = 0°$

Refracted beam has change in speed (v), wavelength (λ), direction but frequency (υ) remains constant.

Laws of Refraction

(1) The incident ray, the refracted ray and the normal at the point of incidence all lie in same plane.

(2) The ratio of sine of angle of incidence (i) to the sine of the angle of refraction (r) is constant for given pair of media.

$\frac{\sin i}{\sin r} = \text{constant} = {}_1\mu_2$ (R.I. of second medium w.r.t. first medium)

This is also known as Snell's law.

Refractive Index

The refractive index of second medium with respect to the first medium is defined as the ratio of sine of angle of incidence in first medium to the sine of angle of refraction in the second medium.

R.I. or absolute R.I. has no unit.

$$\mu = \frac{\text{Speed of light in vacuum or air (c)}}{\text{Speed of light in that medium (v)}}$$

$$\mu = \frac{c}{v} = \frac{f\lambda_{air}}{f\lambda_{medium}} = \frac{\lambda_{air}}{\lambda_{medium}}$$

Relative refractive index

It is the ratio of speed of light in one medium to the speed of light in second medium.

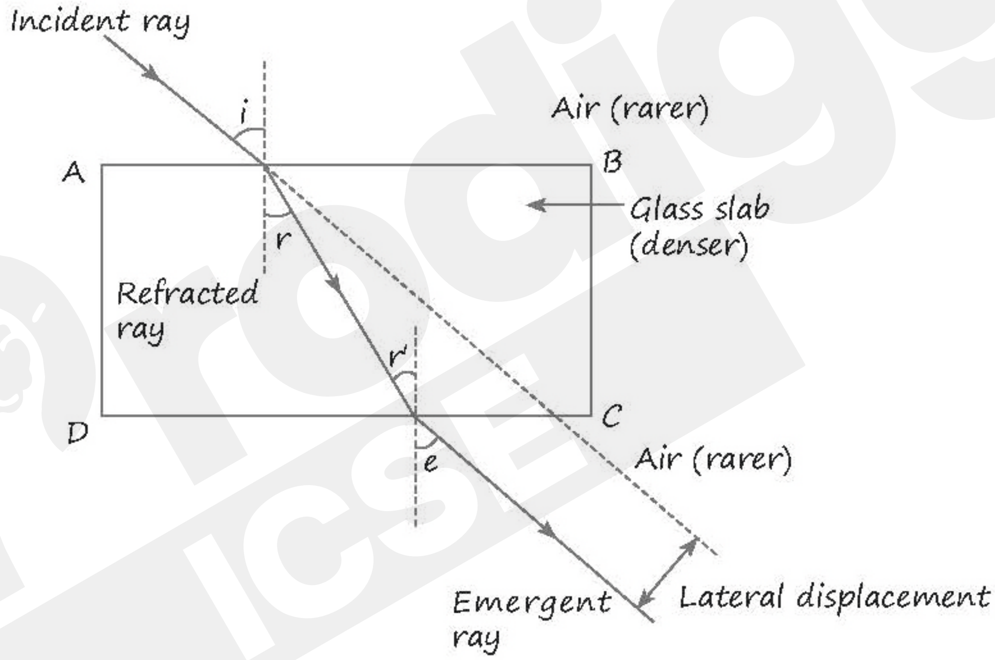
$${}_1\mu_2 \text{ or } n_{21} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

Note: ${}_1\mu_2 = \frac{1}{{}_2\mu_1}$

Factors affecting refractive index of a medium

(1) Nature of medium (optical density)
(2) Temperature of medium (temperature ↑ v↑ μ↓)
(3) Colour or wavelength of light ($\mu_V > \mu_R$)

Refraction of Light Through a Glass Slab

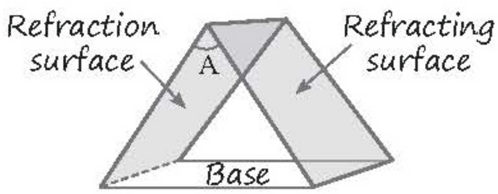


Lateral displacement depends upon

(1) Thickness of glass block
(2) Angle of incidence
(3) Refractive index of glass

Lateral displacement $= \frac{t\sin(i-r)}{\cos r}$

Refraction of light through prism



Prism: It is a transparent medium bounded by five plane surfaces with a triangular cross section.

The different relation $\angle$ in prism

(i) $\delta = (\angle i + \angle e) - (\angle r_1 + \angle r_2)$

(ii) $\angle i + \angle e = \angle A + \delta$

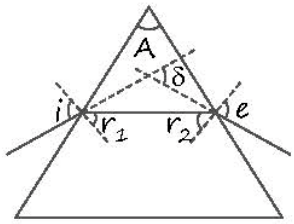
(iii) $\angle r_1 + \angle r_2 = \angle A$

i = angle of incidence

e = angle of emergence

δ = angle of deviation

r_1, r_2 = angle of refraction



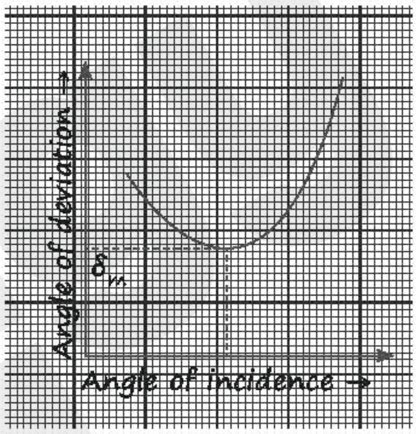
Factors affecting δ:

(1) angle of incidence ($\angle i$)

(2) material of prism (μ)

(3) angle of prism ($\angle A$)

(4) colour of wavelength of light (λ)



Relation between ∠i and ∠s:

In the position of minimum deviation the refracted ray inside the prism is parallel to its base, if prism is equilateral.

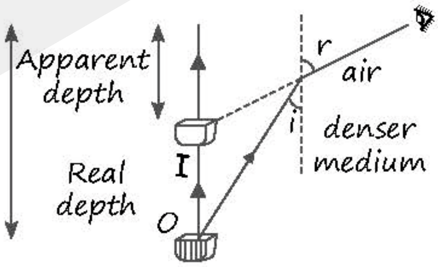
$\delta = \delta_m$, $\angle i = \angle e$, $\delta_m = 2i - A$, $\delta = (\mu - 1)A$

Application of Refraction of Light

Real and apparent depth: An object placed in a denser medium when view from a rarer medium appears to be at a depth lesser than its real depth.

Shift OI = Real depth – Apparent depth

$$\text{Shift} = \text{real depth}\left(1 - \frac{1}{{}_a\mu_m}\right)$$



Shift by which the object appears to be raised depends:

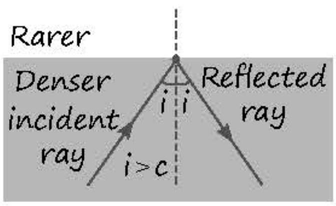
(1) Refractive index of medium $\mu\uparrow$ Shift$\uparrow$

(2) Thickness of medium$\uparrow$ Shift$\uparrow$

(3) Wavelength (color) of light $\lambda\uparrow$ shift$\downarrow$ $\mu_V > \mu_R$ shift V > shift R

Total Internal Reflection

When a ray of light travelling in a denser medium is incident at the surface of rarer medium at the angle of incidence greater than critical angle for the given pair of media, the ray is totally reflected back into the denser medium.



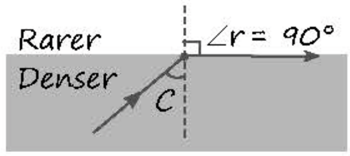
Condition for TIR

(1) Light must travel from denser to rarer medium

(2) $\angle i > \angle c$

Critical angle

The angle of incidence in denser medium for which the angle of refraction in rarer medium is 90°. It is denoted by c.



Factors affecting c

(1) Colour of light $\lambda\uparrow$ $c\uparrow$

(2) Temperature$\uparrow$ $c\uparrow$

Relation between critical angel and refractive index

R.I. of rarer medium w.r.t. denser medium $= {}_d\mu_r = \frac{\sin i}{\sin r}$

If $\angle i = \angle c, \angle r = 90°$ ${}_d\mu_r = \frac{\sin c}{\sin 90°} \Rightarrow {}_d\mu_r = \sin c$

R.I. of denser medium w.r.t. rarer medium

For glass ${}_a\mu_g = \frac{3}{2}$

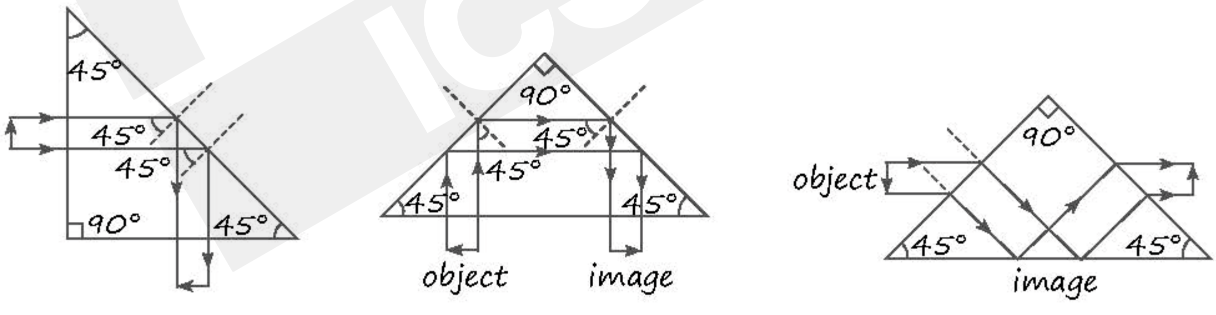
${}_r\mu_d = \frac{1}{\sin c}$, $c = \sin^{-1}\left(\frac{2}{3}\right) = 42°$

Total internal reflection in a prism

(a) To deviate light through 90°: This action of prism is used in periscope, where a total reflecting prism is preferred over a plane mirror.

(b) To deviate light through 180°: This action is used in binocular and camera to invert the image without the loss intensity.

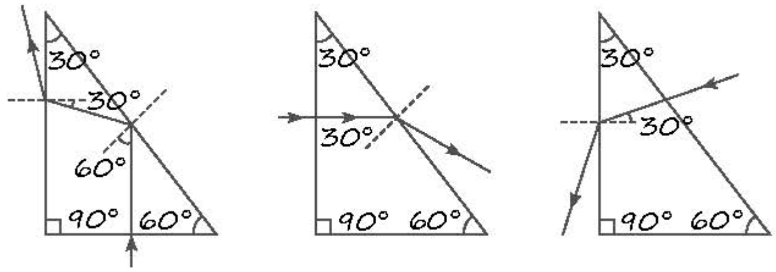
(c) To erect the inverted image with deviation: A prism used in this manner is called erecting prism. This action of prism is used in a slide projector.



