Physics Black Book PDF

Physical Quantities

Those quantities which can describe the laws of physics and possible to measure are called physical quantities.

The physical quantities which do not depend upon other physical quantities are called fundamental quantities.

The physical quantities which depend on fundamental quantities are called derived quantities e.g. speed, acceleration, force, etc.

Units

The unit of a physical quantity is the reference standard used to measure it.

Types of Units

1. Fundamental Units-The units defined for the fundamental quantities are called fundamental or base units.

Fundamental Physical Quantities	Mass (M)	Length (L)	Time (T)	Temperature (K)	Electric Current (I)	Luminous Intensity	Amount of Substance
Fundamental Units	Kilogram (Kg)	Metre (m)	Second (s)	Kelvin (K)	Ampere (A)	Candela (C(d)	Mole (mol)

2. Derived Units-The units defined for the derived quantities are called derived units. e.g. unit of speed or velocity (metre per secon(d), acceleration (metre per second^2) etc.

Rest and Motion

An object is said to be at rest if it does not change its position which respect to its surroundings with time and said to be in **motion** if it changes its position with respect to its surrounding with time.

- **Rectilinear motion** moving car on horizontal road, motion under gravity etc.
- **Angular motion** such as particle going on a circle, projectile motion, rotation of machine shaft etc.
- **Rotational motion** such as motion of a fan.
- It an object travels equal distances in equal intervals of time, then it is said to be in **uniform motion.**
- It an object travels unequal distances in equal intervals of time, then it is said to be in **non-uniform motion.**

Speed

- The distance covered by a moving body in a unit time interval is called its speed.
- Speed = $\frac{\text{Distance travelled}}{\text{Time taken}}$
- When a body travels equal distances with speed v_1 and v_2, then average speed is the **harmonic mean** of the two speeds.
- $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2} \Rightarrow v = \frac{2v_1v_2}{v_1+v_2}$
- When a body travels for equal times with speeds v_1 and v_2, then average speed is the **arithmetic mean** of the two speeds.
- $v = \frac{v_1+v_2}{2}$

Velocity

- The time rate of change of displacement of a body is called its velocity.
- Velocity $= \frac{\text{Displacement}}{\text{Time}}$
- An object is said to be moving with **uniform velocity** if it undergoes equal displacements in equal intervals of time.
- An object is said to be moving with **non-uniform** or **variable velocity** if it undergoes unequal displacement in equal intervals of time.
- Average velocity = $\frac{\text{Time displacement}}{\text{Total time taken}}$

Acceleration

- The time rate of change of velocity of a body is called its acceleration.
- Acceleration = $\frac{\text{Change in velocity}}{\text{Time taken}}$
- It is a vector quantity and its SI unit is ms^{-2}.
- Acceleration at an instant of time is known as **instantaneous acceleration.**
- When the velocity of a body increases with time, then its acceleration is positive and if velocity decreases with time, then its acceleration is negative called **deceleration or retardation.**
- If acceleration does not change with time, it is said to be **constant acceleration.**

Equations of Uniformly Accelerated Motion (Along straight lin(e)

If a body started its motion with initial velocity u and attains final velocity v in the interval t. The acceleration assumed to be uniform in motion is a and the distance travelled is s, then equations of motion:

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

- If any body is falling freely under gravity, then a is replaced by g in above equations.
- If an object is thrown vertically upward, then in above equations of motion a is replaced by (–g).
- Velocity–Time Graph For accelerating or decelerating body the graph will be a straight line inclined to time axis and velocity axis.
- Graph between position (distanc(e)-time for an accelerating or decelerating body is always a parabola.
- Acceleration-time graph for uniformly accelerating body is a line parallel to time axis.
- In case of uniform accelerated, the graph between position and velocity is always parabola.
- In case of uniformly accelerated motion, the graph between velocity and time is always a straight line.
- Slope of displacement-time graph gives velocity and slope of velocity-time graph gives acceleration.

