UNIT – I: WORK, POWER AND ENERGY

CHAPTER-1
FORCE

Topic-1 Turning Forces, Equilibrium

Concepts covered: Force, Equilibrium, Moment of force, Torque

Revision Notes

Translational Motion

- It is basically the motion of the object wherein object shifts from one point to another point in the space.
  - Examples of translational motion include motion of a rectangular wooden block down an inclined plane.
  - Rectilinear motion, object moves in straight line.

Rotational Motion

- When a rigid body rotates about its centre of mass is called rotational motion.
  - An object spinning about a fixed axis is said to be in rotational motion.
  - Examples of rotational motion include a spinning top.

Forces and its Types :

- **Force :** A force is that physical cause which changes or tends to change the state of rest or motion or direction of a body. It can also change the shape or size of a body.
- The S.I. unit of force is Newton (N). It is a vector quantity. C.G.S unit is dyne and gravitational unit is gf or kgf. Where, 1 kgf = 9.8 N.
- Force can be classified into two broad categories: contact forces and non-contact forces.
- **Contact force :** A force that comes into play only when there is a direct contact between two objects is known as contact force. Pushing a car, kicking a ball, pulling an object etc. are the examples of contact force.
- **Non-Contact force :** A force that comes into play, even when there is no direct (physical) contact between the two objects is known as non-contact forces.

  Electrical, magnetic, gravitational and nuclear forces are examples of non-contact forces.

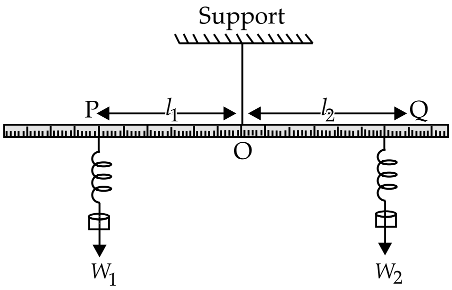
Torque :

- Torque is the measure of rotational tendency of a force. It is also called moment of force.
- Torque is the product of force with the perpendicular distance of force from the point of rotation.
- Mathematically,

  Torque = Force × perpendicular distance from the axis of rotation.
- Torque is a vector quantity. Its S.I. unit is Newton metre (N-m).
- **Couple :** Two equal and opposite forces acting along parallel lines at different points of the body form a couple.

Principle of Moments :

- **Principle of Moments :** When an object is in equilibrium, then the sum of the anti-clockwise moments about a turning point must be equal to the sum of the clockwise moments.



Let the distance of the weight W_1 from the support be l_1 and the distance of weight W_2 from the support be l_2. Let the weight W_1 tries to rotate the scale in anti-clockwise direction. Then, Anti-clockwise moment = $W_1 \times l_1$

And the weight W_2 tries to rotate the scale in clockwise direction. Then,

Clockwise moment = $W_2 \times l_2$

As the scale is in equilibrium, so

Total anti-clockwise moment = Total clockwise moment

$$W_1 \times l_1 = W_2 \times l_2$$

Forces in Equilibrium :

- When a number of forces acting on a body produces no change in its state of rest or of motion, the body is said to be in equilibrium.
- The condition for a body to be in translatory motion equilibrium is that net force acting on the body is zero.
- The condition for a body to be in rotational motion equilibrium is that net torque acting on the body is zero.
- The equilibrium of a body is of three types :
  (i) Stable equilibrium (ii) Neutral equilibrium.
  (iii) Unstable equilibrium.
- A body is said to be in stable equilibrium, if it has a tendency to return to its original position, after being slightly disturbed.
- A body is said to be in neutral equilibrium if on being slightly disturbed, it continues to stay in equilibrium in its new position, in the same way as it was in its original position.
- A body is said to be in unstable equilibrium, if it has no tendency to come to its original position, after being slightly disturbed from that position.

  The necessary conditions for a body to be in equilibrium are :

  (i) The sum of all the forces acting on the body is zero.

  (ii) The algebraic sum of the moments of all the forces acting on the body about any arbitrary point is zero.

Mnemonics

Concept: Moment of force
Mnemonics: **M**usic was **P**layed with a **F**lute and **D**rum.
Interpretations:
M : Moment of force
P : Product of
F : Force
D : distance
Moment of force = Force × distance

Key Equations

- Principle of Moments : Anti-clockwise moment = Clockwise moment

$$W_1 l_1 = W_2 l_2$$

- Torque = Force × perpendicular distances from the axis of rotation

$$\tau = F \times r$$

Topic-2 Centre of Gravity

Concepts covered: Centre of gravity

Revision Notes

Centre of Gravity :

- Centre of gravity of a rigid body is a point at which the entire weight of the body acts and algebraic sum of moments of weights of particles constituting the body is zero about this point.
- Centre of gravity of an irregular lamina is found by taking three points at the edges of the lamina. Then the object is suspended from any of the chosen points, and a weighted string is dropped from the same point and a line is drawn on the lamina along the string. This procedure is repeated from other two points on the lamina. These three lines will intersect at a point on the lamina which is basically the centre of gravity

CHAPTER-2
WORK, ENERGY AND POWER

Topic-1

Work, Energy and its Conservation

Concepts covered: Work, Energy (Potential and Kinetic) Conservation of Energy

Revision Notes

- Energy is the capacity of a body to do work. Its S.I. unit is joule.
- When a non-zero force (F) is applied on an object, it displaces by (d) by making an angle (θ) with the direction of force. Then work done mathematically, is defined as.

  $W = Fd \cos \theta$
- Work is said to be done only when force applied on a body makes the body move. S.I. unit of work is joule.
- Work is equal to force multiplied by displacement in the direction of force.
- Work can be positive, negative or zero.
- If the angle between force and the displacement is acute, then work is said to be positive.
- If the angle between force and the displacement is 90° i.e., displacement is perpendicular to the force applied, work is said to be zero.
- If the angle between force and the displacement is obtuse, the work is said to be negative.
- When a coolie walks horizontally while carrying a load on his head, no work is done against the force of gravity.
- When a body rotates in a circular path, no work is done against the centripetal force, as force and displacement are normal to each other.
- **Work done can be zero if :**

  (i) force applied is zero i.e., no force acts on the body.

  (ii) displacement of body is zero.

  (iii) angle between force and displacement is 90°.
- C.G.S. unit of energy or work is erg.
- One joule of work is said to be done when a force of 1 Newton displaces a body through a distance of 1 metre in its own direction.
- 1 erg of work is said to be done when a force of 1 dyne displaces a body through a distance 1 cm in its own direction.
- One kilowatt hour (1 kWh) is the energy spent (or work done) by a source of power 1 kW in 1 hour.
- Mechanical energy is of two types i.e.,

  (i) Kinetic energy $= \frac{1}{2} mv^2$

  (ii) Potential energy $= mgh$
- Kinetic energy is the energy possessed by a body by virtue of its motion. Examples include a moving train, a running boy, etc.
- **Types of kinetic energy :**

  (i) Translation kinetic energy (e.g.,→ a car moving in straight path, a freely falling body posses translational kinetic energy)

  (ii) Rotational kinetic energy (e.g.,→ a spinning top, a rotating fan posses rotational kinetic energy)

  (iii) Vibrational kinetic energy (e.g.,→ a wire clamped at both the ends when struck in the middle vibrates, possessing vibrational kinetic energy)
- Potential energy is the energy possessed by a body by virtue of its position or configuration.
- **Potential energy is of two types :**

  (i) Elastic potential energy

  (ii) Gravitational potential energy

- According to the law of conservation of energy, energy can neither be created nor be destroyed but it can be changed from one form to another.
- According to the work-energy theorem, the work done by a force on a moving body is equal to increase in its kinetic energy.
- **Derivation of expression of potential energy, $U = mgh$**
  Let a body of mass 'm' be lifted upwards to a height 'h' above the ground.
  Then, work done on the body against the force of gravity = force × displacement
  Force, $F = mg$
  Work done, $W = mg \times h$
  This work done will be stored in the body in form of potential energy, $U = mgh$
- **Derivation of expression of Kinetic energy, $K = \frac{1}{2}mv^2$**

  A body of mass 'm' moving with initial velocity 'v' is acted upon by a constant opposing force 'F' which produces retardation and the body is brought to rest.
  Force, F = mass × retardation ... (i)
  Using 2nd kinematic equation of motion, $v^2 = u^2 + 2as$ .... (ii)
  Where, initial velocity, $u = v$
  Final velocity, $v = 0$
  Acceleration, $a = -a$
  So, the equation (ii) becomes

$$0^2 = v^2 + 2 \times (-a) \times s$$

$$s = \frac{v^2}{2a} \quad \textbf{... (iii)}$$

  Kinetic energy will be equal to the amount of work the body does before coming to rest.

$$\text{Kinetic energy} = F \times s$$

$$= ma \times \frac{v^2}{2a} \quad \text{[Using equation (i) and (iii)]}$$

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

- **Law of conservation of energy :**
  In a closed system, i.e., a system that is isolated from its surroundings, the total energy of the system is conserved. So, the energy cannot be created or destroyed but may be changed from one form to another.

Mnemonics

Concepts: Positive, Negative and Zero work done.

Mnemonics : Appu Planned On a Day to visit New Zealand.

Interpretation :

A : Acute
P : Positive
O : Obtuse
N : Negative
N : Ninety
Z : Zero

When angle between the force and displacement is **acute**, the work done is **positive**.

When angle between the force and displacement is **obtuse**, the work done is **negative**.

When angle between the force and displacement is **ninety** degree, the work done is **zero**.

Key Equations

- Work = Force × displacement (in the direction of force)
- Work = $F s \cos\theta$
- Gravitational potential energy, $P = mgh$
  or, Work done by the force of gravity = mgh

Work energy theorem :

- Kinetic energy = $\frac{1}{2} mv^2$
- 1 joule = 10^7 ergs

- 1 watt hour = 3600 J = 3.6 kJ
- 1 kilowatt hour = 3.6×10^6 J
- 1 calorie = 4.186 joules
- 1 eV = 1.6×10^{-19} J
- $p^2 = 2\,mK$
  Where, p = Momentum
  and K = Kinetic energy
  Work-energy theorem :
  $$W = \frac{1}{2}\,mv^2 - \frac{1}{2}\,mu^2$$
- where, v = final velocity
  and u = initial velocity

Topic-2

Power and Sources of Energy

Concepts covered: Power, Sources of energy, Conversion of energy from one form to another

Revision Notes

- Power is the rate of doing work. Its S.I. unit is Watt.
- 1 Watt = 1 Js^{-1}
- If one Joule of work is done in 1 second, the power spent is said to be 1 Watt.
- 1 horse power = 746 Watts = 0.746 kW
- 1 kW = 1000 W, 1 MW = 10^6 W and 1 GW = 10^9 W
- The C.G.S unit of power is erg per second.
- 1 Watt = 1 J s^{-1} = 10^7 erg s^{-1}
- Solar energy is the energy radiated by the Sun.
- Solar panels, solar furnaces and solar cells use solar energy to do useful work.
- The energy released on burning coal, oil, wood or gas is the heat energy.
- Light is also a form of energy. We can see objects in presence of light only.
- The energy contained in fossil fuels such as coal, petroleum and natural gas is called chemical energy.
- The energy possessed by the fast moving water is called the hydro energy. It is used to generate electricity.
- The energy released due to loss in mass during nuclear reaction is called nuclear energy.
- The heat energy stored in the core of Earth is called geothermal energy.
- The energy possessed by the fast-moving air is called wind energy. Windmills use this energy to produce electricity.
- Sound energy is possessed by vibrating bodies.
- A natural source providing us energy continuously is called a renewable or non-conventional source of energy.
- Examples of renewable source of energy are solar energy, wind energy, energy from flowing water, energy from biomass, ocean thermal energy, geothermal energy, etc.
- The sources of energy which have accumulated in nature over a very long period and cannot be quickly replaced when exhausted are called non-renewable sources of energy or conventional sources of energy.
- Examples of non-renewable sources of energy are coal, petroleum and natural gas.

Key Equations

- $\text{Power} = \dfrac{\text{Work done}}{\text{Time taken}} = \dfrac{W}{t}$
- $\text{Power} = \dfrac{\text{Energy used}}{\text{Time taken}} = \dfrac{E}{t}$
- Power = Force × Velocity = $F \times v$

Mnemonics

Concept : Energy Sources:

Mnemonics : Champak arrived **N**asik via **R**ajkot. **N**itin **C**hopra **r**eceived him.