(a) (b) (c)

Prim of angle (30°, 60° and 90°)

It can be used to deviate a light ray through an angle less than 60° by TIR.



Some Consequences of Total Internal Reflection

(1) On hot sunny day, a driver may see a pool of water (or wet road) in front of him at some distance. (Mirage)
(2) A crack in glass vessel often shines like mirror.
(3) A piece of diamond sparkles when viewed from certain directions.
(4) An optical fibre is used to transmit a light signal over a long distance without much loss of energy.

Formula Sheet

(1) ${}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$, $\mu = \frac{c}{v}$, $\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$

(2) Lateral displacement $= \frac{t\sin(i-r)}{\cos r}$

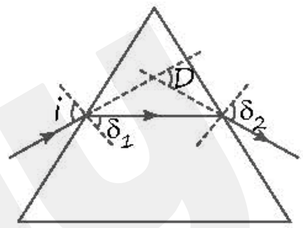
(3) R.I. of prism $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$, $\delta_{min} = 2i - A$, $\delta = (\mu - 1)A$

(4) Shift = real depth $\left[1 - \frac{1}{{}_a\mu_m}\right]$

(5) $\mu = \frac{1}{\sin c}$

5 CHAPTER Spectrum

Deviation Produced by Triangular Prism



Light ray while passing through a prism gets deviated to time while passing through the two refracting surface. The total deviation (D) with respect to incident ray is given as:

$$D = \delta_1 + \delta_2$$

Depends on

1. ∠i at first surface
2. Angle of prism(A)
3. R.I. of prims (color of light)

Dependence of angle deviation on colour of light (λ)

For different colours of light the R.I. of a given transparent medium is different.

$$\lambda\uparrow \ \mu\downarrow$$

$$\lambda_{red} > \lambda_{violet} \quad \therefore \mu_{violet} > \mu_{red}$$

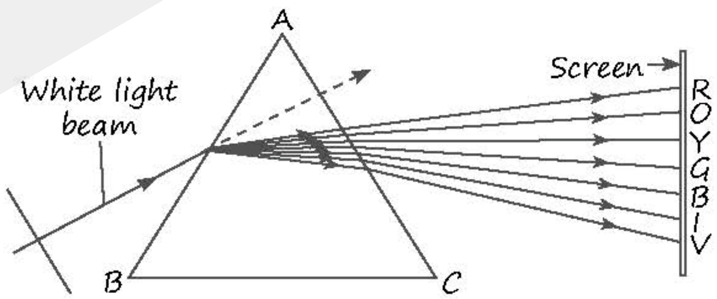
As a result prism deviate violet light most and red light least.

$$\delta_{violet} > \delta_{red}$$

Dispersion of White Light by Glass Prism

The phenomenon of splitting of white light into its constituent colours when it passes through a prism is called dispersion.

This band of seven colours obtained VIBGYOR, (V = violet, I = indigo, B = blue, G = green, Y = yellow, O = orange, R = red) is called spectrum.



Dispersion of white light occurs at the first surface of prism.

Deviation of light occurs at both the surfaces of prism.

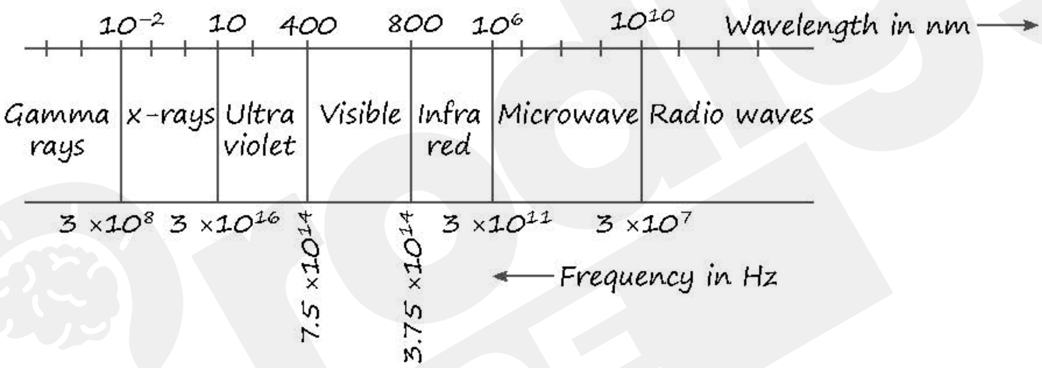
The prism does not produce colours but it only splits the various colours present in the light incident on it.

Wavelength and frequency of different colours of white light

Colour	Wavelength range (Å)	Frequency range (1014)
Violet	4000 – 4460	7.5 – 6.73
Indigo	4460 – 4640	6.73 – 6.47
Blue	4640 – 5000	6.47 – 6.01
Green	5000 – 5780	6.01 – 5.19
Yellow	5780 – 5920	5.19 – 5.07
Orange	5920 – 6200	5.07 – 4.84
Red	6200 – 8000	4.84 – 3.75

Electromagnetic Spectrum and Its Broad Classification

The orderly distribution of electromagnetic radiations according to their wavelength or frequency is called electromagnetic spectrum.



(1) Electromagnetic wave do not require material medium for their propagation.

(2) They travel with same speed in vacuum ($c = 3 \times 10^{8}$ m/s)

(3) Exhibit property of reflection and refraction.

(4) They do not deflect by electric and magnetic fields.

(5) These are transverse waves.

Properties and uses of different rays

Infrared rays:

- Heat waves, i.e., produced from heat radiation bodies and molecules.
- High penetration power – frequency ⇒ 3×10^{11} Hz to 4×10^{14}Hz

Uses:

- Physical therapy
- Weather forecasting
- Solar water heat, solar cells and cooker
- Satellite for army purpose
- Producing dehydrated fruits

Ultraviolet rays:

- Produced by special lamps and very hot bodies.
- Sun is important source of UV rays.
- Frequency 10^{14} to 10^{16} Hz

Uses:

- Burglar alarm
- To study molecular structure
- Surgical instruments (to sterilise)
- Checking mineral sample
- To kill germs in water

Relation between frequency, speed and wavelength of electromagnetic spectrum

$$\text{frequency}(\nu) = \frac{\text{speed of EM wave}(v)}{\text{wavelength}(\lambda)}$$

Scattering of Light

Scattering is the process of absorption and then re-emission of light energy.

The air molecules of size smaller than the wavelength of incident light absorb the energy of incident light and then re-emit it without change in its wavelength. The air molecules of size bigger than wavelength of incident light scatter the light of all wavelengths of white light to he same extent.

$$I \propto \frac{1}{\lambda^4}$$

$I \rightarrow$ Intensity of scattered light, $\lambda \rightarrow$ Wavelength of light

Blue Colour of Sky

The sky appears blue during the day because the particles in the atmosphere scatter shorter wavelengths of light particularly blue more than the longer wavelengths like red. This scattered blue light reaches our eyes.

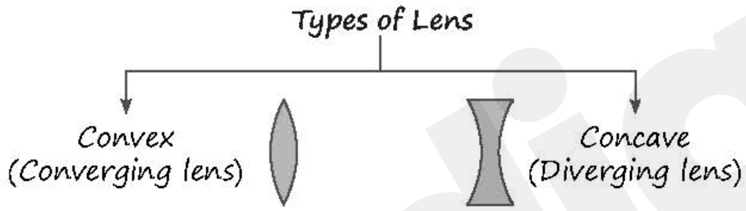
Formula Sheet

- $\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$
- $I \propto \frac{1}{\lambda^4}$
- $\lambda\uparrow \Rightarrow v\uparrow \Rightarrow \mu\downarrow \Rightarrow \delta\uparrow$

6 CHAPTER
Refraction Through a Lens

Lens

A lens is a transparent refracting medium bounded by either the two spherical surfaces or one surface spherical and other surface plane.



Terms related to a Lens

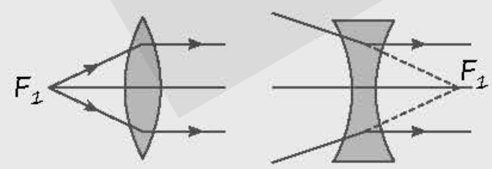
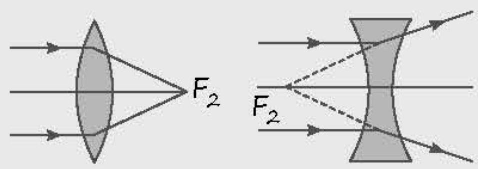
(1) **Centre of curvature:** It is the centre of sphere whose part is a lens surface. It is denoted by C.

(2) **Radius of curvature:** The radius of the sphere whose part is the lens surface.

(3) **Principal axis:** Line joining the centre of curvature of the two surfaces of lens.

(4) **Optical centre:** Point on the principal axis of lens such that a ray of light passing through this point emerges parallel to its direction of incidence.

(5) **Principal focus:**

Principal focus	Second principal focus
Point on principal axis of lens at which the rays starting from or directed to become parallel to principal axis after refraction.	Point on principal axis as which the rays coming parallel to principal axis converge or appears to diverge appears to diverge from the lens.
	

(6) **Focal length:** The distance between focus and optical centre of lens.

(7) **Focal plane:** The plane passing through the focus and perpendicular to the principal axis.