Projectile Motion

- When a body is thrown from horizontal making an angle (θ) except 90°, then its motion under gravity is a curved parabolic path, called trajectory and its motion is called projectile motion.
- Examples:
- The motion of a bullet shot from the gun
- The motion of a rocket after burn-out
- The motion of a bomb dropped from a aeroplane etc.

Properties of Projectile Motion

If we drop a ball from a height and at the same time thrown another ball in a horizontal direction, then both the balls would strike the earth simultaneously at different places.

Circular Motion

- The motion of an object along a circular path is called circular motion.
- Circular motion with a constant speed is called **uniform circular motion.**
- The direction of motion at any point in circular motion is given by the tangent to the circle at that point.
- In uniform circular motion, the velocity and acceleration both changes.
- In case of non-uniform circular motion, the speed changes from point to point on the circular track.

Centripetal Acceleration

During circular motion an acceleration acts on the body towards the centre, called centripetal acceleration. The direction of centripetal acceleration is always towards the centre of the circular path.

Force

It is an external push or pull with can change or tries to change the state of rest or of uniform motion. SI unit is newton (N) and CGS unit is dyne. 1 N = 10^5 dyne. If sum of all the forces acting on a body is zero, then body is said to be in equilibrium.

Centripetal Force

During circular motion a force always acts on the body towards the centre of the circular path, called centripetal force.

Centrifugal Force

In circular motion we experience that a force is acting on us in opposite to the direction of centripetal force called **centrifugal force.** This is an apparent force or imaginary force and also called a pseudo force.

Applications of centripetal and centrifugal forces

- Cyclist inclined itself from vertical to obtain required centripetal force. To take a safe turn cyclist slower down his speed and moves on a path of larger radius.
- Roads are banked at turns to provide required centripetal force for taking a turn.
- For taking turn on a curved road, the **frictional force** is acting between the tyres of the vehicle and the road acts as centripetal force.
- If a bucket containing water is revolved fast in a vertical plane, the water may not fall even when bucket is completely inverted because a centrifugal force equal or greater than the weight of water pushes the water to the bottom of the bucket.
- For orbital motion of electrons around the nucleus **electrostatic force** of attraction is acting between the electrons and the nucleus as centripetal force.
- Cream is separated from milk when it is rotated in a vessel about the same axis. During rotation lighter particles of cream experience a lesser force than the heavier particles of milk.
- For revolution of the earth around the sun, gravitational force of attraction between the earth and the sun acts as centripetal force.

Newton's Laws of Motion

Newton's First Law of Motion

A body continues in its state of rest or of uniform motion in a straight line unless an external force acts on it. It is based on **law of inertia**. Inertia is the property of a body by virtue of which is opposes any change in its state of rest or of uniform motion in a straight line.

Inertia of Rest

- When a bus or train at rest starts, to move suddenly, the passengers sitting in it jerk in backward direction due to their inertia of rest.
- The dust particles come out from a carpet when it is beaten with a stick due to their inertia of rest.
- A passenger jumping out from a rapidly moving bus or train is advised to jump in forward direction and run forward for a short mile due to inertia of rest.

Inertia of Motion

When a running bus or train stops suddenly, the passengers sitting in it jerk in forward direction due to inertia of motion.

Momentum

The momentum of a moving body is equal to the product of its mass and its velocity.

Conservation of Linear Momentum

- The linear momentum of a system of particles remains conserved if the external force acting on the system is zero.
- Rocket propulsion and engine of jet aeroplane works on principle of conservation of linear momentum. In rocket, ejecting gas exerts a forward force which helps in accelerating the rocket upward.

Newton's Second Law

The rate of change of momentum of a body is directly proportional to the force applied on it and change in momentum takes place in the direction of applied force.

$$F = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t} = ma$$

Newton's Third Law

For every action, there is an equal and opposite reaction and both act on two interacting objects. Rocket is propelled by the principle of Newton's third law of motion.