Interpretation :

C : Conventional Energy Sources
N : Non
R : Renewable
N : Non
C : Conventional Energy Sources
R : Renewable

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CHAPTER-3
MACHINES

Topic-1 Simple Machine

Concepts covered: Machines as Force Multipliers, Mechanical Advantage, Velocity Ratio, Efficiency

Revision Notes

- A machine 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.
- The external resistance against which any machine acts is called Load (L).
- The force applied on the machine to overcome the load is called effort (E).
- The ratio of the load to the effort is called the mechanical advantage of the machine, *i.e.*,

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

- Mechanical advantage is a ratio. Hence, it has no unit
- The ratio of the velocity of effort to the velocity of load is called the velocity ratio of machine *i.e.*,

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

- The velocity ratio is also defined as the ratio of the displacement of effort to the displacement of load.
- Velocity ratio is a ratio. Hence, it has no unit.
- A machine in which there is no loss of energy is called an ideal machine.
- The efficiency of an ideal machine is 100% but in practice, it is not possible.
- No machine does work by itself. For an ideal machine, output = input.
- A machine is a device that makes work easier for us. It does so by enabling us to
  - multiply force
  - apply force at a convenient point or in a convenient direction and
  - obtain gain in speed.
- The efficiency of a machine is the ratio of the useful work done by the machine (the output) to the total work done on the machine (input)

$$\text{Efficiency, } \eta = \frac{\text{output}}{\text{input}} \times 100\%$$

- For a practical machine,

$$\text{Efficiency} = \frac{\text{Mechanical advantage}}{\text{Velocity ratio}}$$

Topic-2 Pulley Systems

Concepts covered: Pulley, Block and Tackle

Revision Notes

- A pulley is simply a grooved wheel that is used along with a rope or a chain.
- A pulley which has its axis of rotation fixed in position is called a fixed pulley.
- For a pulley, mechanical advantage $= \dfrac{\text{Load}}{\text{Effort}}$
- For a single fixed pulley, ideal M.A. = 1 and V.R. = 1.
- A pulley whose axis of rotation is movable is called a movable pulley. A single movable pulley can act as a force multiplier.
- For a single movable pulley, ideal M.A. = 2 and V.R. = 2.

- We use single fixed pulley to change the direction of application of effort.
- A combination of pulleys enables us to multiply force by a factor that is dependent on the number of strands used to support the load.
- The block and tackle system of pulleys is made by having two blocks of pulleys in which the lower block is movable but the upper one is attached to a fixed support.
- When the weight of the lower movable block of pulley is negligible as compared to that of load and there is no friction, then M.A. = V.R. = n = number of strands of tackle supporting the load.

Mnemonics

Mnemonics :	Farhad stood	1st	and Madhavan stood	2nd.
	↓	↓	↓	↓
Interpretation :	Fixed Pulley (single)	1 (Both M.A. and V.R.)	Movable Pulley (single)	2 (Both M.A. and V.R.)

Key Equation

- Mechanical advantage = $\dfrac{\text{Load}}{\text{Effort}}$

For single fixed pulley, M.A. = 1, V.R. = 1
For single movable pulley, M.A. = 2, V.R. = 2
For block and tackle system, M.A. = V.R. = n
(n = number of strands of tackle system supporting the load)

UNIT – 2: LIGHT

CHAPTER-4
LIGHT

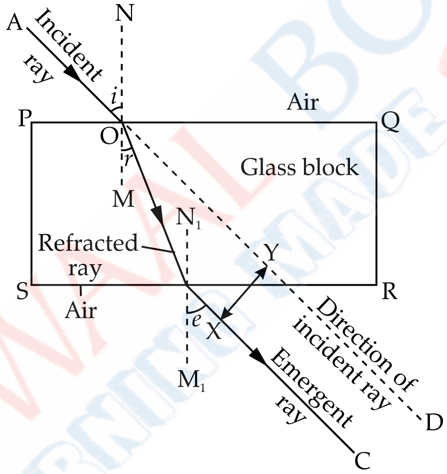
Topic-1 Refraction of Light at Plane Surface and Total Internal Reflection

Concepts covered: Refraction of light through a glass block and a triangular prism Total internal reflection

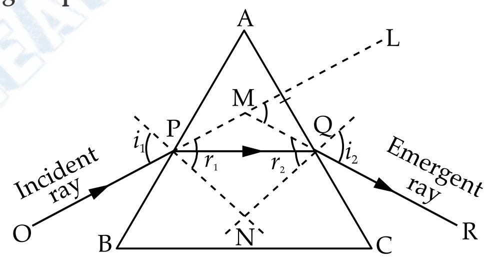
Revision Notes

- The speed of light in air/vacuum is 3×10^8 m/s.
- A medium is said to be optically denser if light slows down in it.
- A medium is said to be rarer if light speeds up in it.
- When a ray of light travels from a rarer medium to a denser medium, it bends towards the normal.
- When a ray of light travels from a denser medium to a rarer medium, it bends away from the normal.
- The conditions when light travelling from one medium to another goes undeviated :
  (i) Optical densities of both the media are the same.
  (ii) Angle of incidence is zero. i.e., light falls normally on the surface.
- Refractive index has no unit.
- When light passes from one medium to another, its frequency does not change but wavelength, speed and direction changes.
- When light passes from rarer to denser medium, its wavelength decreases.

- When light passes from denser medium to rarer medium, its wavelength increases.
- In case of minimum deviation of light while passing through the prism, the refracted ray inside the prism is parallel to the base of the prism.
- Factors affecting the angle of deviation of light travelling through the prism are :
  - **(i)** the angle of incidence.
  - **(ii)** the material of the prism (i.e., refractive index).
  - **(iii)** the angle of prism (A).
  - **(iv)** the colour or wavelength (λ) of light used.
- Factors affecting lateral displacement of light passing through a rectangular glass block :
  - **(i)** The thickness of glass block
  - **(ii)** The angle of incidence
  - **(iii)** The refractive index of the glass and therefore, the wavelength of light used
- Cause of refraction is that light has different speeds in different medium.
- The refractive index of a transparent medium is always greater than 1.
- Factors affecting refractive index of a medium :
  - **(i)** Nature of medium
  - **(ii)** Physical conditions such as temperature
  - **(iii)** The colour or wavelength of light
- Speed of light in glass is 2×10^8 m/s and in water is 2.25×10^8 m/s.
- Refractive index of glass is 1.5, of water is 1.33 and of diamond is 2.41.
- **Refraction of light through a rectangular glass block.**

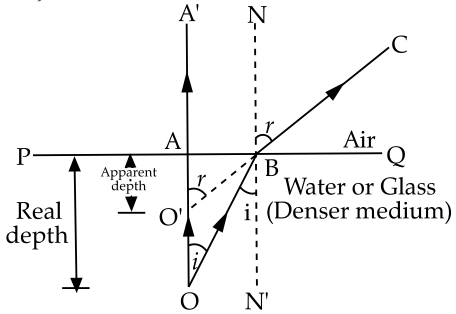


- **Refraction of light through a glass prism**

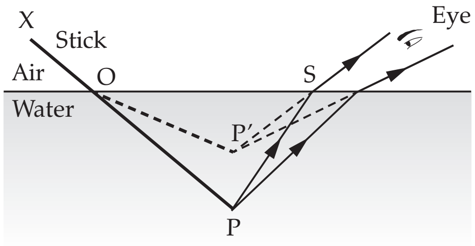


- **Applications of refraction of light**

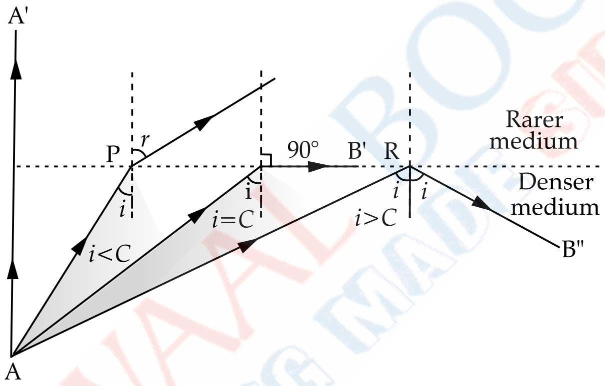
  (a) Real and apparent depths of object in water



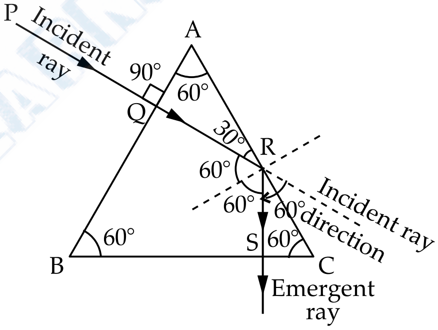
(b) Bending of stick under water



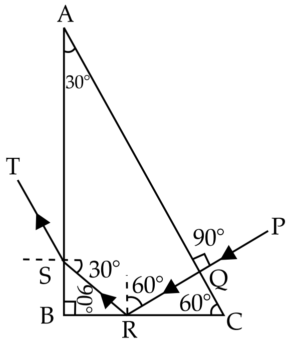
- Critical angle is the angle of incidence in the denser medium for which angle of refraction in the rarer medium is 90°.
- When a ray of light travels from a denser to a rarer medium with an angle of incidence greater than critical angle, then no refraction takes place and the entire light is reflected back in the denser medium. This is known as total internal reflection.
- **Essential conditions for total internal reflection to take place :**
  (i) Light must travel from a denser to a rarer medium.
  (ii) The angle of incidence should be greater than the critical angle for the given pair of medium.



- **Total internal reflection in a triangular glass prism**
  (a) An equilateral prism (60°,60°,60°)

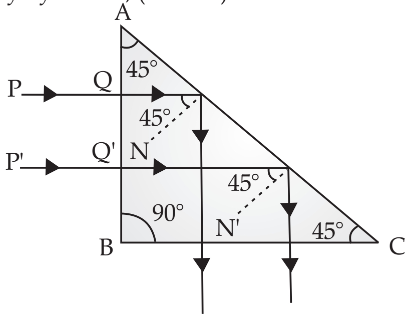


(b) A prism with angles (60°,30°,90°)

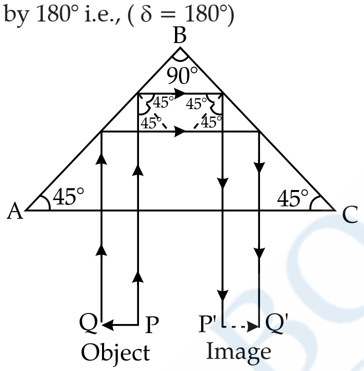


(c) A prism with angles (45°,45°,90°)

(i) To deviate the incident ray by 90° i.e., (δ = 90°)



(ii) To deviate the incident ray by 180° i.e., (δ = 180°)



➢ Comparison between total internal reflection and reflection from a plane mirror

(i) In total internal reflection, light enters from a denser to a rarer medium, whereas in reflection from a plane mirror, light can be incident from any medium.

(ii) There is no loss of energy in total internal reflection, as the entire light is internally reflected, whereas in case of reflection from plane mirror, there is a loss of energy due to absorption and refraction of light.

Key Terms

➢ **Refraction** : The change in direction of the path of light, when it passes from one transparent medium to another transparent medium is called refraction. It is a surface phenomenon.

➢ **Denser medium** : A medium is said to be optically denser if the speed of light in it decreases.

➢ **Rarer medium** : A medium is said to be optically rarer if the speed of light in it increases.

➢ **Angle of incidence** : It is the angle between incident ray and the normal to the surface at point of incidence.

➢ **Angle of refraction** : It is the angle between the refracted ray and the normal at the point of incidence.

➢ **Laws of refraction** :

  ➢ **1st Law** : The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

  ➢ **2nd Law** : The ratio of the sine of the angle of incidence *i* to the sine of the angle of refraction *r* is constant for the pair of given media. This constant is called refractive index. This law is also called Snell's Law.

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

➢ **Lateral displacement** : The distance between the incident ray extrapolated and the emergent ray when light travels through a rectangular glass slab is called lateral displacement.

➢ **Angle of deviation** : The angle between the emergent ray and the incident ray extrapolated when light passes through a prism is called angle of deviation.

Key Equations

➢ Frequency, $f = \dfrac{\text{Speed of light in medium, } v}{\text{Wavelength of light in that medium, } \lambda}$

➢ Refractive index (or absolute refractive index), $\mu = \dfrac{\text{Speed of light in air, } c}{\text{Speed of light in that medium, } v}$

➢ Refractive index of second medium with respect to first medium

$$= \frac{\text{Absolute refractive index in medium 2, } \mu_2}{\text{Absolute refractive index in medium 1, } \mu_1}$$

- $A + \delta = i + e$,where
  A is angle of prism
  δ is the angle of deviation, i is the angle of incidence and e is the angle of emergence
- $\mu = \dfrac{\text{Real depth}}{\text{Apparent depth}}$
- $\mu = \dfrac{1}{\sin C}$,where C is the critical angle.

Mnemonics

Concept: Movement of light ray when refracted from rarer to denser medium.

Mnemonics: Watch RD's Movie ToNight.