Principal Rays for Ray Diagram

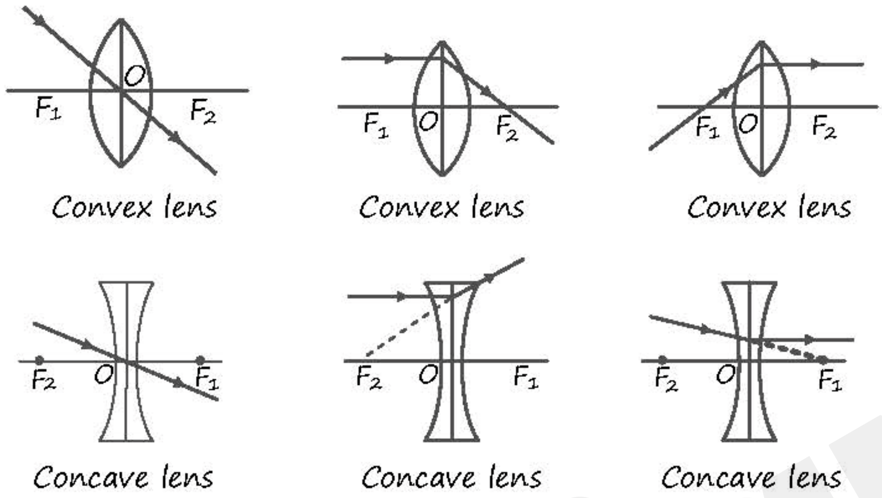
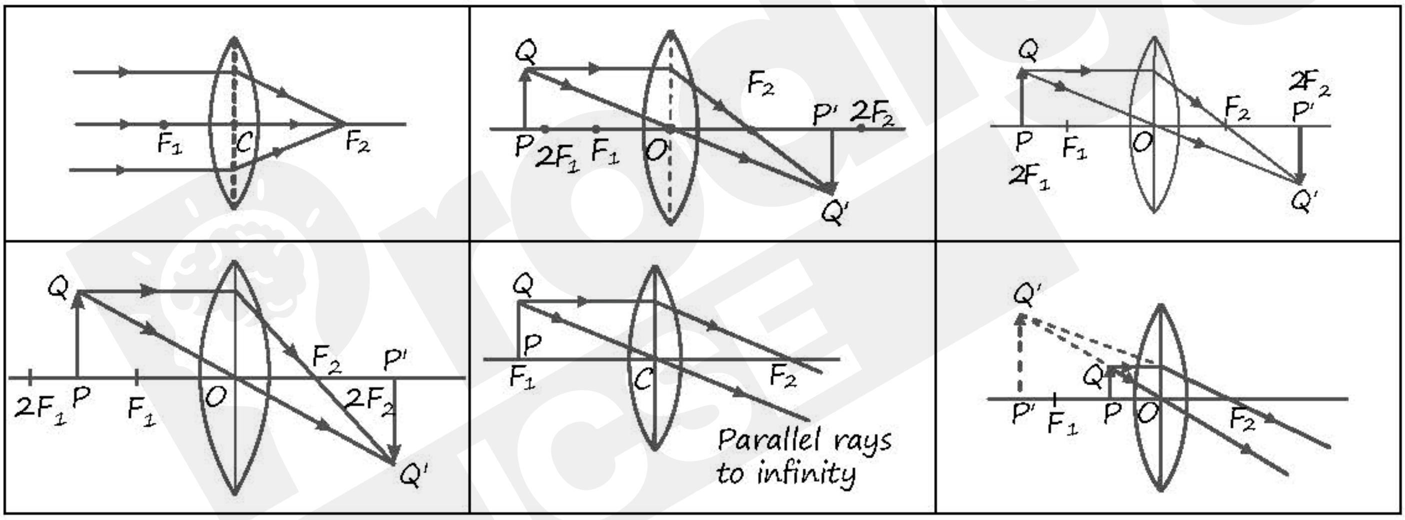


Image Formation by Convex Lens



S.No.	Position of object	Position of image	Size of image	Nature of image
1.	At infinity	At F	Point sized	Real & inverted
2.	Beyond 2F	Between F & 2F	Diminished	Real & inverted
3.	At 2F	At 2F	Same size	Real & inverted
4.	Between 2F & F	Beyond 2F	Enlarged	Real & inverted
5.	At F	At infinity	Highly enlarge	Real & inverted
6.	Between F & O	On the same side of lens as the object	Enlarged	Virtual & erect

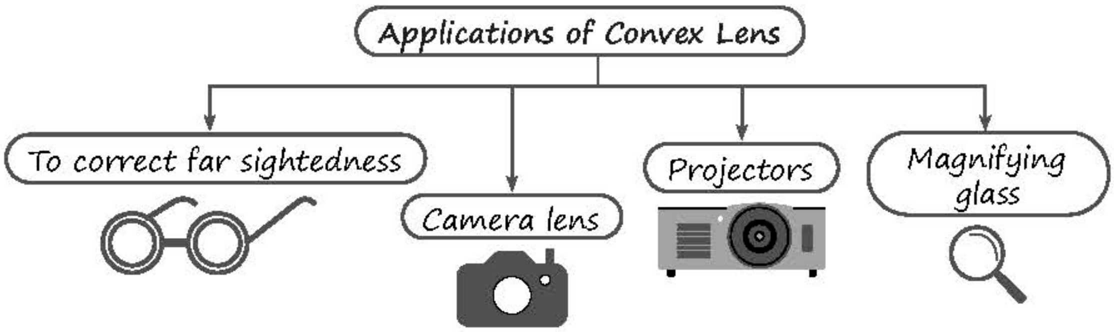
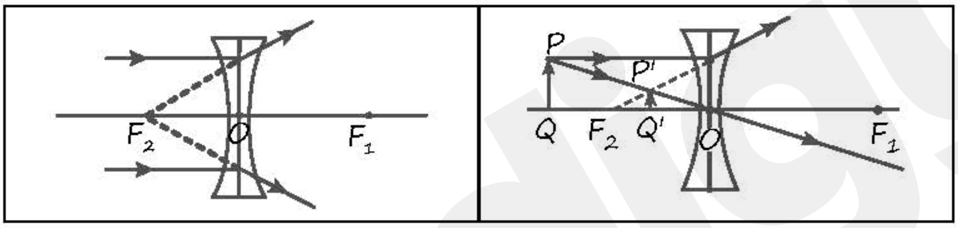
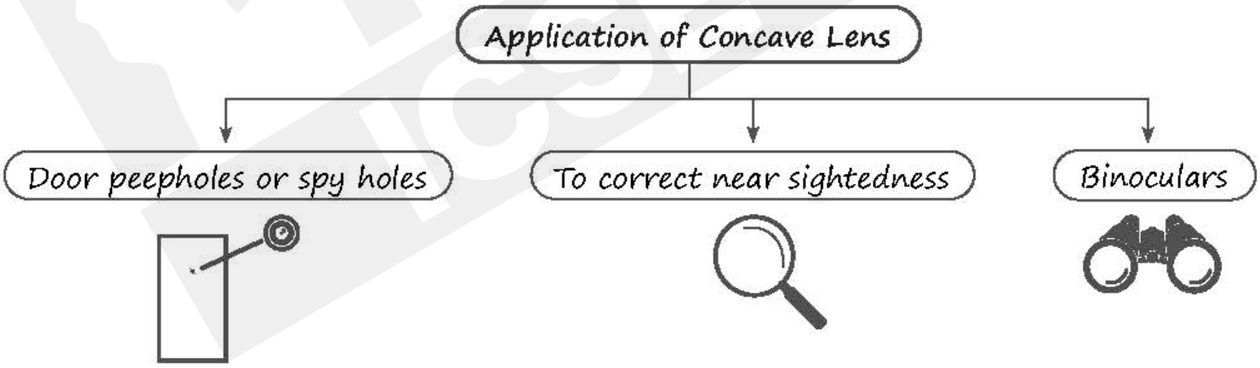


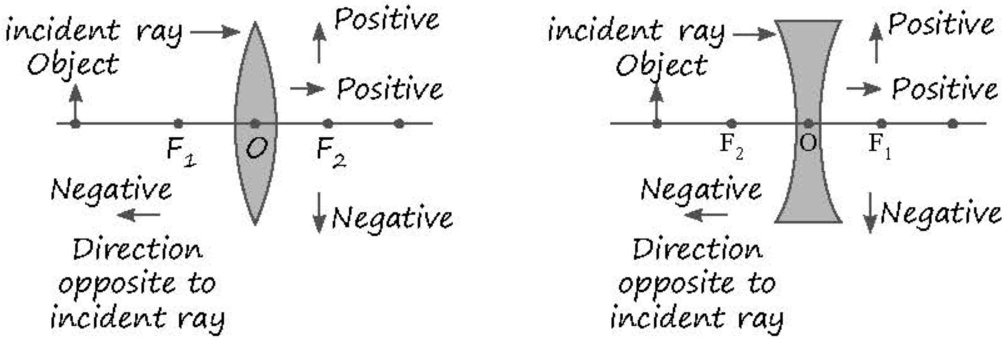
Image Formation by Concave Lens



S.No.	Position of object	Position of image	Size of image	Nature of image
1.	At infinity	At F, same side as the object	Diminished	Virtual & erect
2.	Between lens & infinity	Between F & O, on same side as the object	Diminished	Virtual & erect



Sign Convention and Lens Formula



Lens Formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$f \rightarrow$ focal length
$u \rightarrow$ object distance
$v \rightarrow$ image distance

Linear Magnification

The ratio of length of image to the length of object (both perpendicular to principal axis)

$$m = \frac{h_I}{h_O} = \frac{v}{u}$$

Power of a Lens

The deviation of the incident light rays produced by a lens on refraction through it, is a measure of its power.

$$\text{Power of lens} = \frac{1}{\text{focal length}}$$

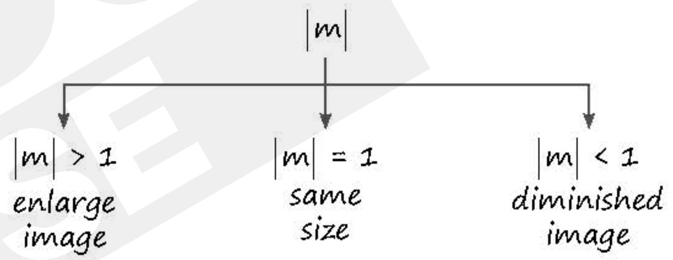
It is measured in diopter (D).

Formula Sheet

(1) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

(2) $m = \frac{h_I}{h_O} = \frac{v}{u}$

$m \Rightarrow + \Rightarrow$ virtual, erect image
$m \Rightarrow - \Rightarrow$ real, inverted image



(3) $P = \frac{1}{f}$

$P \Rightarrow + \Rightarrow$ Convex lens
$P \Rightarrow - \Rightarrow$ Concave lens

7
CHAPTER

Sound

Sound is a form of energy which produces a sensation of hearing in our ears.

It is produced by vibrating objects. It requires a material medium (solid, liquid or gas) for its propagation.

Sound waves are also called mechanical waves.

Type of Waves

(1) **Longitudinal wave:** Individual particles of the medium vibrate in the direction parallel to the direction of propagation of wave.

(2) **Transverse wave:** Individual particles of the medium vibrate perpendicular to the direction of wave propagation.

Light is a transverse wave (but not a mechanical wave)

Propagation of Sound in Air

When a vibrating object moves forwards, it compresses the air, creating compression (high pressure) and when it moves backward it created rarefaction (low pressure). Compression (C) is where particles are close together and Rarefaction (R) is where particles are father apart.

Relationship between speed, frequency and wavelength of sound wave:

Speed = frequency × wavelength

Range of Hearing

The average frequency range over which the human ear is sensitive is called audible range (20 Hz to 20,000 Hz)

Infrasonic sound: Sound of frequency less than 20 Hz, cannot be heard by humans.

Ultrasonic sound: Sound of frequency higher than 20,000 Hz. Bats, dolphins, tortoise and rats can produce as well as hear ultrasound.

Reflection of Sound Waves

The returning back of sound waves on striking a surface such as wall, metal sheet etc.