Impulse

- A large force which acts on a body for a very short interval of time and produces a large change in its momentum is called an impulsive force.
- Its unit is newton-second.
- A fielder lowers its hand when catching a cricket ball because by lowering his hands, he increases the time of contact for stopping the ball and therefore fielder has to apply lesser force to stop the ball. The ball will also exert lesser force on the hands of the fielder and the fielder will not get hurt.
- Wagons of a train are provided with the buffers to increase the time of impact during jerks and therefore, decreases the damage. The vehicles like scooter, car, bus, truck etc. are provided with shockers.

Friction

Friction is a force which opposes the relative motion of the two bodies when one body actually moves or tries to move over the surface of another body.
The cause of friction is the strong atomic or molecular forces of attraction acting on the two surfaces at the point of actual contact.

Uses of Friction

- A **ball bearing** is a type of rolling-element that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and to support loads (weight).
- Friction is necessary for walking, to apply brakes in vehicles, for holding nuts and bolts in a machinery etc.
- Friction can be decreases by polishing the surfaces by using lubricants or by using ball bearings.
- Tyres are made of synthetic rubber because its coefficient or friction with road is larger and therefore, large force of friction acts on it, which stops sliding at turns.
- The tyres are threading which also increases the friction between the tyres and the road.
- When pedal is applied to a bicycle, the force of friction on rear wheel is in forward direction and on front wheel is in the backward direction.

- **Loses due to Friction**
- Too much Loss of Energy in machines and then ultimately the machines are damaged.
- **Laws of Limiting Friction**

i. It depends on the nature of the surfaces in contact and their state of polish.
ii. It acts tangential to the two surfaces in contact and in a direction opposite to the direction of motion of the body.
iii. The value of limiting friction is independent of the area of the surface in contact so long as the normal reaction remains the same.
iv. The limiting friction ($f_{s\ max}$) is directly proportional to the normal reaction R between the two surfaces.

OSCILLATIONS AND WAVES

Periodic Motion

- A motion which repeats itself identically after a fixed interval of time, is called a periodic motion.
- For example
  - Motion of arms of a clock, orbital motion of the earth around the sun, motion of a simple pendulum etc.
- **Oscillatory Motion**
- A periodic motion taking place to and fro or back and forth about a fixed point, is called oscillatory motion.
- For example
  - Motion of a simple pendulum.
  - Motion of a loaded spring etc.

- If a particle oscillates with its own natural frequency without help of any external periodic force. The oscillation is then called **damped oscillation.**
- When a body oscillates with the help of an external periodic force with a frequency different from natural frequency of the body, then oscillation is called **forced oscillation.**

Simple Harmonic Motion (SHM)

- An oscillatory motion of constant amplitude and of single frequency under a restoring force whose magnitude is proportional to the displacement and always acts towards mean position, is called **Simple Harmonic Motion.**

Characteristics of SHM

When a particle executing SHM passes through the mean position:

1. No force acts on the particle.
2. Acceleration of the particle is zero.
3. Velocity is maximum.
4. Kinetic energy is maximum.
5. Potential energy is zero.

When a particle executing SHM is at the extreme end, then:

1. Acceleration of the particle is maximum.
2. Restoring force acting on particle is maximum.
3. Velocity of particle is zero.
4. Kinetic energy of particle is zero.
5. Potential energy is maximum.

Simple Pendulum

- A heavy point mass suspended from a rigid support by means of an elastic inextensible string, is called a simple pendulum.
- Time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$
- The time period of a simple pendulum of infinite length is 84.6 min. The time period of a second's pendulum is 2 s. Its length on the earth is nearly 100 cm.
- Acceleration due to gravity decreases with altitude (height) and therefore time period of a pendulum clock will increase and clock becomes slow.
- If the bob of a simple pendulum is suspended from a metallic wire, then the length of the pendulum increases with increase in temperature and therefore its time period also increases.
- A girl is swinging over a swing. If she stands up over the swing, then the effective length of the swing decreases and therefore, the time period of oscillations decreases.
- A pendulum clock cannot be used in a space-ship.
- **Damped Harmonic Motion**
- When there is friction or any other force acting within an oscillating system, the amplitudes of the oscillation decreases over time to this damping force. This is called damped harmonic motion.