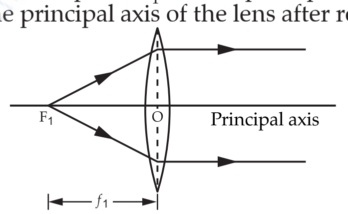
Interpretation:
R : Rarer to
D : Denser
M : Moves
T : Towards
N : Normal

Topic-2 Refraction Through a Lens

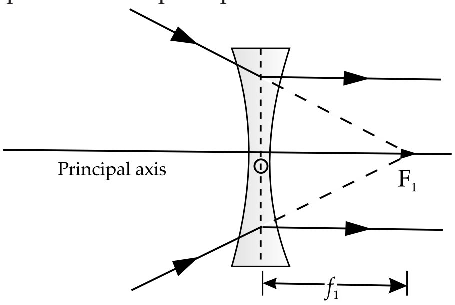
Concepts covered: Lenses (convex and concave)

Revision Notes

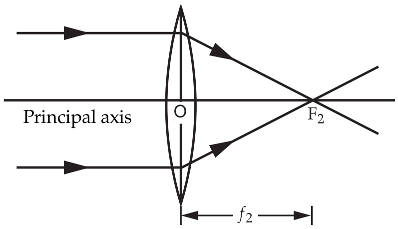
- A lens is a transparent refracting medium bounded by two surfaces, both of which are either spherical in shape or one is plane and other is spherical. A lens may be regarded as being made up of a set of prisms. (A lens is not made up of prisms.)
- There are mainly two types of lenses :
  (i) Convex or converging lens.
  (ii) Concave or diverging lens.
- Convex or converging lenses are thin at the edges and thick at the middle.
- Concave or diverging lenses are thick at the edges and thin at the middle.
- The principal axis of a lens is the line joining the centres of the two spheres of the two surfaces of which lens is a part.
- Optical centre of a thin lens is the point on the principal axis of the lens through which a ray of light passes undeviated.
- For a convex lens, the first focal point is a point F_1 on the principal axis of the lens such that the rays of light coming from it, become parallel to the principal axis of the lens after refraction from the lens.



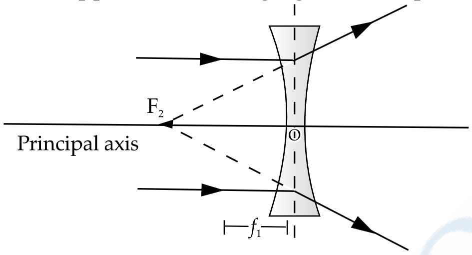
- For a concave lens, first focal point is a point F_1 on the principal axis of the lens such that the incident rays of light appearing to meet at it, become parallel to the principal axis of the lens after refraction from the lens.



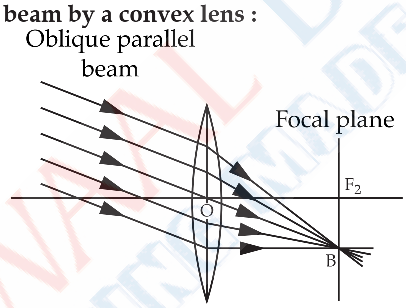
- For a convex lens, the second focal point is a point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis passes through it after refraction from the lens.



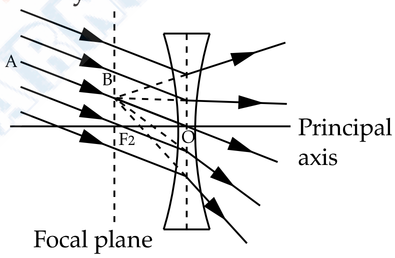
- For a concave lens, the second focal point is a point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis appear to be diverging from this point after refraction from the lens.



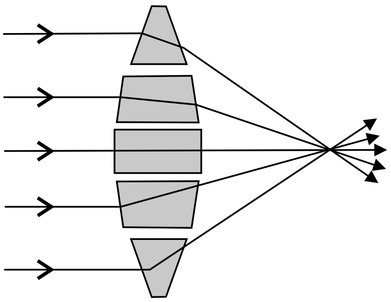
- A concave lens always produces a virtual, erect and diminished image of a real object.
- The power of a lens is the reciprocal of its focal length measured in metre. It is measured in units of **dioptre (D)**.
- A convex lens of small focal length may be used as a simple magnifying glass or a reading lens. For this, the object is kept between the optical centre and the focus of the lens. When it is used in this manner, it is also known as a **simple microscope**.
- The magnification produced by a lens is the ratio of a size of the image produced by it to the size of the object.
- **Refraction of an oblique parallel beam by a convex lens :**



- **Refraction of an oblique parallel beam by a concave lens :**



- A convex lens is made up of a large number of prisms and a glass slab:
  A convex lens may be considered to be a combination of a large number of truncated prisms. The prisms in the upper half have their bases downwards and the prisms in the lower half have their bases upwards with continuously changing angle of each prism. The central part of the lens is like a glass slab.
  Rays of light passing through the prisms tend to deviate towards the base. The central rectangular glass slab allows the incident ray to pass undeviated.

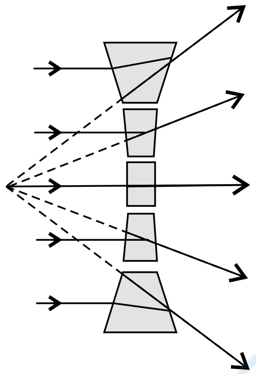


➢ **A convex lens is made up of a large number of prisms and a glass slab:**

A concave lens may be considered to be a combination of a large number of truncated prisms, The prisms in the upper half have their bases upwards and the prism in the lower half have their bases downwards with continuously changing angle of each prism.

The central part is like a rectangular glass block.

Rays of light passing through the prisms tend to deviate away from the base. The central rectangular glass slab allows the incident ray to pass undeviated.



➢ **Distinction between a real and virtual image :**

S. No.	Real image	Virtual image
1.	A real image is formed due to actual intersection of the rays refracted by the lens.	A virtual image is formed when the rays refracted by the lens appear to meet if they are produced backwards.
2.	A real image can be obtained on a screen.	A virtual image cannot be obtained on a screen.
3.	A real image is inverted with respect to the object. *Example :* The image of a distant object formed by a convex lens.	A virtual image is erect with respect to the object. *Example :* The image of a distant object formed by a concave lens.

➢ **Relative positions of the object and image in a convex lens :**

Positions of object	Position of image	Size of image	Name of image	Application
1. At infinity	At F_2	Highly diminished	Real and inverted	Burning glass
2. Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted	Camera lens
3. At $2F_1$	At $2F_2$	Same size	Real and inverted	Terrestrial telescope
4. Between F_1 and $2F_1$	Beyond $2F_2$	Magnified	Real and inverted	Slide projector
5. At F_1	At infinity	Highly magnified	Real and inverted	Collimator of spectrometer
6. Between the optical centre and F_1	On same side, behind the object	Magnified	Virtual and upright	Corrective lens or Magnifying glass

➢ **Relative positions of object and image in a concave lens :**

Position of the object	Position of the image	Nature of the image	Size of the image	Application
1. At infinity	At the focus, on the same side of the lens as the object.	Virtual and upright	Highly diminished	Galilean telescope
2. At any position between infinity and optical centre.	Between the focus and optical centre, on the same side of the lens as the object.	Virtual and upright	Diminished	Corrective lens for myopic eye

- **Difference between the image formed by a convex lens and by a concave lens :**

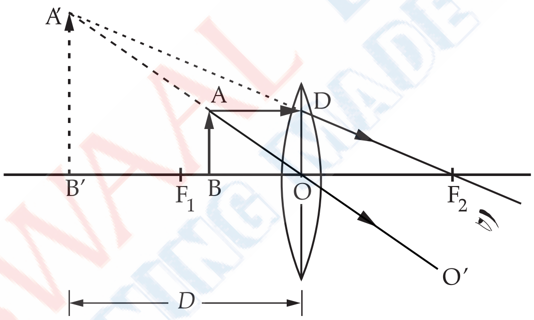
S. No.	Image by a convex lens	Image by a concave lens
1.	The image may be real as well as virtual. It is real if the object lies at or beyond focus, while it is virtual if the object lies between focus and optical centre.	The image is always virtual for all position of the object.
2.	The image may be magnified, of the same size, as well as diminished.	The image is always diminished.
3.	The image may be inverted, as well as erect. The image is inverted if the object is at or beyond focus and erect if the object is between focus and optical centre.	The image is always erect.

- The deviation produced by a lens in the path of rays refracted through it, is a measure of its power. Power of a lens is positive for the convex lens and negative for the concave lens.
- Power of lens (in D) = $1/f$
- **Magnifying power** : The magnifying power of the microscope is given as :

  Magnifying power = $1 + \dfrac{D}{f}$

  Where, D = least distance of distinct vision

  f = focal length of the lens.
- **Ray diagram for location of image in magnifying glass :**



- **Focal Length of Lens :** The distance between focus and optical centre of the lens is called **focal length of a lens**.
- **Focal Plane :** The plane passing through the focus and perpendicular to the principal axis is called **Focal plane**.
- **Aperture :** The effective diameter of the circular outline of a spherical lens is called its **aperture**.
- **Centre of Curvature:** Centre of curvature of a surface of a lens is the centre of the sphere of which lens is a part. A lens having two spherical surfaces has two centres of curvature.
- **Radius of Curvature:** Radius of curvature is the distance between the optical centre and centre of curvature.
- **Sign Conventions :**
  - All distances are measured from the optical centre of the lens.
  - Distances measured in the direction of the incident ray are taken as positive and opposite to the direction of the incident ray are taken as negative.
  - Distances measured upwards direction and perpendicular to principal axis are taken as positive, whereas distances measured downwards direction are taken as negative.
- Lens formula

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

  Where, u = Object distance (always negative)

  v = Image distance (may be positive or negative)

  f = Focal length (positive the for convex lens and negative for the concave lens)
- Lenses are used for eye defect correction, magnifying glass, telescope, camera.

Mnemonics

Concept: Thicker lens has shorter focal length.
Mnemonics : **T**he **L**oaf is **S**oft and **F**resh.

Interpretation:
T : Thicker
L : Lens
S : Softer
F : Focal length

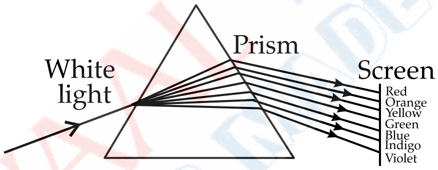
Topic-3

Spectrum

Concept covered: Electromagnetic spectrum, Dispersion

Revision Notes

- The phenomenon of splitting of white light by a prism into its constituent colours is known as **dispersion**.
- The band of colours seen on passing white light through a prism is called the **spectrum**.
- **Cause of dispersion** : The cause of dispersion is the change in speed of light with wavelength. When white light enters the first surface of a prism, light of different colours due to their different speeds in the glass gets deviated toward the base of prism through different angles.
- **Dispersion by a prism** :



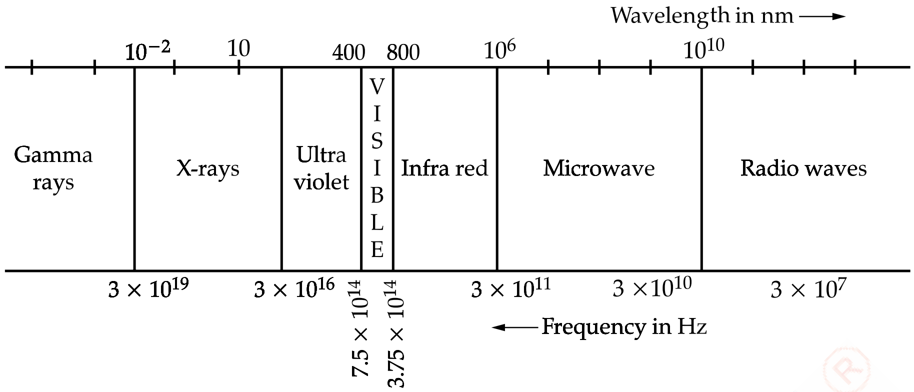
- The angle of deviation depends upon, (i) angle of incidence at first surface (ii) angle of prism (iii) refractive index of the material.
- **Wavelengths and frequencies of different colours in white light** :

Colour	Wavelength range (nearly)	Frequency range in 10^{14} Hz
Violet	4000 Å to 4460 Å	7.5 – 6.73
Indigo	4460 Å to 4640 Å	6.73 – 6.47
Blue	4640 Å to 5000 Å	6.47 – 6.01
Green	5000 Å to 5780 Å	6.01 – 5.19
Yellow	5780 Å to 5920 Å	5.19 – 5.07
Orange	5920 Å to 6200 Å	5.07 – 4.84
Red	6200 Å to 8000 Å	4.84 – 3.75

- The complete electromagnetic spectrum in the increasing order of their wavelength (or decreasing order of their frequency) is given below :

  (1) Gamma rays, (2) X-rays, (3) Ultraviolet rays, (4) Visible light, (5) infrared radiations, (6) Microwaves, and (7) Radio waves.

  Thus, infrared spectrum is the part of the spectrum just beyond the red end while the ultraviolet spectrum is the part of the spectrum just before the violet end.