Sound does not require a smooth and shining surface like mirror for reflection.

Condition for reflection of sound wave is that the size of reflecting surface must be bigger than the wavelength of sound wave.

Echo

The sound heard after reflection from a distant obstacle (such as a cliff, hillside, wall of a building, edge of a forest etc.) after the original sound has ceased is called echo.

Condition for hearing an echo

(1) The size of obstacle/reflector must be large compared to the wavelength of the incident sound.

(2) The distance between the source of sound and the reflector should be at least 17 m.

(3) Intensity of sound must be high enough for echo to be heard clearly.

Note: If there are repeated reflections at the reflecting surface the sound gets prolonged. This effect is known as reverberation.

Determination of speed of sound by method of echo

$$V = \frac{\text{Total distance travelled}}{\text{time interval}} = \frac{2d}{t} (ms^{-1})$$

V = speed of sound

Uses of echo

Ehoes find their application in sound ranging and echo depth sounding by using ultrasonic waves.
Reason for using ultrasonic waves:

(1) They can travel undeviated through a long distance.

(2) Can be confined to a narrow beam.

(3) They are not easily absorbed in a medium.

Uses of echo by:

+ Bats, dolphins, fisherman
+ SONAR (Sound navigation and raging)
+ Medical field – i.e., ultra sonography

Natural, Damped and Force Vibrations

Natural vibrations

The periodic vibrations of a body in the absence of any external force on it are called the natural (or free) vibrations.

E.g.,

(i) if bob of a simple pendulum is displaced slightly.

$$f = 2\pi\sqrt{\frac{g}{l}}$$

$f \rightarrow$ frequency
$g \rightarrow$ acceleration due to gravity
$l \rightarrow$ length of pendulum

(ii) A load suspended from spring when stretched.

$$f = 2\pi\sqrt{\frac{k}{m}}$$

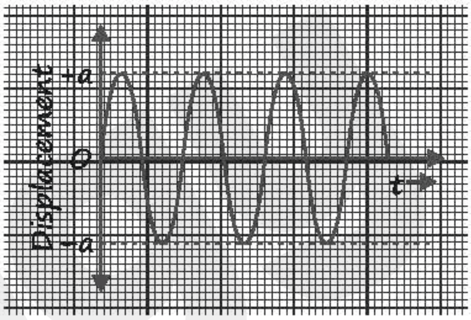
f → frequency
k → force constant
m → mass of load

(iii) Tuning fork struck against rubber pad.

(iv) Striking keys of piano.

(v) When air column in a flute vibrates.

(vi) When stringed instrument (guitar, sitar, violin) is plucked



$$f = 2\pi\sqrt{\frac{T}{\pi r^2 d}}$$

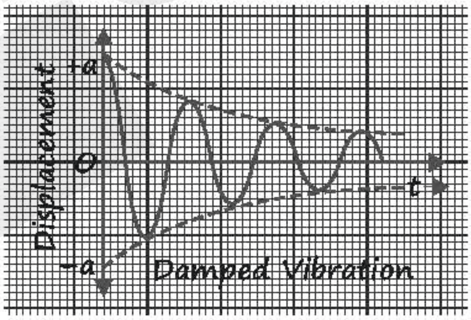
f → frequency
T → Tension
r → radius of string
d → density of string

Note: In ideal condition once a body start vibrating it continues to vibrate with same amplitude & frequency forever.

Damped vibrations

The periodic vibration of a body of decreasing amplitude in presence resistive force.

In damped vibrations two forces act on the body (1) restoring force (2) frictional (resistive) force.



E.g.,

(i) Branch of tree when pulled and released

(ii) Tuning fork vibrating in air

(iii) Oscillating pendulum in air

(iv) Spring (load) vibration in air

Forced vibrations

The vibrations of a body which takes place under the influence of an external periodic force acting on it. The vibrating body is acted upon by 3 forces:

(1) restoring force

(2) resistive force

(3) external periodic force

Amplitude of the forced vibrations depends on the frequency of external force.

E.g.,

(i) Swing pushed at regular interval

(ii) While playing a guitar, artist forces the strings of the guitar to execute forced vibrations.

Resonance: It is special case of forced vibration when the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrated with increased aplitude.

E.g.,

(i) Sympathetic vibrations of pendulums

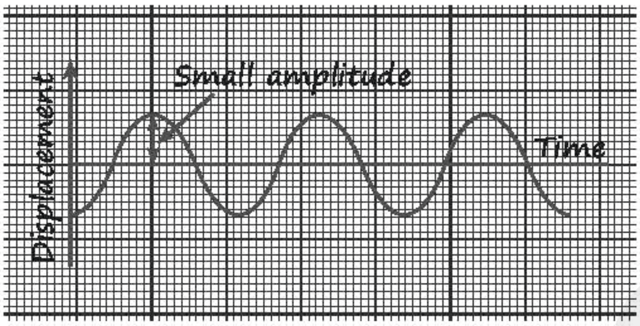
(ii) Resonance in radio and TV receiver

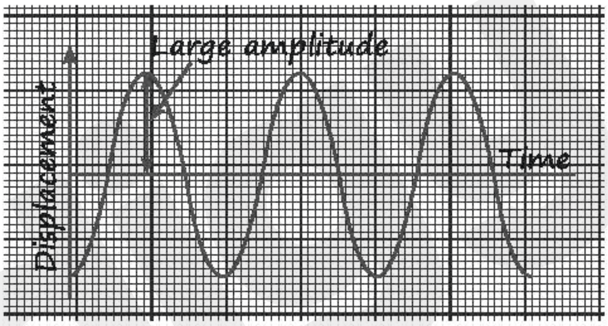
(iii) Resonance in bridge

(iv) Resonance in air column and tuning fork.

Characteristics of Sound

(1) **Loudness:** It is a characteristic by virtue of which a loud sound can be distinguished from a faint one, both having same pitch and quality. It depends on the amplitude of the wave.





Factors affecting loudness:

(i) Proportional to square of amplitude

(ii) Inversely proportional to the square of distance from sound

(iii) Surface area of vibrating body

(iv) Density of medium

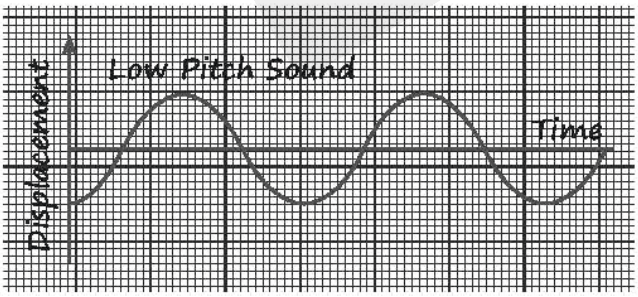
(v) Presence of resonant bodies

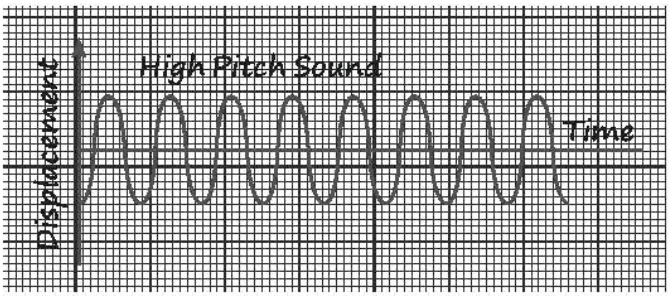
(2) **Intensity:** The amount of sound energy passing each second through unit area.

S.I. unit ⇒ Watt per square metre (W/m^2)

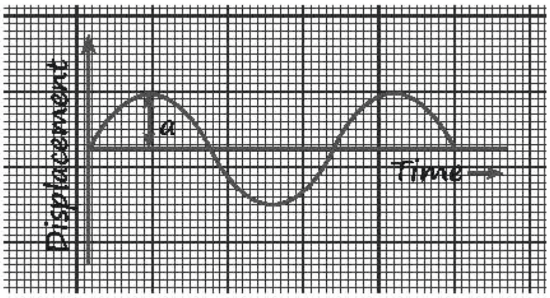
$$L = k\log_{10} I$$

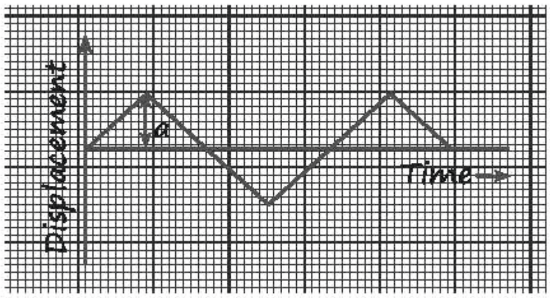
(3) **Pitch (or shrillness):** Pitch is the characteristic of sound by which an acute (shrill) note can be distinguished from a grave or flat note pitch depends on its frequency.





(4) **Quality (or timbre) and waveform:** Quality of a sound is that characteristic which distinguishes the two sounds of the same loudness and same pitch but emitted by two different instruments. The quality of a musical sound depends on the waveform.





Music and Noise

Music		Noise	
(1)	It is regular, smooth and pleasant to ears.	(1)	It is harsh and unpleasant to ears.
(2)	Produced by periodic vibrations.	(2)	Produced by irregular succession of disturbance.
(3)	All the component waves are similar without any sudden change in wavelength & amplitude	(3)	Wave changes their character suddenly and they are short duration.
(4)	Sound level is low (10 dB to 30 dB)	(4)	Sound level is high (about 120 dB)
(5)	Wave form is regular	(5)	Wave form is irregular

Formula Sheet

(1) $v = f\lambda$

$v \rightarrow$ velocity

$f \rightarrow$ frequency

$\lambda \rightarrow$ wavelength

$T \rightarrow$ time period

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

(2) Echo

$D = \frac{vt}{2}$

$D \rightarrow$ distance between source and obstacle

$v \rightarrow$ speed

$t \rightarrow$ time

(3) Frequency of oscillating pendulum

$f = 2\pi\sqrt{\frac{g}{l}}$

Frequency of loaded spring (oscillatin)

$f = 2\pi\sqrt{\frac{k}{m}}$

Frequency of oscillating string

$f = 2\pi\sqrt{\frac{T}{\pi r^2 d}}$

(4) Intensity & loudness

$L = K\log_{10} I$

$L = 10\log_{10}\left[\frac{I_1}{I_0}\right] dB$

$I_0 = 10^{-12}\ W/m^2$

I_1 = intensity of sound

8 CHAPTER Current Electricity

Electric Charge

It is a physical entity which is defined by excess or deficiency of electrons on a body.

S.I. unit $\Rightarrow$ coulomb (C)

The total charge acquired by a body is an integral multiple of magnitude of change on a single electron. This principle is called quantisation of charge.