Resonant Oscillations

- When a body oscillates with its own natural frequency (V_o) with the help of an external periodic force also called forced harmonic motion. And if the frequency (v) provided by the external agent is equal to the natural frequency of the body, the oscillations of the body are called resonant oscillations.

Wave

A wave is a disturbance which propagates energy from one place to the other without the transport of matter.

Waves are broadly of two types:

1. Mechanical Wave
2. Non-mechanical wave

Mechanical Wave: The waves which required material medium (solid, liquid or gas) for their propagation are called mechanical wave or elastic wave. Mechanical waves are of two types.

1. Longitudinal wave: If the particles of the medium vibrate in the direction of propagation of wave, the wave is called longitudinal wave.

2. Transverse Wave: If the particles of the medium vibrate perpendicular to the direction of propagation of wave, the wave is called transverse wave.

Waves on strings under tension, waves on the surface of water are examples of transverse waves.

Non-mechanical waves or electromagnetic waves: The waves which do not require medium for their propagation i.e. which can propagate even through the vacuum are called non mechanical wave.

Light, heat are the examples of non-mechanical wave. In fact all the electromagnetic waves are non-mechanical.

All the electromagnetic wave consists of photon.

The wavelength range of electromagnetic wave is 10^{-14}m to 10^4 m.

Properties of electromagnetic waves

1. They are neutral (uncharge(d).
2. They propagate as transverse wave.
3. They propagate with the velocity of light.
4. They contains energy and momentum.
5. Their concept was introduced by Maxwell.

Following waves are not electromagnetic

1. Cathode rays
2. Canal rays
3. α rays
4. β rays
5. Sound wave
6. Ultrasonic wave

Some Important Electromagnetic Waves & their discoverer

1. γ-Rays - Henry Becqueral
2. X-Rays - W. Rontgen
3. Ultra-violet rays - Johann Ritter
4. Visible radiation - Newton
5. Infra-red rays - Hershel
6. Short radio waves or Hertzian Waves - Heinrich Hertz
7. Long Radio Waves - Marconi

Note: Electromagnetic waves of wavelength range 10^{-3}m to 10^{-2}m are called microwaves.

Amplitude: Amplitude is defined as the maximum displacement of the vibrating particle on either side from the equilibrium position.

Wavelength: Wavelength is the distance between any two nearest particle of the medium, vibrating in the same phase. It is denoted by the Greek letter **lambda**(λ).

In transverse wave distance between two consecutive crests or troughs and in longitudinal wave, distance between two consecutive compressions or rarefactions is equal to wavelength.

Velocity of wave = frequency × wavelength.

Sound

Sound waves are mechanical longitudinal waves and require medium for their propagation. It cannot propagate through vacuum. When propagated speed and wavelength changes but frequency remains constant. It is of three types:

Infrasonic waves – 0 to 20,000 Hz

Audible waves – 20 to 20,000 Hz

Ultrasonic waves – >20,000 Hz

Properties of Sound Wave

Reflection

- The bouncing back of sound when it strikes a hard surface, is called reflection of sound.
- The laws of reflection of light are also obeyed during reflection of sound.
- The working of megaphone, sound boards and ear trumpet is based on reflection of sound.
- The repetition of sound due to reflection of sound waves, is called an **echo.**
- The persistence of hearing on human ear is $\frac{1}{10}$th of a second.
- The minimum distance from a sound reflecting surface to hear an echo is nearly is nearly 17 m.
- Sound proof rooms are made of two layers of walls having vacuum between them.
- **Reverberation** arises due to multiple reflection of sound.
- While designing an auditorium for speech or musical concerts, one has to take proper care for the absorption and reflection of sound.
- Time taken by reverberant sound to decrease its intensity by a factor of 10^6 is called **reverberation time.**

- **Refraction**
- When a sound wave move from one mechanical medium to another mechanical medium, it shows deviation from the original path of the incident wave. The phenomenon is called refraction. It is due to difference is speed of sound in media.
- **Diffraction**
- When sound waves originated by a vibrating source, they spread in the medium and if the medium is homogeneous, this leads to bending of sound waves around the edges. Which is known as diffraction.
- The sound waves diffracted broadly and one can easily hears the voice of the another person.