Electromagnetic spectrum

Name of the wave	Frequency in Hz	Discoverer	Source	Method of detection
Gamma rays	above 3×10^{19}	Paul Villard	In cosmic rays, In radiations from radioactive substances.	By their large penetrating power
X-rays	$3 \times 10^{19} - 3 \times 10^{16}$	Roentgen	When highly energetic electrons are stopped by a heavy metal target of high melting point.	By the fluorescence produced on a zinc sulphide screen. The photographic film gets affected.
Ultraviolet	$3 \times 10^{16} - 7.5 \times 10^{14}$	Ritter	Sunlight, arc-lamp or spark	By their chemical activity on dyes. Photographic plates get affected. It causes fluorescence.
Visible light	$7.5 \times 10^{14} - 3.75 \times 10^{14}$	Newton	Sunlight, light from electric bulb, flame, white hot bodies.	Other objects can be seen in its presence.
Infrared waves	$3.75 \times 10^{14} - 3 \times 10^{11}$	Herschel	Lamp with thoriated filament, heated silicon carbide rod, red hot bodies	Heating effect is more. The mercury rises rapidly when a thermometer with the blackened bulb is kept in these radiations.
Microwaves	$3 \times 10^{11} - 3 \times 10^{7}$	Hertz	Electronic devices such as crystal oscillators	Oscillatory electrical circuit.
Radio waves	below 3×10^{7}	Maxwell predicted the existence of radio waves.	TV and radio transmitters	Aerials of radio and TV receiver.

- **Properties common to all electromagnetic spectrum :**
  - **(i)** The electromagnetic waves of the entire wavelength range do not require any material medium for their propagation.
  - **(ii)** They all travel with the same speed in a vacuum which is the same as the speed of light in vacuum *i.e.,* 3×10^{8} m/s.
  - **(iii)** They exhibit the properties of reflection and refraction.
  - **(iv)** These waves are not deflected by the electric and magnetic fields.
  - **(v)** These waves are transverse waves.
- **Properties and uses of the electromagnetic spectrum :**

➢ **γ-rays**

These rays are the most energetic electromagnetic waves of wavelength less than 0.01 nm.

- **Properties of γ-rays are as follows :**
  - **(i)** They cause fluorescence when they strike on the fluorescent materials as zinc sulphide.

(ii) They can easily penetrate through the thick metallic sheets.
(iii) γ-rays can easily penetrate through the human body.

- **Uses of γ-rays are as follows :**
  (i) They are used in the treatment of cancer and tumours.
  (ii) They are used to produce nuclear reactions.
  (iii) γ-rays are used to preserve the foodstuffs for a long time.
  (iv) It provides valuable information about the structure of the atomic nucleus.

➢ **X-rays**

X-rays, discovered by German physicist W Roentgen, having a range of wavelength from 0.01 nm to 10 nm. They are produced when highly energetic cathode rays are stopped by a heavy metal target of high melting point.

- **Properties of X-rays are as follows :**
  (i) They have high penetrating power.
  (ii) They strongly affect the photographic plate.
  (iii) They cause fluorescence in certain material such as zinc sulphide, etc.
- **Uses of X-ray are as follows :**
  (i) In surgery for the detection of fracture, foreign bodies like bullets, stone in a human body, etc.
  (ii) For detecting faults, cracks, flaws and holes in the final product of metals.
  (iii) For curing untraceable skin diseases and malignant growths.
  (iv) For investigation of the structure of crystals, arrangement of atoms, etc.

➢ **Ultraviolet Radiation**

It was discovered by Ritter in 1801. They are produced by some special lamps and very hot bodies. Ultraviolet rays coming from the Sun are absorbed by the ozone layer in the Earth's atmosphere. The wavelength range varies from 10 nm to 400 nm.

- **Properties of ultraviolet radiation are as follows :**
  (i) They can pass through quartz but are absorbed by glass.
  (ii) They can be scattered by dust particles in the atmosphere.
  (iii) They cause health hazards like skin cancer, if our body is exposed for a long period of time.
- **Uses of ultraviolet radiation are as follows :**
  (i) For sterilizing purposes.
  (ii) For detecting the purity of gold, eggs, ghee, etc.
  (iii) For producing vitamin D in food of plants and animals.

➢ **Visible Light**

It is the narrow region of the electromagnetic spectrum which can be detected by the human eyes. Its wavelength ranges from 390 nm to 700 nm.

➢ **Uses of visible light are as follows:**

(i) The visible light emitted or reflected from the object around us provides the information surrounding us.
(ii) It is used in photography, photosynthesis and to see objects around us.

➢ **Infrared Radiation**

It was discovered by Herschel. They are sometimes called heat wave, because their absorption causes the heating effect in the bodies and surroundings. They are produced by hot bodies and molecules. Its range is from 700 nm to 1 mm.

- **Properties of infrared radiation are as follows :**
  (i) They do not affect ordinary photographic film.
  (ii) They are absorbed by the glass but are not absorbed by rock salt.
  (iii) They are detected by their heating property.
  (iv) They are less scattered by the atmosphere.
- **Uses of infrared radiation are as follows :**
  (i) They are used in photography at night and also in mist and fog.
  (ii) They are used for therapeutic purpose.
  (iii) They are used in remote control of TV and other gadgets.
  (iv) They are used as signals during the war.

➢ **Microwaves**

Microwaves are the electromagnetic waves of the wavelength having a range of 10^{-3} m to 0.3 m.

They are produced by special vacuum tubes.

- **Uses of microwaves are as follows :**
  - **(i)** They are used for aircraft navigation.
  - **(ii)** They are used for cooking purposes.
  - **(iii)** They are used for observing the movement of trains while sitting in a microwave operated control room.

➢ **Radiowaves**

These are the waves of longest wavelength amongst all the electromagnetic waves. They have a wavelength above 10 m. They show all the properties of electromagnetic waves.

- **Uses of radiowaves are as follows :**
  - **(i)** It is used in ground wave propagation.
  - **(ii)** It is used in sky wave propagation.
  - **(iii)** They are used mainly in radar communication and television transmission.

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UNIT – III: SOUND

CHAPTER-5
SOUND

Topic-1 Reflection of Sound – Echo, Resonance.

Concepts covered: Echoes, Natural vibrations, Damped vibrations, Forced vibrations, Resonance

Revision Notes

➢ **Range of hearing :**

The average frequency range over which the human ear is sensitive is called **audible range**. The audible range of sound for human beings is from 20 Hz to 20000 Hz. As people grow older, their ears become less sensitive to higher frequencies.

➢ **Infrasonic sound :**

The sound of frequencies lower than 20 Hz are known as infrasonic sounds or infrasound, which cannot be heard by human beings. It is generated during earthquake.

➢ **Ultrasonic sound :**

The sounds of frequencies higher than 20000 Hz are called as ultrasonic sounds or ultrasound which cannot be heard by human beings. Dogs can hear ultrasonic sounds of frequency upto 50000 Hz. This is why dogs are used for detective work by the police. Monkeys, bats, cats, dolphins, leopard and tortoise can also hear ultrasonic sounds. Dolphins, tortoise and rats can also produce ultrasonic sounds as well as hear ultrasonic sound.

➢ **Reflection of sound waves :**

The returning back of the sound wave on striking a surface such as wall, metal sheet, etc., is known as reflection of sound wave. It does not require a smooth and shining surface like mirror. The reflection of sound takes place in accordance with the same laws as those governing the reflection of light. The condition for reflection of sound wave is that the size of the reflecting surface must be bigger than the wavelength of the sound wave.

➢ **Echo :**

It is a reflection of sound, arriving at the listener sometime after the original sound. Basically, a reflected sound from an (distant) object is heard after the original sound has "died down." e.g., The echoes are produced by the bottom of a well, by a building or by the walls of an enclosed room and an empty room.

➢ Bats and dolphins make use of the phenomenon of echoes in nature.

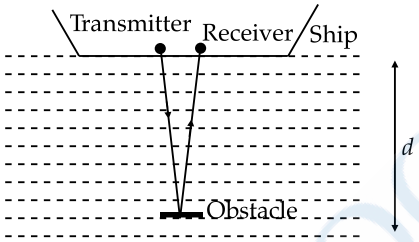
➢ Trawlerman makes use of echoes for finding the depth of ocean beds or for detecting submerged objects.

➢ RADAR and SONAR also make use of echoes for finding the position and distance of an enemy airplane, under water dangers.

➢ A tuning fork is made by shaping a metal piece in the form shown alongside. It enables us to produce a pure sound note.

- **Conditions for formation of echo/hearing the echo distinctly :**
  (i) The size of the obstacle/reflector must be large compared to the wavelength of the incident sound (for reflection of sound to take place).
  (ii) The distance between the source of sound and the reflector should be atleast 17 m (so that the echo is heard distinctly after the original sound is over).
  (iii) The intensity or loudness of the sound should be sufficient for the reflected sound reaching the ear to be audible. The original sound should be of short duration.
- Echoes also find use in medical field for imaging of human organs (womb, liver, uterus).
- Echoes find application in SONAR (Sound navigation and ranging). In order to find the distance of obstacle from ship, waves are transmitted and then reflected waves are received by the receiver.

  Let the distance of the obstacle from source of sound be "d" then,



$$2d = v \times t$$

Where,

v is the velocity of ultrasonic waves in water and t is the time between sending and receiving of waves.

- The periodic vibrations of a body of decreasing amplitude in presence of a resistive force are called the damped vibrations. Examples : oscillations of simple pendulum in air.
- The periodic vibrations of a body of constant amplitude in the absence of any external force on it, are called the free vibrations. Examples : vibration in instruments like sitar, violin when they are plucked.
- The vibrations of a body which take place under the influence of an external periodic force acting on it are called the forced vibrations.
- The frequency of vibrations of a body executing forced vibrations equals to the frequency of the applied periodic force. Examples : vibrations produced in the diaphragm of microphone sound box with frequency matching the speech of speaker.
- **Resonance** is a special case of forced vibrations. When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrate with an increased amplitude. This phenomenon is known as resonance. The vibrations of large amplitude are called the resonant vibrations. For example, tuning of a radio is based on resonance.
- **Condition for resonance :**

  Resonance occurs only when the frequency of the applied force is exactly equal to the natural frequency of the vibrating body.
- **Difference between the free and damped vibrations :**

S. No.	Free vibrations	Damped vibrations
1.	The amplitude of free vibrations remains constant and the vibrations continue forever.	The amplitude of damped vibrations gradually decreases with time and ultimately the vibrations cease.
2.	There is no loss of energy in free vibrations.	In each vibration, there is some loss of energy in the form of heat.
3.	No external force acts on the vibrating body. The vibrations are only under the restoring force.	The frictional or damping force acts to oppose the motion.
4.	The frequency of vibrations is nearly equal to the natural frequency and it remains constant.	The frequency of vibrations is less than the natural frequency.

➢ **Difference between the free and forced vibrations :**

S. No.	Free vibrations	Forced vibrations
1.	The vibrations of a body in absence of any resistive force are called the free vibrations.	The vibrations of a body in presence of an external periodic force are called the forced vibrations.
2.	The frequency of vibration depends on the shape and size of the body.	The frequency of vibration is equal to the frequency of the applied force.
3.	The frequency of vibration remains constant.	The frequency of vibration changes with change in the frequency of the applied force.
4.	The amplitude of vibration is constant.	The amplitude of vibration depends on the frequency of applied force.

➢ **Difference between the forced and resonant vibrations :**

S. No.	Forced vibrations	Resonant vibrations
1.	The vibrations of a body under an external periodic force of frequency different than the natural frequency of the body are called the forced vibrations.	The vibrations of a body under an external periodic force of frequency exactly equal to the natural frequency of the body are called the resonant vibrations.
2.	The amplitude of vibration is usually small.	The amplitude of vibration is very large.
3.	The vibrations of the body are not in phase with the external periodic force.	The vibrations of the body are in phase with the external periodic force.
4.	These vibrations last for a very small time after the periodic force has ceased to act.	These vibrations last for a long time after the periodic force has ceased to act.

Mnemonics

Concept: Relation of frequency and wavelength of sound with its velocity. $V = f\lambda$.

Mnemonics: Seagull **e**gg is **f**amous in **M**alaysia and **W**ashington.

Interpretation:
S : Speed
E : Equal to
F : Frequency
M : Multiplied by
W : Wavelength

Topic-2 Characteristics of Sound

Concepts Covered: Loudness, pitch quality sound level in dB noise pollution

Revision Notes

➢ **Characteristics of Sound Waves**

Sound waves can be described by its :

- **Wavelength**

  The distance between the two consecutive compressions (C) or two consecutive rarefactions (R), is called the wavelength. Wavelength is the minimum distance in which sound wave repeats itself. Its SI unit is metre (m). It is denoted by 'λ'.

- **Frequency**

  The number of complete waves (or oscillations) produced in one second is called frequency of the wave. It is the number of vibrations that occurs per second. The frequency of a wave is fixed and does not change even when it passes through different substances. Its SI unit is Hertz. (Hz). It is denoted by 'γ' or 'f'.