$\boxed{q = ne}$ q = total charge, n = number of electrons, e = charge on 1 electron = 1.6×10^{-19}C

$1mC = 10^{-3}C$, $1\mu C = 10^{-6}C$, $1nC = 10^{-9}C$

Current

Rate of flow of charge

$\boxed{I = \frac{Q}{t}}$ $I = \frac{ne}{t}$ I = current, Q = charge, t = time

S.I. unit $\Rightarrow$ ampere (A), $1mA = 10^{-3}A$, $1\mu A = 10^{-6}$ A

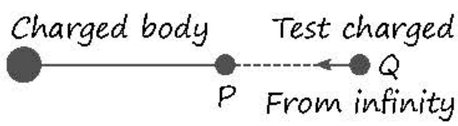
Note: Direction of current is taken opposite to the flow of electrons.

Electric Potential

Potential at a point is defined as the amount of work done in bringing a unit positive charge from infinitely to that point. It is a scalar quantity.

$\boxed{V = \frac{W}{Q}}$ V = potential W = work done Q = charge

S.I. unit $\Rightarrow JC^{-1}$ or volt (V)



Potential Difference (p.d.)

The potential difference between two points is equal to the work done in moving a unit positive charge from one point to the other.

$$\boxed{V_A - V_B = \frac{W}{Q}}$$

S.I. unit $\Rightarrow$ Volt (V)

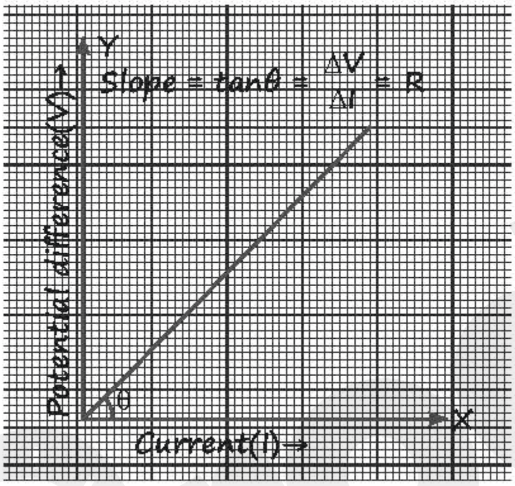
Resistance

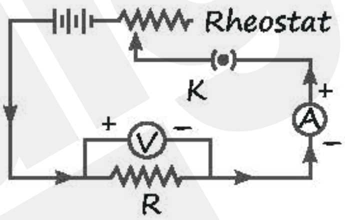
The obstruction offered to the flow of current by the conductor (or wire) is called its resistance.

Ohm's Law

According to Ohm's law the current flowing in a conductor is directly proportional to the potential difference applied across its ends provided the physical conditions and the temperature of conductor remains constant.

$$I \propto V, \quad \frac{V}{I} = \text{constant}, \quad \boxed{R = \frac{V}{I}}, \quad \boxed{V = IR}$$





Resistance of a conductor is numerically equal to the potential difference across its ends when unit current flows through it.

S.I. unit is ⇒ ohm (Ω)

Ohmic and Non-ohmic resistors:

	Ohmic resistor		Non ohmic resistor
(1)	Obey's ohm's law	(1)	Do not obey ohm's law
(2)	V-I graph is a straight line	(2)	V-I graph is not straight line
(3)	Slope of V-I graph is same at all values	(3)	Slope of V-I graph is different for different values
	e.g., silver, iron, copper, nichrome		e.g., junction diode, L.E.D., transistor, filament bulb.

Factors affecting the resistance of a conductor

(1) Nature of conductor

(2) Length of conductor, $R \propto l$

(3) Area of cross section of conductor, $R \propto \frac{1}{A}$

(4) Temperature,

$$R \propto l,\ R \propto \frac{1}{A} \text{ or } R \propto \frac{1}{\pi r^2}, \quad \boxed{R \propto \frac{l}{A} \text{ or } R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}}$$

Specific resistance or Resistivity (ρ): It is the resistance of a wire of that material of unit length and unit area of cross section. S.I. unit $\Rightarrow \Omega m$

Conductivity

The reciprocal of specific resistance is known as conductivity (σ), $\boxed{\sigma = \frac{1}{\rho} = \frac{l}{RA}}$ S.I. unit $\Rightarrow \Omega^{-1}m^{-1}$

Conductance

Reciprocal or resistance, $\boxed{\text{Conductance} = \frac{1}{R}}$ S.I. unit $\Rightarrow \Omega^{-1}$

Superconductor

It is a substance of zero resistance (or infinite conductance) at a very low temperature.

Electromotive force (E.M.F.) of a cell

The E.M.F. of a cell is defined as the energy spent (or the work done) per unit charge in taking a positive test charge around the complete circuit of cell.

$$\boxed{E = \frac{W}{q}}$$

Factors affecting the E.M.F. of a cell:
(i) shape of electrodes
(ii) distance between electrodes
(iii) amount of electrolyte

Terminal voltage of a cell

The terminal voltage of a cell is defined as the work done per unit charge in carrying a positive test charge around the circuit, connected across the terminals of cell.

$$\boxed{V = \frac{W'}{q}}$$

Voltage drop in a cell

Work done in carrying a unit charge through the electrolyte is called voltage drop in the cell.

$$\boxed{V = \frac{W}{q}}$$

Relationship between E.M.F. and terminal voltage of a cell:

$$\boxed{E = V + v}$$

Internal resistance of a cell

Resistance offered by the electrolyte inside the cell, to the flow of current is called internal resistance of cell.

$$\boxed{V = Ir}$$

Factors affecting internal resistance of a cell:
(1) Surface area of electrodes

(2) Distance between the electrodes
(3) Nature & concentration of electrolyte
(4) Temperature of electrolyte

Relationship between E.M.F., terminal voltage and internal resistance:

Total resistance = R + r

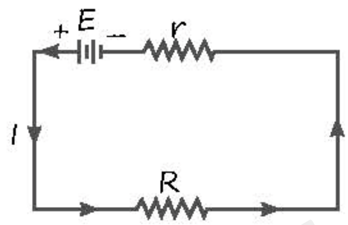
Current drawn from cell, $I = \dfrac{E}{R+r}$

E.M.F. (E) = I(R + r)

Terminal voltage of cell, V = IR = E − Ir

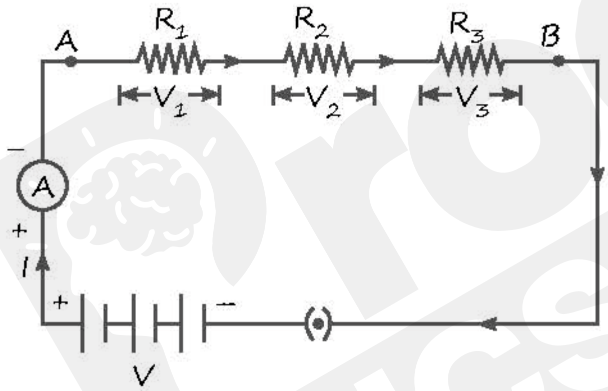
Voltage drop due to internal resistance = Ir

Internal resistance, $r = \dfrac{E-V}{I} = \dfrac{E-V}{\frac{V}{R}} = \left[\dfrac{E}{V} - 1\right]R$



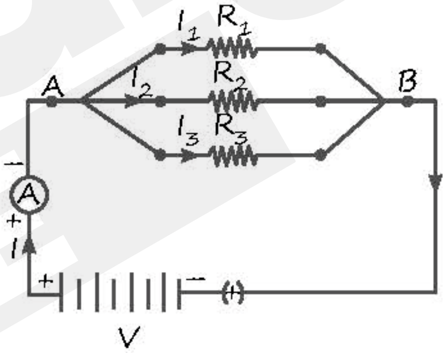
Combination of Resistors

Series



$R = R_1 + R_1 + R_3$

Parallel



$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Measurement of Electrical Energy (E)

E = work done

$$W = QV = VIt = I^2Rt = \frac{V^2t}{R}$$

S.I. unit ⇒ joule (J)

Electrical power: The rate at which electrical energy is supplied by the source.

$$P = \frac{W}{t} = VI = \frac{V^2}{R} = I^2R$$

S.I. unit ⇒ watt (W) or Js^{-1}

Bigger units ⇒ 1 kW = 1000 W

$1 \text{ MW} = 10^6 \text{ W}$

$1 \text{ HP} = 746 \text{ W}$

Commercial unit of electric energy: $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$

Power rating of common electrical appliances:

(i) Resistance of filament of bulb, $R = \frac{V^2}{P}$

(ii) Safe current limit through the filament of the bulb, $I = \frac{P}{V}$

Household consumption of electrical energy: Cost of electricity = electrical energy (in kWh) × cost per kWh

Heating effect of electric current

The heat produced in a wire on passing current through it is called heating effect of current. This is known as Joule's law of heating.

$$H = I^2Rt \text{ (in joule)} = 0.24\, I^2Rt \text{ (in cal)}$$

Formula Sheet

(1) $I = \frac{Q}{t} = \frac{ne}{t}$

(2) $V = \frac{W}{Q}, V_A - V_B = \frac{W}{Q}$

(3) $V = IR$

(4) $\text{Conductance} = \frac{1}{R}$

(5) $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

(6) Conductivity $(\sigma) = \frac{1}{\rho} = \frac{l}{RA}$

(7) $EMF(E) = \frac{W}{q}$

(8) Terminal voltage $(V) = \frac{W'}{q}$

(9) $E = I(R + r)$

(10) $r = \left(\frac{E}{V} - 1\right)R$

(11) Series combination

$R = R_1 + R_2 + \ldots\ldots + R_n$

(12) Parallel combination

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots + \frac{1}{R_n}$

(13) Electrical energy

$W = QV = VIt = I^2Rt = \frac{V^2t}{R}$

(14) Electrical power

$P = \frac{W}{t} = VI = \frac{V^2}{R} = I^2R$

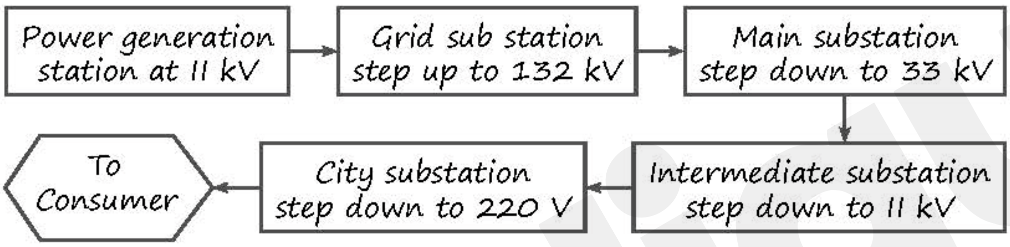
(15) $H = I^2Rt$ (in joule)

$H = 0.24 I^2Rt$ (in calorie)

9
CHAPTER

Household Circuits

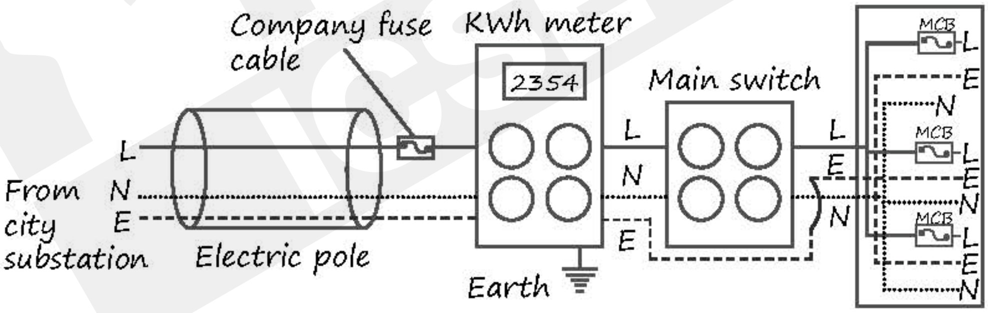
Power Distribution



The power is transmitted over a long distance at a high voltage to minimize the loss of energy in the form of heat in the line wire. At high voltage, the value of current is very less, therefore heat produced, $H = I^2Rt$, will also be less.