Musical Scale

- In theory of music, a musical scale is a set of musical notes by the frequencies of which are in simple ratios to one another. Sa, re, ga, ma, pa, dha, ni is one such scale called the diatonic scale. The interval sa-sa is called an octave (8).

Noise Reduction in Recording Media

- Five types of noise reduction system exists in recording media as discussed below
  - Dolby A noise reduction system, intended for use in professional recording studios. It provided about 10 dB of broadband noise reduction.
  - Dolby B was developed to achieve about 9 dB noise reduction primarily for cassettes. It was much simpler than Dolby A and therefore less expensive to implement in consumer products.
  - Dolby C provides about 15 dB noise reduction.
  - Dolby SR (Spectral Recording) system is much more aggressive noise reduction approach than Dolby A. Dolby SR is much more expensive to implement than Dolby B or C, but it is capable of providing upto 25 dB noise reduction in the high frequency range.
  - Dolby S is found on some Hi-Fi and semi-professional recording equipment. It is capable of 10 dB of noise reduction at low frequencies and upto 24 dB of noise reduction at high frequencies.

Doppler's Effect

The apparent change in the frequency of source due to relative motion between the source and observer is called Doppler's effect.

Applications of Doppler's Effect

The measurement of Doppler shift (based on Doppler's effect) has been used -

- By police to check over speeding of vehicles.
- At airports to guide the aircraft.
- To study heart and blood flow in different parts of the body.
- By astrophysicist to measure the velocities of planets and stars.

SONAR

- SONAR stands for **Sound Navigation And Ranging.** It is used to measure the depth of a sea, to locate the enemy submarines and shipwrecks.
- The transmitter of a sonar produces pulses of ultrasonic sound waves of frequency of about 50000 Hz. The reflected sound waves are received by the receiver.
- **Human Ear**
- We are able to hear with the help of an extremely sensitive organ of our body called the ear. There are three parts of human ear.
- The **outer ear** is called **pinna**. It collects the sound from the surroundings. The **middle ear** transmits the amplified pressure variations received from the sound wave to the **inner ear**.
- In the inner ear, the pressure variations are turned into electrical signals by the cochlea. These electrical signals are sent to the brain via the auditory nerve and the brain interpret them as sound.

HEAT

• Heat is the form of energy which produces the sensation of warmth. Its SI unit is joule and other unit is calorie (1 cal = 4.2 Joul(e).

• The transfer of heat is always from hotter to colder body.

Temperature

• Temperature is measure of hotness or coldness of a body.

• The heat flows from one body to another due to the difference in their body temperature.

Scale of Temperature

- To measure the temperature of a body following temperature scales are used.
- **Celsius scale** of temperature freezing point is 0°C Boiling point of water is 100°C
- **Fahrenheit scale** of temperature ice point or freezing of water = 32° F
- Boiling point of water = 212° F
- **Kelvin or absolute scale** of temperature ice point of water = 273° K
- Boiling point of water = 373° K
- **Reaumur scale** of temperature ice point of water is 0° R,
- Boiling point of water = 80°R

Relation between Different Scales of Temperature

Different scales of temperature are related as follows:

$$\frac{C}{100} = \frac{F - 32}{180} = \frac{R}{80} = \frac{K - 273}{100}$$

K =273+ °C

• At temperature – 40°C = – 40°F, Celsius scale is equal to Fahrenheit.

• The temperature at which the three phases of water remains at equilibrium is called triple point of water (273.16 K)

Thermometers

• The instruments used to measure temperature of a body is called thermometer.