- **Time Period**

  The time taken by two consecutive compressions or rarefactions to cross a fixed point is called the time period of the sound wave. In other words, the time required to produce one complete wave (or oscillations) is called time period of the wave. It is denoted by symbol T. Its SI unit is second (s). The time period of a wave is the reciprocal of its frequency. *i.e.,*

$$\text{Time period} = \frac{1}{\text{Frequency}} \quad \text{Or} \quad \boxed{T = \frac{1}{\nu}}$$

$$\textbf{Or} \quad \boxed{\text{Frequency} = \frac{1}{\text{Time period}}}$$

- **Amplitude**
  The maximum displacement of the particles of the medium on either side from their original mean positions on passing a wave through the medium, is called amplitude of the wave. It is used to describe the size of the wave. It is usually denoted by A. Its SI unit is metre (m). The amplitude of a wave is the same as the amplitude of the vibrating body producing the wave.
- **Speed**
  The distance travelled by a wave in one second is called speed of the wave or velocity of the wave. Under the same physical conditions, the speed of sound remains same for all frequencies. It is represented by letter 'v'. Its SI unit is metre per second (ms^{-1}).

➢ **Relationship among speed, frequency and wavelength of a wave**
Suppose distance travelled by a wave is λ (wavelength) in time T; then the speed is given by

$$\boxed{v = \frac{\lambda}{T}}$$

We know that, $f = \dfrac{1}{T}$

Therefore, $v = \lambda \times f$ or ($v = f\lambda$)

Or, Speed (or velocity) = Frequency × Wavelength

➢ Three main characteristics of a given musical sound are (i) loudness, (ii) pitch and (iii) quality or timbre.

➢ Loudness is the property by virtue of which a loud sound can be distinguished from a faint one, both having the same pitch and quality.
Loudness is proportional to the square of amplitude of the wave.
Pitch is that characteristic of sound by which an acute (or shrill) note can be distinguished from a grave or flat note.

➢ Pitch of a note depends on its frequency. Two notes sounded on the same instrument with same amplitude, will differ in pitch when their vibrations are of different frequencies.

➢ Quality (or timbre) 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.
Thus the quality of a musical sound depends on the number of the subsidiary notes and their relative amplitudes present along with the principal note.

➢ **Comparison between musical sound and noise**

S. No.	Musical sound	Noise
1.	It is pleasant, smooth and acceptable to the ear.	It is harsh, discordant and non-acceptable to the ear.
2.	It is produced by the vibrations which are periodic.	It is produced by an irregular succession of disturbances.
3.	All the component waves are similar without any sudden change in their wavelength and amplitude.	The component waves change their character suddenly and they are of short duration.
4.	The sound level is low (between 10 dB and 30 dB).	The sound level is high (above 120 dB).
5.	The wave form is regular. **Example :** The sound produced by the musical instruments.	The wave form is irregular. **Example :** The sound produced by an aeroplane, road roller, industrial machines, etc.

Mnemonics

Concepts: Characteristics of sound.
Mnemonics: We **A**re **S**et **F**ree **T**oday.

Interpretation:

W : Wavelength

A : Amplitude

S : Speed

F : Frequency

T : Time period

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UNIT – IV: ELECTRICITY AND MAGNETISM

CHAPTER-6
CURRENT ELECTRICITY

Topic-1 Current, E.M.F., Resistance and Ohm's Law

Concepts covered: Ohm's Law, emf, Potential difference, Resistance

Revision Notes

- A sustained electric current flows through a conductor only when it is connected to a source of emf.
- The electric current, in a given conductor is simply the rate of flow of charge across its cross section. Thus,
$$I = Q/t$$
- The unit of current is **ampere** (A). We have
$$\mathbf{1\ A = 1\ Coulomb\ per\ second = 1\ Cs^{-1}}$$
- The current, flowing through a wire, is said to be one ampere when one Coulomb of charge flows across its cross-section in one second.
- Potential is the electrical state of a conductor which determines the direction of flow of charge when two conductors are either kept in contact or joined by a metallic wire. The potential at a point is defined as the amount of work done in bringing a unit positive charge from infinity to that point. The potential difference (p.d.) between two points is simply the work done in transporting a positive charge of one Coulomb from the first point to the second point. $W = QV$
- The unit of potential difference is **Volt** (V). We have 1 volt = 1 joule per Coulomb = 1 JC^{-1}. The potential difference between two points equals one volt if the work done in transporting a charge of one coulomb between these points equals one joule.
- **Electromotive Force:** When no current is drawn from a cell, then the potential difference between the terminals of the cell is called electromotive force. It is denoted by ε. Its unit is Volt. The electromotive force of a cell depends upon
  (i) the material of the electrodes. **(ii)** the electrolyte used in the cells.
- **According to Ohm's Law :**

  The current flowing through a given conductor is directly proportional to the potential difference across its ends, provided the physical conditions of the conductor (*e.g.*, its length, its area of cross-section, its temperature, etc.) remain constant.

  The resistance of a conductor equals the ratio of the potential difference across its ends to the current flowing through it. Thus, the resistance of the conductor is numerically equal to the potential difference across its ends when unit current flows through it.
$$R = V/I \text{ or } V = IR \text{ or } I = V/R$$
- The obstruction offered to the flow of current by the conductor (or wire) is called its resistance. The unit of resistance is **ohm** (Ω). A conductor has a resistance of one ohm when a potential difference of one volt across its ends causes a current of one ampere to flow through it.
- The resistance associated with the electrolyte of a cell—within its electrodes—is known as the **internal resistance** of the cell.
- When a cell of emf ε or E, and internal resistance r, is connected across an external resistance R, current flows through the circuit, which is given by $I = E/(R + r)$
  and V = 'p.d.' across $V = IR$
- The internal resistance of a cell depends on
  (i) the nature, concentration and temperature of its electrolyte.
  (ii) the surface area of the ('dipped within the electrolyte' part) electrodes.
  (iii) the distance between the electrodes.
- An increase in the surface area of the electrodes causes the internal resistance to decrease, whereas an increase in the distance between the electrodes causes the internal resistance to increase. Internal resistance decreases with increasing temperature or concentration of an electrolyte.

- **Factors Affecting the Resistance of a Conductor**

  The electrical resistance of a conductor depends on the following factors :

  (i) Length of the conductor : The resistance of a conductor R is directly proportional to its length l

  i.e., $$R \propto l$$

  $\therefore$ When the length of a wire is doubled or halved, then its resistance also gets doubled or halved respectively.

  (ii) Area of cross-section of the conductor : The resistance of a conductor R is inversely proportional to its area of cross-section A.

  i.e., $$R \propto \frac{1}{A}$$

  $\therefore$ When the area of cross-section of wire is doubled, its resistance gets halved and if area of cross-section of wire is halved, its resistance will get doubled.

  (iii) Nature of the material of the conductor : The resistance of a conductor depends on the nature of the material of which it is made of. Some materials have low resistance whereas others have high resistance.

  (iv) Effects of temperature :

  (a) Resistance of a conductor increases linearly with increase in temperature.

  (b) Resistance of a semiconductor decreases with increase in temperature.

  (c) Resistance of insulators (non-conductor) decreases with increase in temperature.

  (d) Resistance of electrolytes decreases with increase in temperature.

  From the above relation (i) and (ii), we can write $R \propto \frac{1}{A}$ or $R = \rho \frac{l}{A}$ where, ρ is the constant of proportionality called resistivity or specific resistance of the conductor.

- **Ohmic and non-ohmic resistor :**

  The conductor which obeys Ohm's law is called ohmic resistor (or linear resistance), *e.g.,* Silver, nichrome, copper, iron, etc. The graph of V vs I is a straight line. The conductor which does not obey Ohm's law is known as non-ohmic resistor for non-linear resistance) *e.g.,* Triode valve, junction diode, transistor, etc. The graph of V vs I is a curved line.

- **Superconductor :** It is a substance of zero resistance at a very low temperature. *e.g.,* Mercury, niobium, etc.
- Resistivity of a material is the resistance of a wire of that material of a unit length and unit area of cross section.
- **Difference between ohmic and non-ohmic resistor :**

S. No.	Ohmic resistor	Non-ohmic resistor
1.	It obeys Ohm's law. i.e., V/I is constant for all values of V or I.	It does not obey the Ohm's law i.e., V/I is not the same for all values V or I.
2.	The graph for potential difference (V) versus current (I) is a straight line.	The graph for potential difference (V) versus current (I) is not a straight line.
3.	The slope of V–I graph is same at all values of V or I at a given temperature. *Examples* : All metallic conductors such as silver, iron, copper, nichrome, electrolyte with suitable electrodes, etc.	The slope of V–I graph is different at different values of V or I at a given temperature. *Examples*: Junction diode, diode valve, transistor, filament of a bulb, etc.

- **Difference between resistance and resistivity :**

S. No.	Resistance	Resistivity
1.	Resistance of a conductor is the obstruction offered by the conductor in the flow of current through it. It is measured by the potential difference needed across the conductor to flow one ampere current through it. $\left(R = \frac{V}{I}\right)$	It is the property of the conductor due to which it offers resistance to the flow of current through it. It is measured by the resistance offered by 1 m length of wire of that material of area of cross-section 1 m^2. $\left(\rho = \frac{RA}{l}\right)$
2.	The resistance of a conductor depends upon its material, temperature, length and area of cross section	The resistivity of a conductor depends only on its material and temperature but not on its shape and size.
3.	Its SI unit is ohm (or Ω).	Its SI unit is ohm metre (or Ω m).

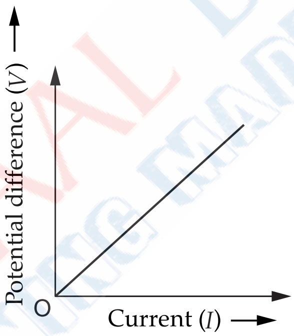
- The p.d. of a cell is defined as the energy spent (or the work done) per unit charge in taking a positive charge around the complete circuit of the cell (i.e., in the circuit outside the cell as well as in the electrolyte inside the cell).

- When no current is drawn from a cell i.e., when the cell is in open circuit, the potential difference between the terminals of the cell is called its electromotive force or *(e.m.f.)*.
- When current is drawn from a cell i.e., when the cell is in a closed circuit, the potential difference between the electrodes of the cell is known as its terminal voltage.
- The terminal voltage of a cell is defined as the work done per unit charge in carrying a positive charge around the circuit across the terminals of the cells.
- **Difference between E.M.F. and the terminal voltage of cells :**

S. No.	E.m.f. of cell	Terminal voltage of cell
1.	It is measured by the amount of work done in moving a unit positive charge in the complete the circuit inside and outside the cell.	It is measured by the amount of work done in moving a unit positive charge in the circuit outside the cell.
2.	It is the characteristic of the cell, i.e.,. it does not depend on the amount of current drawn from the cell.	It depends on the amount of current drawn from the cell. More the current is drawn from the cell, less is the terminal voltage.
3.	It is equal to the terminal voltage when cell is not in use, while greater than the terminal voltage when a cell is in use.	It is equal to the e.m.f. of the cell when the cell is not in use, while less than the e.m.f when the cell is in use.

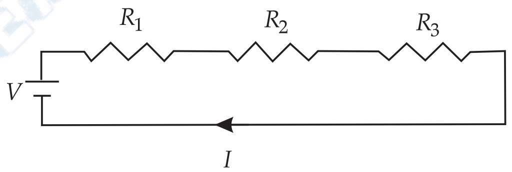
- When the resistance of the combination is to be increased, they are connected in series and when the resistance of the combination is to be decreased, in order to pass a heavy current in the circuit, they are connected in parallel.
- ***V-I* graph :**

  The below graph gives the graphical representation of Ohm's law where the slope of *V*-*I* graph gives the resistance of the conductor.



- **Combination of resistors in series :**

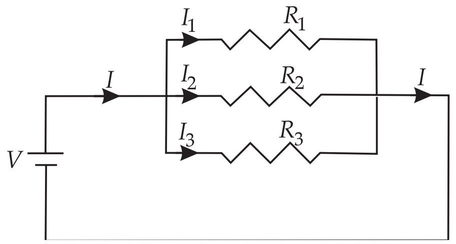
  Three resistors R_1, R_2 and R_3 are connected in series. The same current *I*, flows through all the three resistors but the potential across each resistor is different and let it be V_1, V_2 and V_3 respectively.



$$V = V_1 + V_2 + V_3$$
$$= IR_1 + IR_2 + IR_3 \text{(Using Ohm's law, } V = IR\text{)}$$
$$IR_{eq} = I(R_1 + R_2 + R_3)$$
$$R_{eq} = R_1 + R_2 + R_3$$

So, the equivalent resistance in a series combination is the sum of all resistances.

- **Combination of resistors in parallel :**



Three resistors R_1, R_2 and R_3 are connected in parallel. The same potential difference, V exist through all the three resistors but the current across each resistor is different and let it be I_1, I_2 and I_3 respectively.

$$\text{Net current, } I = I_1 + I_2 + I_3$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \text{ (Using Ohm's law, } I = \frac{V}{R}\text{)}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

So, the reciprocal of equivalent resistance in a parallel combination is equal to the sum of reciprocal of individual resistances.