Power Distribution to House (Components of Household Electric Circuit)

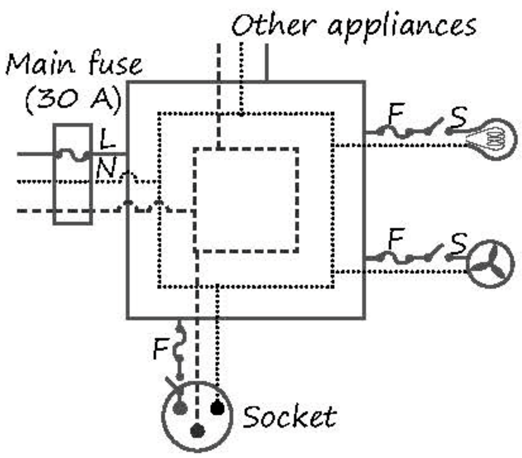
(1) **Main circuit:** Electricity is transmitted to home via two wires, the live wire (220 V) and the neutral wire (0 V). The live wire carries current, while the neutral wire returns it. An earth wire ensures safety. The main fuse is in live wire and the main switch controls both live and neutral wires. Homes have two separate circuits; a 5A fuse for lighting and a 15A fuse for power devices.



Main Circuit

Main switch: It controls the flow of electricity to the home. It is the primary connection between the external power supply and home's wiring. The main switch is often a double pole switch, which means it can break the connection to both the neutral wire and live wire at the same time.

House wiring (Ring system): In this system wires starting from main fuse box run around all the rooms of house and then come back to fuse box again forming the ring.



Advantage:

(i) Each appliance can operate independently without affecting the other appliances connected in the system.

(ii) New appliance can be connected directly without new wiring.

Fuse

An electric fuse is a safety device which is used to limit the current in an electric circuit, fuse safeguards the circuit and the appliances connected in that circuit from being damaged.

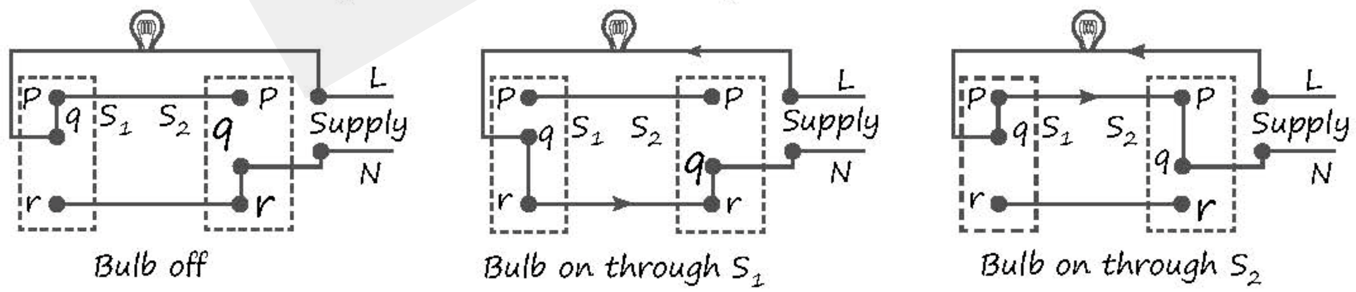
- Thin wire of tin (25%) & lead (75%) alloy
- Low melting point (≈ 200°C)
- Works on the principle of heating effect of current
- Always connected to live wire before appliance.

$$\text{Current rating of fuse} = \frac{\text{Total power of appliances in circuit}}{\text{Voltage of supply}}$$

Switch

A switch is an on-off device for current in a circuit. It is connected to live wire in series.

Dual control switch (staircase wiring): Switch that controls a load from two different locations. It is also known as multiway switch or staircase wiring.



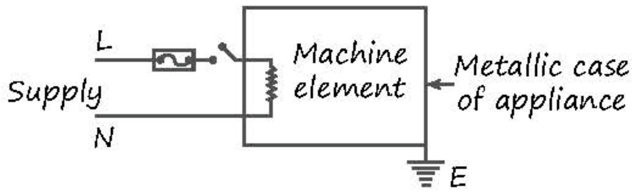
MCB (Miniature Circuit Breaker)

- Safety device automatically shuts off an electrical circuit when there is power surge or short circuit.

Advantage: More reliable than fuses because they can be reset instead of replaced.

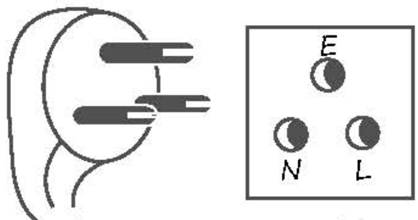
Earthing

Process of connecting an electrical appliance's metal case to the ground using earth wire.
It is a safety measure that protects people from electric shocks.



Three pin plug and socket

Top pin: Earthing
Left pin: Live
Right Pin: Neutral
The earth pin is thicker and loner than other two.



Plug Socket

Safety precautions

- ❑ Do not touch switch with wet hands.
- ❑ Switch should always be connected to live wire.
- ❑ Appliances should be earthed.
- ❑ Use appropriate fuse rating in live wire of circuit.

Colour Coding of Wires		
Wire	Colour	
	Old	New convention
Live	Red	Brown
Neutral	Black	Blue
Earth	Green	Green or Yellow

10 CHAPTER Electromagnetism

Oersted's Experiment

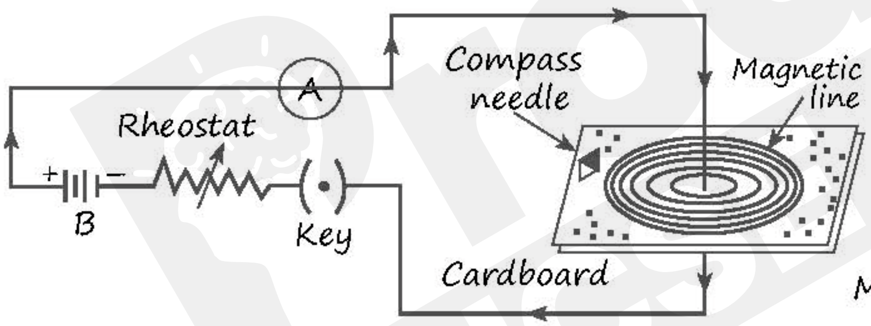
When an electric current is passed through a conducting wire, a magnetic field is produced around it, which is detected using compass needle.

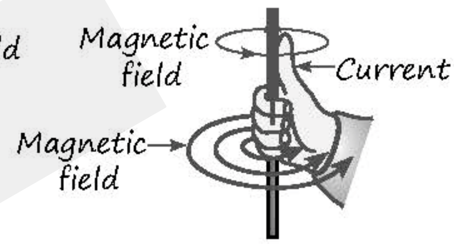
Magnetic field

The region around a magnet in which its effect can be experienced. It is denoted by B.

- Vector quantity
- S.I. unit ⇒ tesla (T)

Magnetic field due to straight current carrying conductor

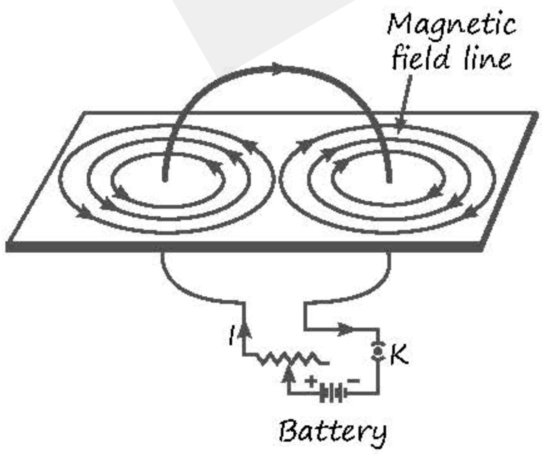


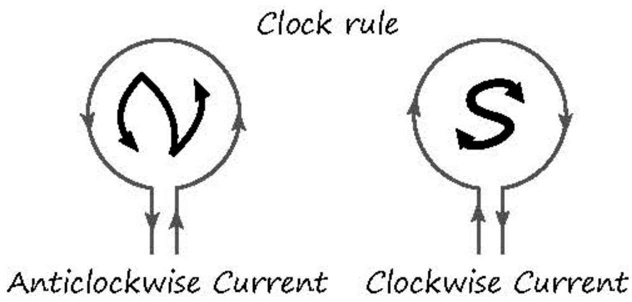


Maxwell's right hand rule-current

If we hold the current carrying conductor in our right hand such that the thumb points in the direction of flow of current, then the fingers encircle the wire in the direction of magnetic field lines.

Magnetic field due to current in a loop

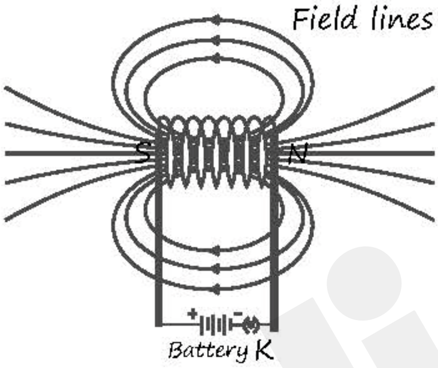




Magnetic field lines become dense if:
(1) the strength of current in the loop is increased.
(2) the number of turns in loop are increased.

Magnetic field due to solenoid

If a conducting wire is wound in form of a cylindrical coil whose diameter is less than comparison to its length, the coil is called solenoid.