Thermometers are of following three types -

1. **Clinical thermometer -** It is used to measure human body temperatures and ranges from 96° F to 110°F or 35°C to 43°C.

2. **Electronic thermometer -** Basic components of an electronic thermometer are thermistors or thermoresistors. Range of electronic thermometer is –40° to 450°F.

3. **Other thermometers** - These include constant volume gas thermometer, platinum resistance thermometer etc.

- Clinical thermometer measures temperature in degree fahrenheit (°(F).
- In thermometer, mercury is commonly used through a wide range from –30°C to 300°C.
- Thermometer was developed by **Galileo** who found that the gases expand on heating.

Thermal Expansion

- The expansion of a body caused by heat is known as thermal expansion.

Thermal Expansion of Solids

Thermal expansion of solids is of three types

1. Expansion in length on heating, is called **linear expansion**. The increase in length of a rod of unit length of a substance due to increase in its temperature by 1°C is called the **coefficient of linear expansion** of the substance of that rod. It is represented by α.

$$\alpha = \frac{\text{Increase in length}}{\text{Initial length} \times \text{Rise in temperature}} = \frac{\Delta L}{L \times \Delta t}$$

— Its unit is $°C^{-1}$.

2. Expansion in area on heating, is called **superficial expansion**.
Coefficient of superficial expansion is given as

$$\beta = \frac{\text{Increase in area}}{\text{Initial area} \times \text{Rise in temperature}} = \frac{\Delta A}{A \times \Delta t}$$

— Its unit is °C^{-1}.

3. Expansion in volume on heating, is called **volume expansion** or **cubical expansion**.
Coefficient of volume or cubical expansion is given as

$$\gamma = \frac{\text{Increase in volume}}{\text{Original volume} \times \text{Rise in temperature}} = \frac{\Delta V}{V \times \Delta t}$$

— Its unit is °C^{-1}

Relation between Coefficients of Expansions

- Coefficients of thermal expansions are related as
- $\beta = 2\alpha$ and $\gamma = 3\alpha$
- and $\alpha : \beta : \gamma = 1 : 2 : 3$

- In laying a railway line, a small gap is left in between two iron rails otherwise railway line will become curved on heating in summer.
- Telephone wires are not tighten on poles because in winter, wires get contract and can break.

Thermal Expansion of Liquids

- In liquids, only expansion in volume takes place on heating.

- Expansion of liquid is of two types:
- When expansion of the container, containing liquid, on heating, is not taken into account, then observed expansion is called **apparent expansion** of liquids.
- When expansion of the container, containing liquid, on heating, is also taken into account, then observed expansion is called **real expansion** of liquids.

$$\gamma_r = \gamma_a + \gamma_g$$

where, γ_r and γ_a, are coefficients of real and apparent expansion of liquids and γ_g = coefficient of cubical expansion of the container.

Anomalous Expansion of Water

When temperature of water is increased from 0°C, then its volume decreases up to 4°C, becomes minimum at 4° C and then increases. This behavior of water expansion around 4°C is called, anomalous expansion of water.

Thermal Expansion of Gases

There are two types of coefficient of expansion in gases.
— At constant pressure, the change in volume per unit volume per degree celsius, is called **volume coefficient** (γ_v).
— At constant volume, the change in pressure per unit, pressure per degree celsius, is called **pressure coefficient** (γ_p).

Calorimetry

- Amount of heat required to raise the temperature of 1 g of water by 1°C is called 1 calorie.
- Calorimetry states that heat lost by hotter body equals the heat gained by colder body.

Specific Heat

- The amount of heat required to raise the temperature of unit mass (m) of a substance through 1°C, is called its specific heat (s).
- It is denoted by s and its unit is 'cal/g°C or Joule/g°/C.
- The specific heat of water is 4200 J/kg^{1}/°C or 1000 cal/ g^{1}/°C^{-}, which is high compared with most other substances. Therefore, water is used as coolant in radiator in vehicle and hot water is used for the fermentation.
- Heat energy given or taken to change the temperature of a body is given by
  $Q = ms\Delta\theta$
  where, m = mass of the body
  and $\Delta\theta$ = change in temperature.
  The amount of heat required to raise the temperature of 1 mole of a gas by 1°C is called molar specific heat.