- The following two facts are to be noted about the series combination.
  - **(i)** The current has a single path for its flow. Hence, the same current passes through each resistor, so the potential difference across any resistor is directly proportional to its resistance.
  - **(ii)** The potential difference across the entire circuit is equal to the sum of potential differences across the individual resistor, *i.e.*,

$$V = V_1 + V_2 + V_3 \ldots.$$

- The following two points are to be noted about the parallel combination.
  - **(i)** The potential difference across each resistor is the same (say $V_1 = V_2 = V_3$) which is equal to the potential difference across the terminals of the battery (or source).
  - **(ii)** The main current I from the battery divides itself in different arms. The low resistance arm allows more current and the high resistance arm allows less current, *i.e.*, the current in a resistor is inversely proportional to its resistance. The sum of currents I_1 I_2 I_3 ... in the separate branches of the parallel circuit is equal to the current I drawn from the source *i.e.*, $I = I_1 + I_2 + I_3 + \ldots$

Mnemonics

Concept: Equivalent resistance of series and parallel combination of resistors.

Mnemonics: **S**unny **A**rrived **D**adar and **P**ari **A**rrived **R**ajasthan.

Interpretation:

S : Series Combination

A : Add

D : Directly

P : Parallel combination

A : Add

R : Reciprocals

(For series combination of resistors: $R_{EQ} = R_1 + R_2 + R_3 + \ldots\ldots..$

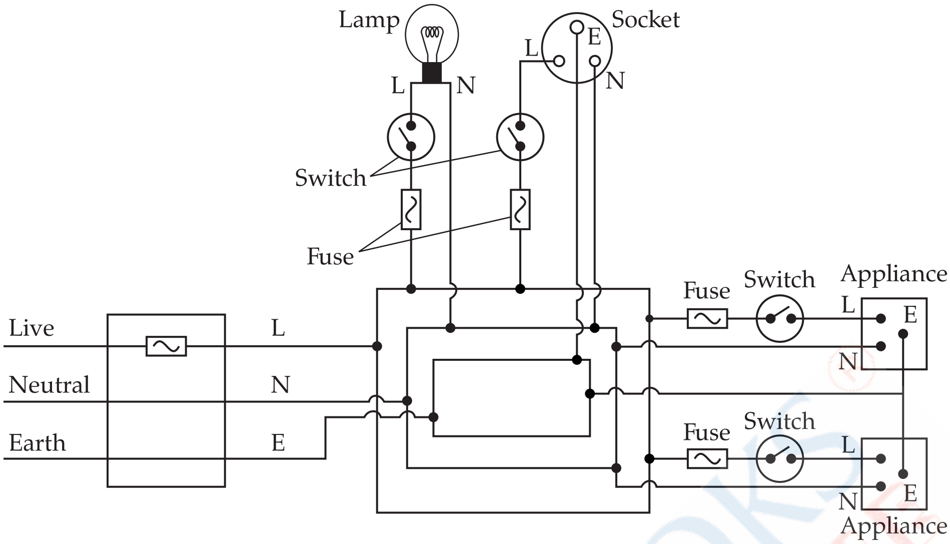
For parallel combination of resistors: $1/R_{EQ} = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots\ldots$)

Topic-2 Electric Power and Energy, Fuse, Household Circuit

Concepts covered: Electrical power, Electrical energy, Household circuits, Safety precaution

Revision Notes

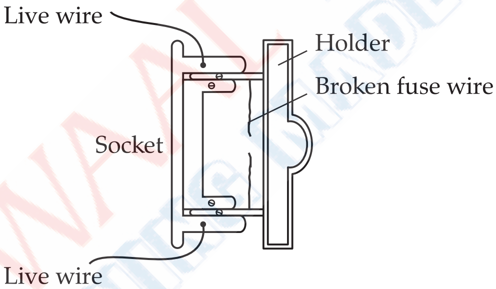
- In India, electric power for domestic use is supplied with alternating current (a.c.) at a frequency of 50 Hz with a (rms) potential difference of 220 V between the phase (or live) wire and the neutral wire.
- The neutral and the earth wires of the local sub-station are usually connected together so that the neutral wire is at the same potential as the earth. The live or the phase wire is then at a potential of 220 V (rms) with respect to either the neutral or the earth wire.
- We use two systems for domestic wiring – the tree system and ring system. Of the two, the ring system is more popular because of its several advantages. It is shown as



➢ **Advantages of the ring system :** The ring system has the following advantages :

(i) In the ring system, the current from mains can reach to an individual appliance through two separate paths. Thus each appliance gets connected to the mains effectively through a thick wire. Therefore, the wire required for the main ring is of a lower current carrying capacity than that which would be required for a direct connection to the mains. This reduces the cost of wiring considerably.

(ii) Each appliance has a separate fuse. Therefore if due to some fault, the fuse of one appliance burns, it does not affect the other appliances.



(iii) In this system, all the plugs and sockets of the same size can be used, but each socket should have its own fuse of rating suitable for the appliance to be connected with it.

(iv) While installing a new appliance in a room, a new line up to the distribution box is not required, but it can be directly connected to the ring circuit in that room. The care is taken that the total current drawn from the mains in the ring circuit does not exceed the rating of the main fuse (viz. 30 A).

➢ **Connection of all appliances (bulb, fan, socket, etc.) with the mains :**

We note that all the electrical appliances (say, bulbs, fans, sockets, etc) are connected in parallel at the mains, each with a separate switch and a separate fuse connected in the live wire.

➢ **Advantages of connecting the appliances in parallel :**

(i) Each appliance gets connected to 220 V supply (= its voltage rating) for its normal working.

(ii) Each appliance works independently without being affected by the status of the other appliance being switched on or off.

➢ **Disadvantages of connecting the appliances in series :**

(i) The voltage of source gets divided in all the appliances connected in series, in a ratio of their resistances, so each appliance does not operate at its rated voltage.

(ii) On connecting one more appliance in the same circuit, the resistance of the circuit will increase. Hence, it will reduce the current in the circuit, so each appliance will get less power.

(iii) All appliances connected in series operate simultaneously. None of the appliances can be operated independently. If one appliance is switched off or not operated, no other appliance connected with it in series will then operate.

➢ Electrical energy is very important in our day-to-day life. This is because of the case with which it can be converted into other forms of energy.

- The flow of an electrical current through a conductor produces heat. The heating effect associated with a current is expressed by Joule's Law, according to which

$$H = I^2 Rt = V^2 t/R = IVt.$$

- The electrical power of a given device is simply the rate at which electrical energy is being consumed by it.
- We have $P = IV = I^2R = V^2/R$
- The resistance R (in ohm) of a device of power P watt, working at an applied p.d. of V volt, is given by

$$R = V^2/P \text{ ohm.}$$

- 1 watt is the electric power consumed when a current of 1 ampere flows through a circuit having a potential difference of 1 volt.
- We need both **conductors** (materials which let electricity flow through them easily) and **insulators** (materials which do not (easily) let electric current flow through them) for safe and proper use of electrical energy.
- All electric circuits (closed conducting paths used for ensuring flow of electric current) need :
  (i) a source of electricity (cell, battery, generator, 'mains', etc.)
  (ii) conducting wires or conductors for providing a path for the flow of current and
  (iii) a switch or a key for switching 'ON' and 'OFF' electric energy as per our requirements.
- **SI Units :**

S. No.	Physical Quantity	SI Unit	
		Name	Symbol
1.	Current	ampere	A
2.	Voltage	volt	V
3.	Resistance	ohm	Ω
4.	Heat energy/Electric energy	joule	J
5.	Electric power	watt	W

By the definition of potential difference, work needed to move a charge Q through a potential difference V is

$$W = QV$$

But $Q = I \times t$

$$W = VIt$$

Using Ohm's law, $W = I^2 Rt = (V^2/R)\, t$

- The unit often used for estimating the consumption of electrical energy is the kilowatt hour (kWh). One **kilowatt-hour** (kWh) is the electrical energy consumed by an electrical appliance of power 1 kW when it is used for 1 hour.

$$1 \text{ kWh} = 1000 \text{ W} \times 3600 \text{ s}$$
$$= 3.6 \times 10^6 \text{ J}$$

- **Electrical energy consumed by appliance** (in kWh) = power (in kW) × time (in h)

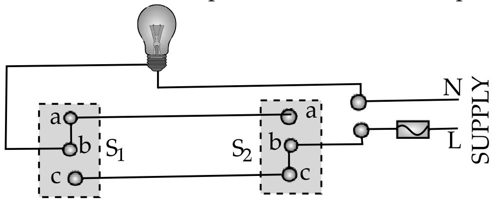
$$= \text{power (in watt)} \times \text{time (in hour)} \times 10^3$$
$$= V \text{ (volt)} \times I \text{ (in ampere)} \times t \text{ (hour)} \times 10^3$$

- **Cost of electricity** = Electrical energy in kWh × cost per kWh
- **Colour coding of wires in a cable :**

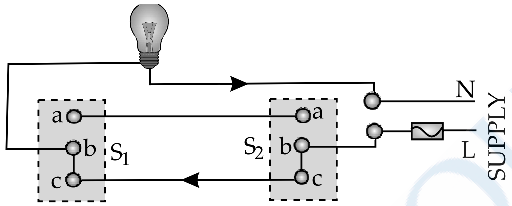
Wire	Colour	
	old convention	new convention
Live	Red	Brown
Neutral	Black	Light blue
Earth	Green	Green or Yellow

- A fuse is a safety device which limits the flow of current in a circuit and thus protecting the device from being damaged.
- Fuse is made up of material having low melting point.
- A switch is an ON/OFF device which is connected in a circuit to the live wire.
- Earthing protects the appliance and the user from getting damaged /hazardous shock due to excessive current. If excess current flows due to short circuit in electrical appliance, it passes through the earth wire to the earth. In local earthing, the earth connection at a meter is connected to a thick copper wire, which is buried deep in the earth and its ends are connected to a copper plate surrounded by a mixture of charcoal and salt. The thick copper wire is covered by a hollow pipe and water is poured into the pipe from time to time to provide a conducting layer between the plate and the ground.

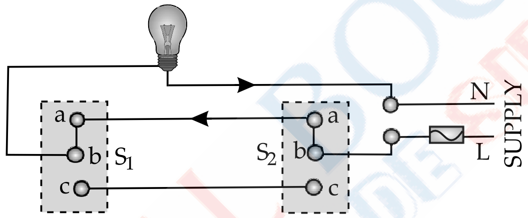
➤ Staircase wiring or dual control switch has two pathways for making the switch ON/OFF. The following diagrams illustrate a dual switch with two switches S_1 and S_2. The circuit can be switched on either using switch S_1 or S_2. When the connection ba is changed to bc, the circuit is completed and the switch operates by S_1 whereas when the connection bc is changed to ab, the circuit is completed and the switch operates by S_2.



(a) Bulb OFF

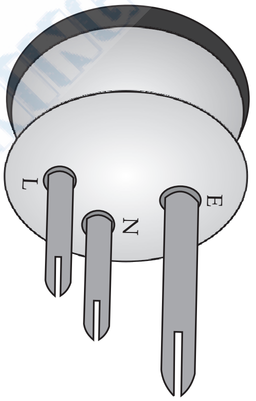


(b) Bulb ON through switch S_1



(c) Bulb ON through switch S_2

➤ Three pin plug has three pins – the top pin is for earth (E), the left pin is for live (L) and the right pin is for neutral (N).The earth pin is made longer and thicker so that firstly earth connection is made and if the device is faulty then after live connection is made, the current passes to the earth through earth wire.



➤ A socket is fixed in the board of the circuit so that plug can be inserted. It has three holes which have a hollow metallic tube. The upper bigger hole is for earth connection, the left is for neutral and right for a live wire.

➤ Safety precautions while using electricity :

(i) Never touch the appliance with wet hands.

(ii) The wires carrying current should be having higher capacity than the total current which would flow when all the appliances are switched on.
(iii) Each appliance must be provided with a fuse and earthing.
(iv) The insulation of wires should be of good quality and that should be checked from time to time.
(v) Local earthing should be done near kWh meter.

Mnemonics

Concept: Joule's law of electrical heating.
Mnemonics: He **P**refers to **C**ome to **S**chool at **R**ight **T**ime.
Interpretation:
H : Heat
P : Proportional to
C : Current
S : Square
R : Resistance
T : Time

$H \propto I^2RT$

Heat generated is proportional to (i) square of current, (ii) resistance of the conductor and (iii) time of current flow.