Magnetic field depends on:
(1) No. of turns of solenoid $B \propto N$
(2) Strength of current, $B \propto I$
(3) Nature of core material used to make solenoid

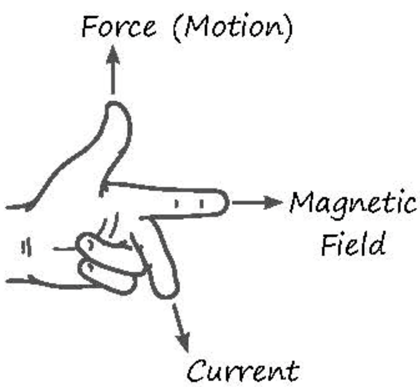
Comparison of electromagnet and permanent magnet

Electromagnet		Permanent magnet	
(1)	It is made of soft iron.	(1)	It is made of steel
(2)	Produces temporary magnetic field	(2)	Produces permanent magnetic field
(3)	Magnetic field strength can be changed	(3)	Magnetic field strength cannot be changed
(4)	Polarity can be reversed	(4)	Polarity cannot be reversed
(5)	Can be easily demagnetized	(5)	Cannot be demagnetized

Uses of electromagnet
(1) Lifting and transporting large masses of iron scrap.
(2) Loading furnace with iron.
(3) Magnetic separation.
(4) Removing iron pieces from wounds.

Force on a current carrying conductor

Fleming's Left hand Rule: Stretch the forefinger central finger and thumb of your left hand mutually perpendicular to each other. If forefinger indicates the direction of magnetic field and the central finger indicates the direction of current, then the thumb will indicate the direction of motion of conductor. (i.e. force on conductor)



Simple D.C. motor

An electric motor is a device which converts the electrical energy into mechanical energy.

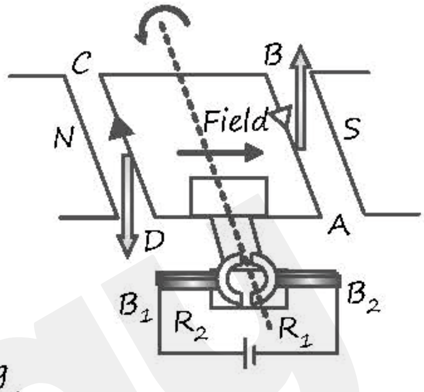
Principle: When current is passed through a conductor placed normally in a magnetic field, force acts on the conductor.

Parts of motor:

(1) Armature (2) Split rings (3) Brushes
(4) Magnet (5) DC source

Speed rotation of motor can be increased by:

(i) Current (ii) No. of turns
(iii) Area of coil (iv) Magnetic field strength



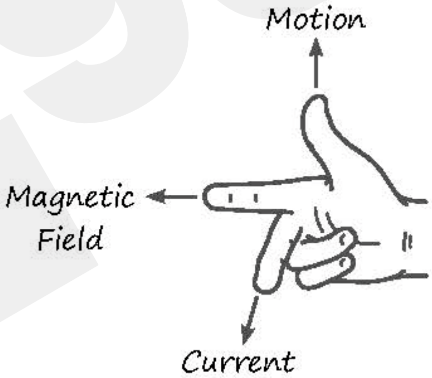
Electromagnetic induction

The phenomenon of production of emf in a conductor on changing the magnetic field around it. The emf produced is called induced emf.

The factors affecting the magnitude of induced emf are:

(i) change in the magnetic flux
(ii) Time in which the magnetic flux changes.

Fleming's Right Hand Rule



Fleming's right hand rule

Stretch the thumb, central finger and forefinger of your right hand mutually perpendicular to each other. If the forefinger indicates the direction of magnetic field and thumb indicates the direction of motion of conductor then the central finger will indicate the direction of induced current.

A.C. generator

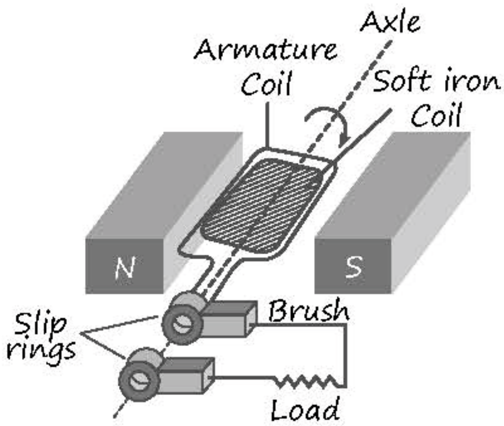
Device which converts mechanical energy into electrical energy is called generator.

Principle: Electromagnetic induction.

Parts of generator:

(1) Field magnet (2) Armature coil
(3) Slip rings (4) Brushes

Frequency of alternating current: If the coil makes n rotations per second, then the magnitude of induced emf is given as: $e = e_0 \sin 2\pi nt$ and current is: $i = i_0 \sin 2\pi nt$



Difference between A.C. and D.C.

	Direct current (D.C.)		Alternating current (A.C.)
(1)	Current of constant magnitude	(1)	Current of varying magnitude
(2)	Flows in one direction	(2)	Reverses its direction while flouring in circuit
(3)	Source – Cell (or battery)	(3)	Source – AC generator or mains

Advantages of A.C. over D.C.:

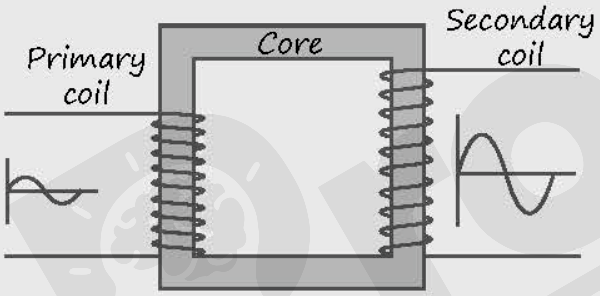
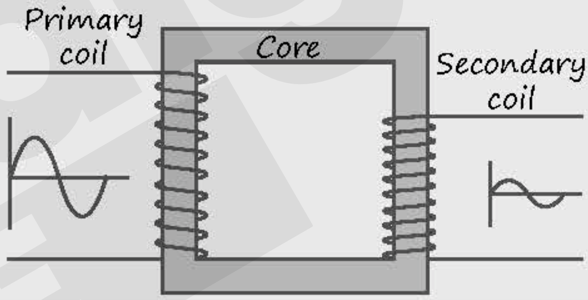
(i) A.C. at any desirable voltage can be obtained using transformer.
(ii) A.C. can be converted to D.C. using rectifier.
(iii) Cost of generation is less.
(iv) A.C. can be controlled without much power loss.
(v) A.C. machines are very durable.
(vi) For long-distance transmission A.C. is preferred as it causes minimum loss of energy.

Transformer: Device which is used to increase or decrease the amplitude of an alternating emf.

They are of two types:

(1) Step-up transformer
(2) Step-down transformer

Principle: Transformer is based on the principle of mutual induction.

Step-up transformer	Step-down transformer
Changes low alternating voltage too high alternating voltage. ($E_S > E_P$, $N_S > N_P$)	Changes high alternating voltage to low alternating voltage. ($E_S < E_P$, $N_S < N_P$)
	
Uses: ❑ Transmission of electric power at the power generating station to step up the voltage ❑ Television ❑ Wireless sets ❑ X-ray tubes to provide high accelerating voltage.	**Uses:** ❑ Electric bells, night bulbs, mobile phones, computers. ❑ At the power substation to step down the voltage before its distribution to consumers.

11
CHAPTER

Calorimetry

Heat

Heat is the internal energy of molecules constituting the body. It flows from a hot body to a cold body when they are kept in contact.

It is represented by Q. S.I. unit ⇒ joule (J). Other units: 1 calorie = 4.2 joule. 1 kcal = 10^3 cal = 4.2×10^3 joule

Note: The measurement of the quantity of heat is called calorimetry.

Temperature

It is the measure of hotness or coldness of any body. S.I. unit ⇒ Kelvin (K)

Other units: Celsius (°C), Fahrenheit (°F)

$$T(K) = T(°C) + 273.15$$
$$\Delta T(°C) = \Delta T(K)$$

Factors affecting the quantity of heat absorbed to increase the temperature of a body:

(1) mass of body (m)

(2) increase in temperature of body Δt

(3) material of the body

$Q \propto m \quad Q \propto \Delta t$

$\boxed{Q = cm\Delta t}$ c = specific heat capacity

Thermal Capacity or Heat Capacity (c)

Amount of heat energy required to raise the temperature of a body by 1°C (or 1K). It is denoted by C.

$$\text{Heat capcity}(C) = \frac{\text{Heat supplied}(Q)}{\text{Rise in temperature }(\Delta t)}$$

S.I. unit ⇒ JK^{-1} or $J°C^{-1}$

Specific Heat Capacity (c)

Amount of heat energy required to raise the temperature of unit mass of the substance through 1°C (or 1K)

$$c = \frac{\text{Amount of heat energy supplied}}{\text{mass} \times \text{rise in temperature}}, \quad \boxed{c = \frac{Q}{m\Delta t}}$$

S.I. unit ⇒ J Kg^{-1} K^{-1} or J Kg^{-1} $°C^{-1}$

Relationship between C and c

$$C = m \times c$$

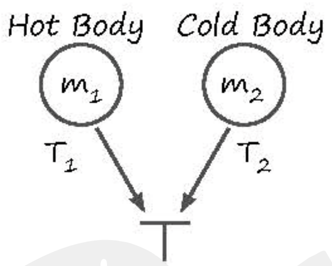
Specific heat capacity (c) → low ⇒ conductor
Specific heat capacity (c) → high ⇒ Poor conductor
Water has an unusually high specific heat capacity (= 4200 J Kg^{-1} K^{-1})

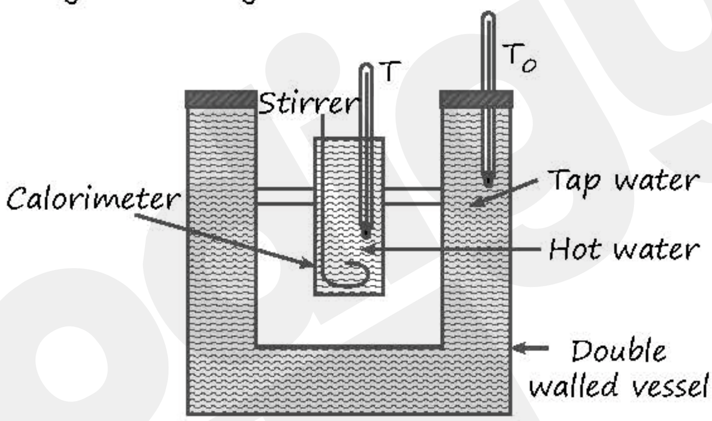
Calorimeter

It is a cylindrical vessel which is used to measure the amount of heat gained (or loss) by body when it is mixed with the other body.