Latent Heat

- The heat energy absorbed or released at constant temperature per unit mass for change of state, is called **latent heat**.
- It is denoted by L and its SI unit is cal/g or kcal/kg.
- Heat energy absorbed or released during change of state is given by

$Q = mL$
where, m = mass of the substance.

- Latent heat of fusion of ice is 80 cal/g.
- Latent heat of vaporisation of steam is 536 cal/g.

Thermodynamics

The branch of physics which deals with the study of relation of heat energy with different types of energy is called thermodynamics.

Zeroth Law

- Zeroth law of thermodynamics tells about thermal equilibrium.

First Law

- As per first law about energy, heat given to a substance is equal to sum of change in internal energy and work done.

Second Law

- In second law work can be converted into heat and vice-versa but conversion is not possible with 100% efficiency.
- It is impossible for a machine operating in a cyclic process to convert heat completely into work, it is **kelvin's statement**.

- Heat by itself can not transfer from a colder to a hotter body. It is **clausius statement**. Refrigerator is based on this statement.
- **Heat engine** is a device which converts heat into mechanical work. Internal combustion and external combustion heat engine are two types of heat engine.
- Car engine uses coolant added with water to reduce harmful effects like corrosion, rusting etc. Such as ethylene glycol, potassium dichromate etc,
- **Carnot's theorem** tells about maximum efficiency of heat engine. It refers to carnot cycle.
- **Entropy** measures the molecular disorder of a system and is a thermodynamic function depending only on the temperature of the system.
- **Evaporation** is a process in which molecules escape slowly from the surface of a liquid.
- For a given liquid the rate of evaporation demands on the temperature and area of evaporating surface.
- **Refrigerator** is a device used for cooling things by the evaporation and compression of a volatile liquid inside a copper coil.

Humidity

- The presence of moisture in the atmosphere, is called humidity.
- The amount of water vapour present in the unit volume of atmosphere, is called **absolute humidity**.
- The **relative humidity** of air at a given temperature is the ratio of mass of water vapour present in a certain volume of air to the mass of water vapour required to saturate the same volume of air at the same temperature, multiplied by 100.
- Relative humidity is measured by **hygrometer**.
- Relative humidity of about 50% is considered comfortable at temperature 22°– 25° C.
- If the relative humidity is very low in air, then lips become dry and cracks appear in them.
- If relative humidity is very high in air then the sweat from our body does not evaporate readily and therefore we feel uncomfortable.
- **Air conditioning** provides comfortable conditions by regulating temperature and humidity.

Transmission of Heat

- Heat can be transferred from one place to another by process of transmission.
- There are three methods of transmission of heat.

Conduction

- The mode of transmission of heat in solids from higher temperature part to lower temperature part without actual movement of the particles, is called conduction.
- Transmission of heat in solids takes place mainly through conduction.
- Metals are good conductors of heat.
- Wood, cotton, wool, glass are bad conductors of heat, dry air is also a bad conductor of heat.
- Woollen clothes do not allow the heat of our body to escape and therefore we feel warm.
- On a cold night two thin blankets give more warmth than a single thick blanket because the layer of air between the two blankets works as a better insulator.
- Refrigerators and ice-boxes have double walls having thermocol between them which minimise heat gain by conduction.

Convection

- The mode of transmission of heat in fluids (liquids and gases) due to actual movement of the particles, is called convection.
- In liquids and gases, heat is transmitted by convection.
- When a liquid in a vessel is heated at the bottom, the liquid at bottom gets heated and expands.
- Due to its lower density, hot liquid rises and its place is taken by cold liquid from above. Convection currents are set up in the liquid until the temperature of the whole liquid becomes same.
- The cooling unit in a refrigerator is fitted near the top as cold air move downward and keeps cool the whole interior.
- Radiator in a motor car works on the principle of convection.