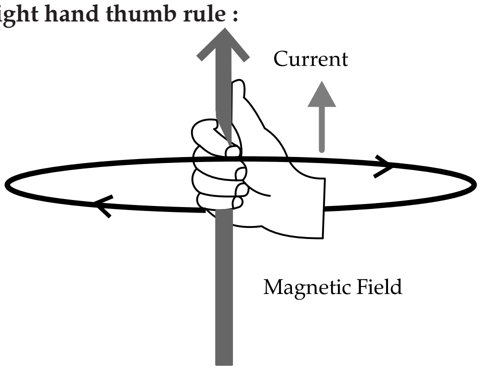
CHAPTER-7
MAGNETISM

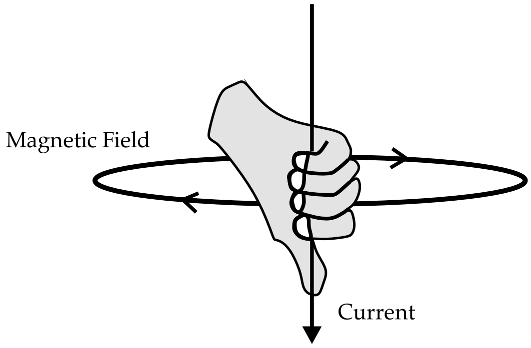
Topic-1 Magnetic Effect of Current

Concepts covered: Magnetic effect of current, Fleming's left hand rule

Revision Notes

- Besides the *heating effect* and the *chemical effect*, current also has a *magnetic effect* associated with them.
- The experiments of **Oersted** and **Ampere**, on the effects of a current- carrying wire deflecting a compass needle led to the discovery of the magnetic effects of current.
- Magnetic field lines due to a straight conductor carrying current :
  (i) The magnetic field lines form concentric circles around the wire, with their plane perpendicular to the straight wire and with their centre lying on the wire.
  (ii) If a cardboard is inserted perpendicular to the current carrying wire and some iron filings are sprinkled over the cardboard, then iron filings arrange themselves in a circular pattern.
  (iii) When the direction of current in the wire is reversed, the pattern of iron filings does not change, but the direction of deflection of the compass needle gets reversed. The north pole of the compass needle now points in a direction opposite to the previous direction showing that the direction of the magnetic field has reversed.
  (iv) On increasing the current in the wire, the magnetic field lines become denser and the iron filings get arranged in circles up to a larger distance from the wire, showing that the magnetic field strength has increased and it is effective up to a larger distance.
- **Right hand thumb rule :**





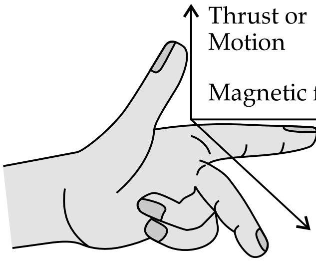
If we hold the current carrying conductor in our right hand such that the thumb points in the direction of current, then encircling of fingers will give the direction of the magnetic field.

- It is now believed that currents (i.e., moving charges) – and not magnetic poles – are the basic cause of all magnetism.
- The *lines of force* of the magnetic field due to a straight current-carrying wire are *concentric circles* around the wire.
- From the pattern of magnetic field lines, it is noted that
  - **(i)** In the vicinity of wire at P and Q, the magnetic field lines are nearly circular.
  - **(ii)** Within the space enclosed by the wire (i.e., between P and Q), the magnetic field lines are in the same direction.
  - **(iii)** Near the centre of the loop, the magnetic field lines are nearly parallel to each other, so the magnetic field may be assumed to be nearly uniform in a small space near the centre.
  - **(iv)** At the centre, the magnetic field lines are along the axis of the loop and normal to the plane of the loop.
  - **(v)** The magnetic field lines become denser (i.e., the magnetic field strength is increased) if:
    - **(a)** the strength of the current in the loop is increased, and
    - **(b)** the number of turns in the loop increased.
- When a material is placed inside a coil carrying current, it will get magnetized. A bunch of nails or an iron rod placed along the axis of the coil can be magnetized by the current allowed to pass through the coil. Such magnets are called electromagnets.
- For finding the polarity of the two faces of a current-carrying circular coil, the following rule applies: When an observer, looking at the circular coil, finds the current to be flowing in the anti-clockwise sense, that face of the coil behaves like the north-pole(N-pole) of the equivalent magnet. On the other hand, if the current is seen to flow in the clockwise sense, that face of the coil behaves like the south-pole (S-pole) of the equivalent magnet.
- The solenoid is made by closely winding a large number of turns of an insulated wire on a long cylindrical core.
- A current-carrying solenoid produces a uniform field close to its centre and its field is very similar to that of a bar magnet.
- The electromagnet consists essentially of a soft iron core around which a large number of turns of insulated wire are wounded. It is a temporary magnet which can be magnetized or demagnetized, in a very short time, simply by switching 'ON' or 'OFF' the current through it.
- **Comparison of Electromagnet and Permanent Magnet :**

S. No.	Electromagnet	Permanent magnet
1.	It is made of soft iron.	It is made of steel.
2.	It produces the magnetic field so long as current flows in its coils i.e., it produces the temporary magnetic field.	It produces a permanent magnetic field.
3.	The magnetic field strength can be changed.	The magnetic field strength cannot be changed.
4.	The electromagnets of a very strong field can be made.	The permanent magnets are not so strong.
5.	The polarity of an electromagnet can be reversed.	The polarity of a permanent magnet cannot be reversed.
6.	It can easily be demagnetized by switching off the current.	It cannot be demagnetized easily.

- **Uses of Electromagnet :**
  - **(i)** It is used for lifting and transporting the large masses of iron scrap, girder, plates, etc.
  - **(ii)** It is used for loading the furnace with iron.
  - **(iii)** It is used for separating the magnetic substances such as iron from debris and raw materials.
  - **(iv)** It is used for removing pieces of iron from wounds.
- **An electromagnet has the following advantages over a permanent magnet :**
  - **(i)** An electromagnet can produce a strong magnetic field.
  - **(ii)** The strength of the magnetic field of an electromagnet can easily be changed by changing the current (or the number of turns) in its solenoid.
  - **(iii)** The polarity of the electromagnet can be reversed by reversing the direction of current in its solenoid.

- It is not Ampere's law when a current I passes through a conductor of length l placed in magnetic field B, then the force experienced is given by, $F = IBl\sin\theta$ where θ is an angle between the length of the conductor and magnetic field.
- **Fleming's left hand rule:** Stretch the forefinger, central finger and the thumb of your left hand mutually perpendicular to each other. If the forefinger indicates the direction of magnetic field, central finger indicates the direction of current, then the thumb will indicates the direction of motion of conductor (i.e., force on conductor).



Key Terms

- When a bar magnet is placed on a cardboard and iron-filings are sprinkled, they will arrange themselves in a pattern of lines known as **magnetic field lines**.
- The area around a magnet in which its effect can be experienced is called a **magnetic field**.
- When electric current flows through a conductor, a magnetic field is produced around it. This is called **magnetic effect of current**.
- An **electromagnet** is a solenoid coil that attains magnetism due to the flow of current. It works on the principle of magnetic effect of current.
- The production of electric current due to relative motion between a conductor and a magnetic field is called **electromagnetic induction**. The electric current produced due to this phenomenon is called **induced current**.
- **Magnetic flux** is defined as the product of the magnetic field and the area through which magnetic field passes perpendicularly, $\phi = NBA$, when the field passes perpendicular to the plane of the coil. If B and A are at angle θ, $\phi = NBA\cos\theta$, where N is the number of turns.

Mnemonics

Concept: Fleming's left hand rule.
Mnemonic: **H**ave **L**ight **F**ood, **F**eel **C**omfortable.
Interpretation:
L : Left hand rule
F : Force (represented by thumb)
F : Field (represented by fore finger)
C : Current (represented by second/central finger)

Topic-2 Electromagnetic Induction

Concepts covered: Electromagnetic Induction, Fleming's right hand rule

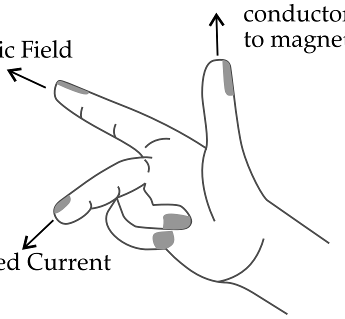
Revision Notes

- Faraday's experiments were concerned with the production of an electric current from a magnetic field.
- From his experiments, Faraday observed that whenever there is a change in the magnetic flux (number of magnetic lines of force passing normally) linked with a circuit and an induced emf is produced. Thus, Electromagnetic Induction is the phenomenon in which an e.m.f. is induced in the coil if there is change in the magnetic flux linked with the coil.
- Faraday's and Lenz's Laws on the phenomenon of electromagnetic induction are :
  (i) Faraday's Law :
  Whenever there is a change in the (normal) magnetic flux linked with a circuit, an emf is induced. The induced emf lasts as long as the change in magnetic flux is taking place.
  The magnitude of the induced emf is proportional to the time rate of change of the (normal) magnetic flux.
  (ii) Lenz's Law : The direction of the induced emf is such that it always opposes the change responsible for its production.
- From Faraday's laws the following conclusions can be drawn.
  (i) A current flows in the coil when there is a relative motion between the coil and the magnet.

(ii) The direction of current is reversed if the direction of motion or polarity of the magnet is reversed.

(iii) The current in the coil is increased (i) by the rapid motion of the magnet or coil, (ii) by the use of a strong magnet and, (iii) by increasing the area of the coil and (iv) the number of turns in the coil.

- The direction of induced emf can be determined by Fleming's right hand rule.
- **Fleming's right hand rule :** It states that if the thumb, forefinger and the middle finger of right hand are spread at right angle to one another in such a way that the forefinger points in the direction of the magnetic field, thumb gives the direction of motion of conductor relative to magnetic field, then the direction in which the middle finger points, gives the direction of induced current.



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S.No.	Direct current (D.C.)	Alternating current (A.C.)
1.	It is the current of constant magnitude.	It is the current of magnitude varying periodically with time.
2.	It flows in one direction in the circuit.	It reverses its direction periodically while flowing in a circuit.
3.	It is obtained from a cell (or battery)	It is obtained from an a.c. generator and mains.

Mnemonics

Concept: Fleming's right hand rule.

Mnemonic: Have Right Minerals, Feel Comfortable.

Interpretation:

R : Right hand rule
M : Motion (represented by thumb)
F : Field (represented by fore finger)
C : Current (represented by second/central finger)

UNIT – V: HEAT

CHAPTER-8
HEAT

Topic-1 Calorimetry

Concepts covered: Heat, Temperature, Thermal (Heat) Capacity, Specific Heat Capacity, Principle of Method of Mixtures

Revision Notes

- **Heat** : It is the form of energy which flows from one part to other parts of the system without any mechanical work involved (by virtue of temperature difference only). It measures the total internal energy possessed by the particles. It is represented by Q. The S.I. unit of heat is Joule (J). Another unit of heat is Calorie (cal).

- **Temperature** : It is the measure of the degree of hotness or coldness of any body. Heat flows from a body at higher temperature to a body at the lower temperature, until they reach to equal temperature. The SI unit of temperature is Kelvin (K). Other units of temperature are Celsius (°C) and Fahrenheit (°F).
  Temperature (in K) = 273 + temperature (in °C)
  Temperature in (in °F) = (Temperature (°C) × 9/5) + 32
- **Different units of heat energy** :
  (i) One calorie : Calorie is the quantity of heat needed to raise the temperature of 1 g of water from 14.5°C to 15.5°C, *i.e.*, through 1°C, around the mean value of 15°C or the amount of heat required to raise the temperature of 1 g of pure water by 1°C.
  $$1 \text{ cal} = 4.186 \text{ J} \approx 4.2 \text{ J}$$
  (ii) One kilocalorie : It is the amount of heat required to raise the temperature of 1 kg of pure water by 1°C.
  $$1 \text{ kcal} = 10^3 \text{ cal} = 4.2 \times 10^3 \text{ J}$$
- **Thermal capacity or heat capacity** : Thermal capacity is defined as the total amount of heat required to raise the temperature of a body by 1°C (or 1K). It is represented by C′
  $$\text{Heat capacity, } C' = \frac{\text{Heat supplied to the body } (Q)}{\text{Change in temperature } (\Delta T)}$$
  Its SI unit is J/°C or J/K.
- **Difference between heat and temperature :**

S. No.	Heat	Temperature
1.	The kinetic energy due to the random motion of molecules of a substance is known as its heat energy.	The quantity which determines the direction of flow of heat between the two bodies kept in contact is called temperature.
2.	The S.I. unit of heat is joule (J).	The S.I. unit of temperature is Kelvin (K).
3.	It is measured by the principle of calorimetry.	It is measured by a thermometer.
4.	It is an additive quantity.	It is not an additive quantity.

- The **specific heat capacity** of a substance is the amount of heat energy required to raise the temperature of unit mass of that substance through 1°C (or 1 K). Its S.I. unit is J/(kg K).
- **Difference between heat capacity and specific heat capacity :**

S. No.	Heat capacity	Specific heat capacity
1.	It is the amount of heat energy required to raise the temperature of the entire body by 1°C.	It is the amount of heat energy required to raise the temperature of unit mass of the body by 1°C.
2.	It depends both on the material and mass of the body. More the mass of the body, more is its heat capacity.	It does not depend on the mass of the body but is the characteristic property of the material of the body.
3.	Heat capacity, $C' = \frac{Q}{\Delta t}$ = mass (m) × specific heat capacity (C)	Specific heat capacity, $C = \frac{Q}{m\,\Delta t} = \frac{\text{Heat capacity } (C')}{\text{mass } (m)}$
4.	Its unit is J K^{-1}.	Its unit is J kg^{-1} K^{-1}.