Principle

Heat lost by hotter body = Heat gained by cooler body



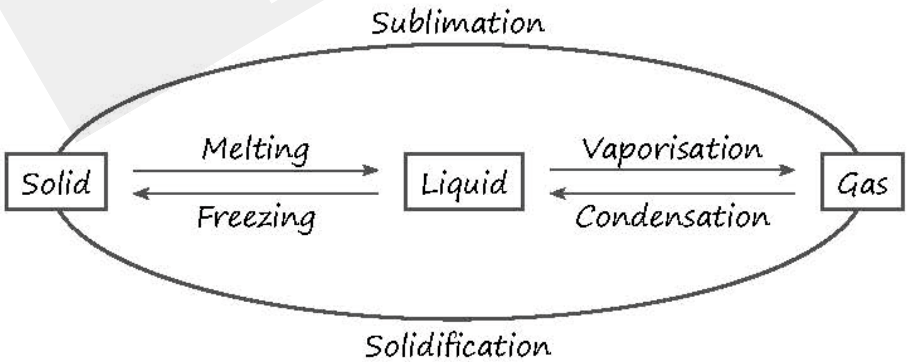


Heat lost (Q_1) = Heat gained (Q_2)

$$m_1 c_1 (T_1 - T) = m_2 c_2 (T - T_2)$$

Changes of Phase (State)

The process of converting one state of substance into another state is known as change of state of substance. It happens by heat absorption or rejection.



Latent Heat

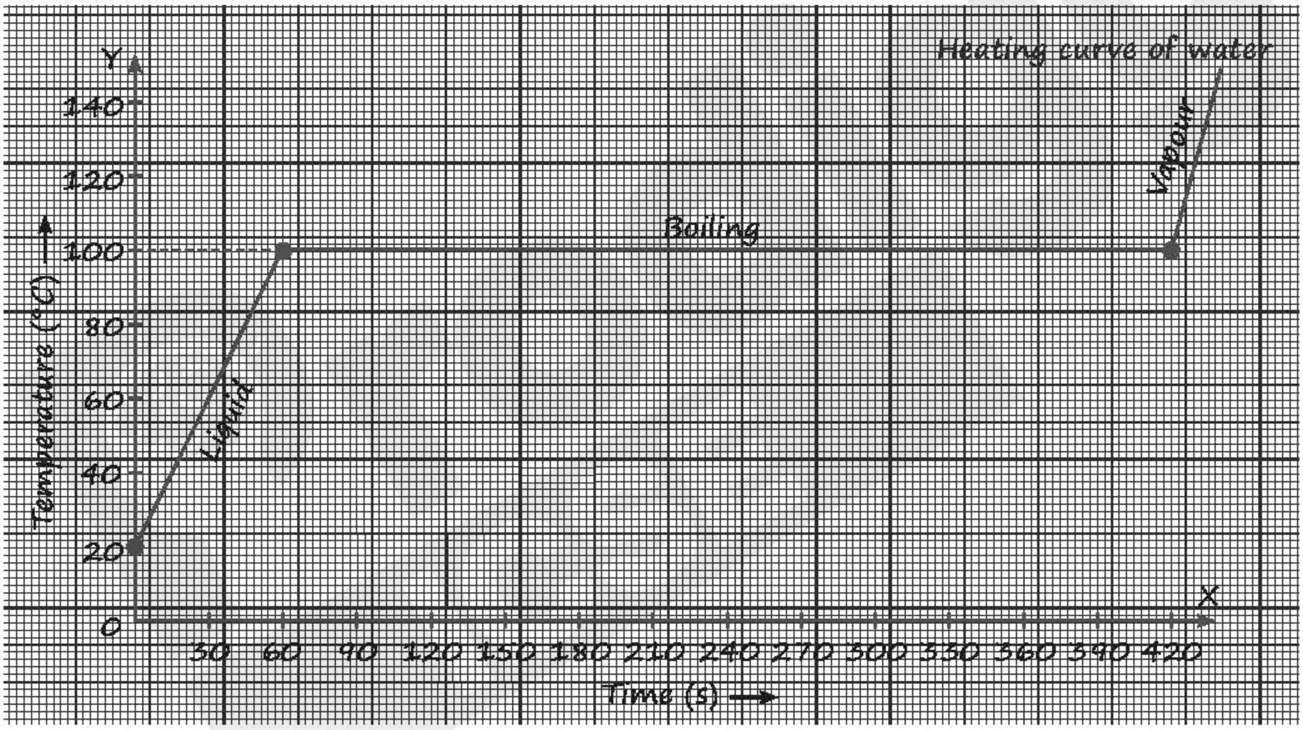
It is the hidden amount of heat that is given out or taken by the unit mass of any substance to change its state without change in temperature. It may also be called as change in potential energy of molecules.

Specific Latent Heat

Quantity of heat absorbed (or liberated) by the unit mass of the substance for the change in its phase at constant temperature. It is denoted by L.

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

S.I. unit $\Rightarrow$ J kg^{-1}, Other unit $\Rightarrow$ cal g^{-1}, kcal kg^{-1}



Formula Sheet

(1) T(K) = T(°C) + 273.15

(2) $Q = mc\Delta t$ [Heat energy]

(3) $C = \frac{Q}{\Delta t}$ [Heat capacity]

(4) $c = \frac{Q}{m\Delta t}$ [Specific heat capacity]

(5) $C = m \times c$ [Relation between C and c]

(6) $m_1c_1(T_1 - T) = m_2c_2(T - T_2)$ [Principle of calorimetry]

(7) $L = \frac{Q}{m}$ [specific heat capacity]

12 CHAPTER Radioactivity

Atoms

Smallest part of any substance which consists of a centralized dense part called nucleus.

Atomic Number (Z)

Number of proton present in nucleus of an atom.

Mass Number (A)

Total number of proton and neutron present in nucleus.

Isotopes

Atoms belonging to the same element having same atomic number (z) but different mass number.
E.g., Protium $\left({}_{1}^{1}H\right)$ and deuterium $\left({}_{1}^{2}H\right)$

Isotones

Atoms with same neutrons (N) but different atomic number (Z). E.g., $\Rightarrow$ ${}_{11}^{23}Na$ and ${}_{12}^{24}Mg$

Isobars

Atoms with same mass number (A) but different atomic number. E.g., $\Rightarrow$ ${}_{11}^{23}Na$ and ${}_{12}^{23}Mg$

Radioactivity

Spontaneous process by which a nucleus of an unstable atom decay by emitting radiations such as α, β and γ. Substances which disintegrate by spontaneous emissions are radioactive substances. E.g., Uranium, Radium, Polonium, Thorium, Actinium etc. Radioactivity is a nuclear phenomenon.

Properties of α (alpha) particles

- Consists of Helium nuclei, ${}_{2}He^{4}$.
- It is positively charged particle.
- Least penetration power.
- Highest ionisation power.
- Can't penetrate skin but harmful for humans.
- Effects a photographic plate.
- Causes fluorescence on striking a fluorescence material.
- Affected by electric and magnetic fields.

Properties of β (Beta) particles

- Highly energetic electrons, which release from inside of a nucleus.
- Denoted by $_{-1}\beta^0$ and $_{+1}\beta^0$.
- They are negatively and positively charged.
- They have negligible mass.
- For emission of negative β particles, a neutron divides into proton and an electron and for +β protons converts into neutron.
- Greater penetration power compared to α particles.
- Less ionization power, still harmful.
- Effects photographic plate
- Causes fluorescence on striking fluorescent material.
- Affected by electric & magnetic field.

Properties of γ particles (Gamma)

- Waves from high frequency end of electromagnetic spectrum which do not have mass.
- Neutral in nature.
- Denoted by $_0\gamma^0$
- High penetrating power compared by α and β particle.
- Very harmful for living cell & causes mutation.
- Effects photographic plate.
- Cause fluorescence when they strike a fluorescent material.
- Not affected by electric and magnetic fields.

Changes within the nucleus in α, β and γ emission

(1) Alpha emission

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

Parent nucleus → Daughter nucleus + α-particle

(2) Beta emission

$$^{A}_{Z}P \longrightarrow {}^{A}_{Z+1}Q + {}^{0}_{-1}e$$

Parent nucleus → Daughter nucleus + β-particle

(3) Gamma emission

$$^{A}_{Z}X \longrightarrow {}^{A}_{Z}X + \gamma$$

Parent nucleus → Daughter nucleus + γ-radiation

Uses of Radioactivity

(1) Medical use (2) Industrial use (3) Scientific use

X-Rays

- These are electromagnetic waves
- Frequency ranges from 10^{16} to 3×10^{20} Hz

Uses:

(i) Surgery to detect fracture, stones in body
(ii) To detect fault, crack on bridges
(iii) For security purpose to detect metal or explosive material.
(iv) Used in scientific research.

Sources of harmful radiation

(1) Radioactive fall out from nuclear power plants
(2) Nuclear waste
(3) Cosmic radiations

Background radiations

All the radiations which are present in the atmosphere, even if there is no radioactive source present are called background radiations. The sources of these radiations are:

(i) cosmic radiations
(ii) natural and artificial radioactive isotopes
(iii) products after nuclear explosion
(iv) traces of radioactive substance present in earth, i.e., rocks.

Safety measures for handling radioactive materials

- Know radiation safely limits to prevent excessive exposure.
- Wear lead lined apron and gloves for protection.
- Store radioactive substances in thick lead containers with narrow opening to prevent radiation spread.

Nuclear energy

Energy released during the transformation of nuclei to another nuclei.

Two distinct ways of obtaining nuclear energy.

Nuclear Fission		Nuclear Fusion	
(1)	Breaking of heavy nucleus into lighted nucleus	(1)	Involves binding of two nucleus
(2)	It is a chain reaction	(2)	It is not a chain reaction
(3)	It is a controlled process	(3)	It is uncontrolled process
(4)	Produces enormous energy	(4)	More energy than fission
(5)	Fission products are hazardous	(5)	It does not cause pollution
	$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,_{0}n^{1} + Q$ $^{235}_{92}U$: Heavy nucleus; $^{1}_{0}n$: Thermal nucleus; Ba + Kr: Fission product; $3\,_0n^1$: Product neutron; Q: Huge amount of energy (220 Mev)		$_1H^1 + _1H^1 \rightarrow _1H^2 + _1e^+ + v + 0.42\ meV$ $_1H^2 + _1H^2 \rightarrow _2He^3 + _0n^1 + 3.27\ meV$ $_1H^2 + _1H^2 \rightarrow _1H^3 + _1H^1 + 4.03\ meV$