- The amount of heat gained or lost by a substance depends on the following three factors :
  (i) The rise or fall in the temperature of the substance.
  (ii) The quantity or the mass of the substance taken.
  (iii) The nature of substance.
- The supply of heat to a body generally increases the kinetic energy of its molecules, and this shows itself as a rise in the body's temperature.
- Relation between thermal capacity and specific heat capacity :
  $$\text{Thermal capacity} = \text{mass} \times \text{specific heat capacity.}$$
- We may view the specific heat capacity as one of the factors on which thermal inertia of the body depends. More the specific heat capacity, more it is difficult to change the thermal state, *i.e.*, the temperature of the body.
- Specific heat capacity of water = 1 cal /(g°C) = 4.2 × 10^3 J /(kg°C).
- The specific heat capacity of water is much higher than that of most of the substances. Thus, water has a high *thermal inertia*.
- According to the *principle of heat transfer or principle of calorimetry :*
  The heat gained by the cold body is equal to the heat lost by the hot body, provided no transfer of heat to the surroundings.
- When m kg of a substance of specific heat capacity c is heated (or cooled) through °C, the quantity of heat Q gained (or lost) by the substance is given by
  $$Q = mc\theta$$
- The equilibrium temperature θ, during heat transfer, is given by

$$m_1c_1(\theta_1 - \theta) = m_2c_2\,(\theta - \theta_2)$$

Or
$$\theta = \frac{[m_1c_1\theta_1 + m_2c_2\theta_2]}{[m_1c_1 + m_2c_2]}$$

- **The method of mixtures** based on the principle of heat transfer is often used for measurement of the specific heat capacity of a given body.
- The high value of the specific heat capacity of water finds many applications in nature and in practice. For example, due to the high specific heat of water, it is used as a coolant.
- **SI units** :

S. No	Physical quantity	SI unit	
		Name	Symbol
1.	Specific heat capacity	Joule per kilogram kelvin	J /(kg K)
2.	Thermal capacity	Joule per kelvin	J/K
3.	Heat	Joule	J

- **Relevant physical constants** :
  (1) Specific heat capacity of water = 1 cal/(g °C) = 4.2×10^3 J /(kg °C)
  (2) Specific heat capacity of ice = 2100 J kg^{-1} K^{-1}
  (3) The following table gives the values of specific heat capacities of some common substances :

S. No	Substance	Sp. heat capacity	
		in J/kg °C	in cal/(g °C)
1.	Aluminium	882	0.21
2.	Copper	399	0.095
3.	Gold	134	0.032
4.	Iron	483	0.115
5.	Lead	130	0.031
6.	Brass	386	0.092
7.	Silver	235	0.056

S. No	Substance	Sp. heat capacity	
		in J/kg °C	in cal/(g °C)
8.	Zinc	291	0.0693
9.	Tin	231	0.055
10.	Alcohol	218	0.52
11.	Kerosene	210	0.50
12.	Turpentine	176	0.42
13.	Mercury	139	0.033
14.	Water	4200	1.00

Mnemonics

Concept : Quantity of heat required to raise the temperature of a body (Q) = $mc\Delta t$.
Mnemonics : Quiz **M**aster **C**ontributed our **T**eam.
Interpretation :
Q : Quantity of heat
m : Mass of the body
C : Specific heat capacity
ΔT **:** Temperature difference

Quantity of heat required to raise the temperature of a body (Q)
= mass × specific heat capacity × temperature difference

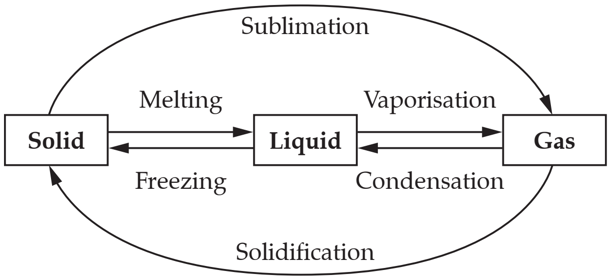
$$Q = mc\Delta T$$

Topic-2 Latent Heat

Concepts covered: Change of Phase (state), Latent Heat, Heating Curve

Revision Notes

- Phase change diagram.



- The phenomenon of melting, freezing, boiling (evaporation) and condensation make up the subject matter of change of state.
- During the change of state, average kinetic energy does not change but average potential energy changes (increases on melting).
- The melting or fusion of crystalline solid into its corresponding liquid takes place (under given external condition) at a particular temperature known as its melting point.
- Melting point decreases due to the presence of impurities and increase in pressure.
- The specific latent heat of fusion of a given solid is the heat required to melt 1 kilogram of it, at its melting point, without change in temperature. It is measured in J/kg.
- Specific latent heat of fusion of ice = 336×10^3 J/kg.
- The heat Q needed to melt m kg of a substance of specific latent heat of fusion L, is given by $Q = mL$.
- The boiling point of a liquid, under given external conditions, is that constant temperature at which the liquid starts boiling, i.e., gets converted into the vapour state (at a very fast rate).
- We can explain a number of natural phenomena using the ideas of specific latent heat of fusion.
  - In cold countries, water in lakes does not freeze all at once.
  - Drinks get more cool by adding ice than by ice cold water at 0°C.
  - It is colder after a hail storm than before or during it.
- **Change of state curve**

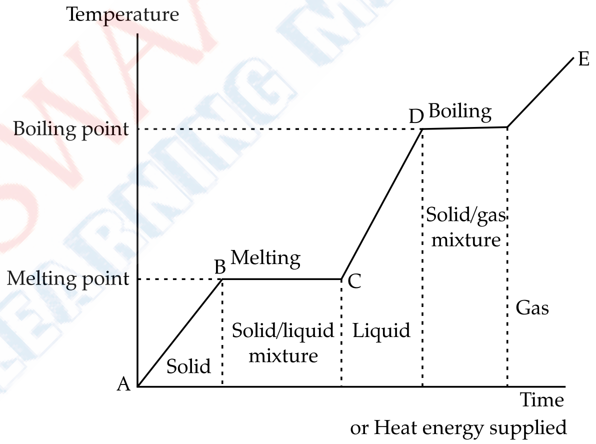
  When a substance is heated, its temperature rises.

  When the temperature reaches its melting point, the temperature becomes constant till the total solid mass is converted into liquid. During this stage, the solid substance absorbs latent heat and increases the potential energy of the molecules so that change of state takes place.

  After full conversion into liquid, the temperature again starts increasing till it reaches its boiling point where again the temperature becomes constant till the whole liquid mass is converted into gaseous state.

  After full conversion into gaseous state, the temperature again starts rising.

  Graphically, this can be represented by plotting temperature along Y axis and time along X axis.



Since specific heat capacity of liquid is more than the specific heat capacity of solid, therefore the slope of CD is less compared to the slope of AB portion.

Mnemonics

Concept : Liquid state to gaseous state conversion is vaporisation. Liquid state to solid state conversion is freezing.

Mnemonics : **L**ittle **G**uy **V**anished in the **L**arge **S**pace of the **F**air.

Interpretation :

L : Liquid to

G : Gaseous state

V : Vaporisation

L : Liquid to

S : Solid

F : Freezing

Mnemonics

Concept : Solid state to liquid state conversion is melting. Gaseous state to liquid state conversion is condensation.

Mnemonics : Mina **S**lept **L**ate. She **C**ame to the **G**athering **L**ate.

Interpretation :

M : Melting
S : Solid to
L : Liquid
C : Condensation
G : Gaseous state
L : Liquid

UNIT – VI: MODERN PHYSICS

CHAPTER-9
MODERN PHYSICS

Concepts covered: Radioactivity , Isotope, Isobar, Isotone

Revision Notes

- **Atomic number :** The atomic number (*Z*) of an atom is the number of protons in its nucleus (which is the same as the number of electrons in a neutral atom).
- **Mass number :** The mass number (*A*) of an atom is the total number of nucleons (*i.e.*, number of protons and neutrons combined) in its nucleus.
- **Isotopes :** The atoms belonging to the same element, having same atomic number *Z*, but different mass number *A*, are called isotopes.
  Examples include : ${}^{1}_{1}H$, ${}^{2}_{1}H$ and ${}^{3}_{1}H$ which are the three isotopes of hydrogen.
- **Isotones :** The atoms having a different number of protons but same number of neutrons, *i.e.*, different Z and *A*, but same *A* – *Z*, are called isotones. They have a different number of electrons.
  Examples of isotones include : ${}^{23}_{11}Na$ and ${}^{24}_{12}Mg$.
- **Isobars :** The atoms of different elements which have the same mass number *A*, but a different atomic number (*Z*), are called isobars.
  Examples of isobars include : ${}^{23}_{11}Na$ and ${}^{23}_{12}Mg$.
- The substances which disintegrate (or decay) by the spontaneous emission of radiations, are called the radioactive substances, *e.g.*, uranium, radium, polonium, thorium, actinium, etc.
- **Radioactivity** is the process of spontaneous decay of unstable nuclei emitting α or β particles and γ rays from the nucleus of atoms.
- **Effect on atomic number (*Z*) and mass number (*A*) due to alpha, beta and gamma emissions :**

Quantity	α emission	β emission	γ emission
(i) *Z*	decreases by 2	increases by 1	no change
(ii) *A*	decreases by 4	no change	no change

- **Properties of α-particles :**
  - α-particle consists of a helium nucleus. It is denoted by ${}_{2}He^{4}$ (Atomic number 2 and mass number 4). It is a positively charged particle.
  - It has least penetration power and highest ionization power.
  - They can't penetrate the skin but is harmful to the human body.
  - α-particles effect a photographic plate.
  - α-particles cause fluorescence on striking a fluorescent material.
  - These are affected by electric and magnetic fields.
- **Properties of β-particles :**
  - β-particles are highly energetic electrons, which are released from inside of a nucleus. It is denoted by ${}_{-1}\beta^{0}$ (atomic number–1 and mass number 0) and ${}_{+1}\beta^{0}$ (atomic number 1 and mass number 0).

  - β-particles may be either negatively or positively charged, and it has negligible mass.
  - For the emission of negative β-particle, a neutron changes into a proton and an electron, inside the nucleus and for +β-particle, a proton converts into neutron and a positron.
  - β-particle has 100 times penetration power as compared to α-particle.
  - It has less ionization power but is still harmful.
  - β-particles effect a photographic plate.
  - β-particles cause fluorescence on striking a fluorescent material.
  - These are affected by electric and magnetic fields.
- **Properties of γ-Rays :**
  - The waves from the high frequency end of the electromagnetic spectrum which don't have mass and moves with speed of light are called γ-rays.
  - It is neutral in nature and denoted by ${}_0\gamma^o$ (Charge 0 and mass 0).
  - It is 1000 times and 100 times penetrating in nature as compared with α and β-particles respectively. It is very harmful to the living cell.
  - These radiations affect a photographic plate.
  - These radiations cause fluorescence when they strike a fluorescent material.
  - These rays are not affected by electric and magnetic fields.
- **Uses of Radioisotopes :**
  - Medical use - in treatment of leukemia , cancer
  - Scientific use - Carbon dating
  - Industrial use - as fuel for atomic energy reactors
- Sources of harmful radiations are radioactive fallout from nuclear power plants, nuclear waste and other sources (Cosmic radiations, X-rays).
- Harmful effects of radiation include short term effects (diarrhoea, sore throat, loss of hair), long term effects (leukemia, cancer) and genetic defects.
- **Safety measures to be taken while using nuclear energy :**
  - **While establishing a nuclear power plant :** Nuclear plant must have a shield with lead and steel walls, housing it in an airtight building with a back-up of a cooling system.
  - **While handling Radioisotopes :** People handling radioisotopes should put on lead-lined aprons and gloves and handle the material with long lead tongs.
  - **In safe disposal of nuclear waste :** Nuclear waste must be kept in thick casks and must be buried in specially constructed deep underground stores away from populated areas.
- Background radiations are the radioactive radiations which exist even in the absence of actual radioactive source. These are emitted both by internal and external sources.

Mnemonics

Concept: Isotope, Isotone and Isobar.
Mnemonics: **T**opewala **S**ales **P**ista. **T**onebabu **S**ales **N**asta. **B**arbeque **N**othing **S**asta.
Interpretation:
T : Isotope
S : Same
P : Proton
Tone : Isotone
S : Same
N : Neutron
Bar : Isobar
N : neither
S : same

Isotope has same number of protons and different number of neutrons.

Isotone has same number of neutrons and different number of protons.

Isobar has neither same number of protons nor same number of neutrons.