Newton's Law of Cooling

The rate of loss of heat from a body is directly proportional to the difference in temperatures of the body and its surroundings. If we take hot water and fresh water and put it in a refrigerator, then rate of cooling of hot water will be faster than the fresh tap-water.

- **Sea Breeze** During day time, the seashore warms up much faster than sea water. Hot air over the seashore rises and cooler air from sea water moves towards seashore to take its place resulting in a sea breeze.
- **Land Breeze** At night, land cools faster than sea water. Now hot air over sea water rises and cooler air from land moves towards sea to take its place and resulting in a land breeze.
- Cloudy night are warmer than clear night because clouds reflect the radiations emitted by the earth at night and keep it warm.

Radiation

- The process of heat transmission in the form of electromagnetic waves, is called radiation.
- Radiation does not require any medium for propagation and it propagates without heating the intervening medium.

Black Body

- A body that absorbs all the radiation incident on it is called perfectly black body.
- Ratio of heat absorbed (radiation) to total incident radiation for a body is called absorptive power (a) of body. It has no unit.
- Amount of heat radiation per unit area of the surface at a given temperature is called emissive power of the surface.
- Its unit is $J/m^2 - s$.
- The ratio of emissive power and absorptive power of a body is always same. It is equal to emissive power of a black body. This is known as **Kirchhoff's law**.
- White colour is a bad absorbers and good reflectors of heat radiations while black colour is good absorbers and bad reflectors of heat. Therefore, clothes of light colors give better feeling in summer and clothes of dark colors give better feeling in winter.

MATTER

Matter

Matter is considered as any thing which has weight and occupy space. It exist in three states: Solid, liquid and gas.

Solid

It is that, state of matter which has definite shape and definite volume. In this state molecules are very closely packed.

Properties of Solids

Elasticity

The property of a body by virtue of which it regain its original configuration after the removal of deforming force, is called elasticity. Quartz and phosphor bronze are almost perfectly elastic bodies.

Plasticity

The property of a body by virtue of which it does not regain its original configuration after the removal of deforming force, is called plasticity.

Strain

The fraction I change in configuration i.e. length, volume and shape, is called strain. Strain has no unit.

On the basis of change in configuration, strain is of three types

- Longitudinal strain = $\frac{\Delta I}{I}$
- Volume strain = $\frac{\Delta V}{V}$
- Shearing strain = $\Delta\theta/\theta$

Stress

The internal restoring force acting per unit area of cross-section of a deformed body, is called stress. Stress is of two types

- Normal stress
- Tangential stress

The maximum deforming force upto which a body retains its property of elasticity is called the limit of elasticity of the material body. The minimum stress required to break a wire is called breaking stress.

The torque required to produce a given twist in a hollow cylinder is greater than that required to produce the same twist in a solid cylinder. Therefore, hollow shaft is stronger than a solid shaft. Springs are made of steel, not of copper as Young's modulus of elasticity of steel is more than that of copper.

Elastic Limit

It is the limit of stress and strain upto which a wire remains elastic.

Plastic Behaviour

If the wire is stretched beyond the elastic limit, the strain increases much more rapidly. If the stretching force is removed, the wire does not comes back to its natural length.

Fracture Point

If the deformation is increased further the plastic behaviour, the wire breaks at a point known as fracture point.

Ductile and Brittle Materials

If large deformation takes place between the elastic limit and the fracture point, the material is called ductile. If the wire breaks soon after the elastic limit is crossed, it is called **brittle.**

Elastic Fatigue

It is the property of an elastic body by virtue of which its behaviour becomes less elastic under the action of repeated alternating deforming force. Due to elastic fatigue, the bridges becomes less elastic after a use of long time and therefore are declared unsafe.

Fluid

A substance which begins to flow under an external force is called a fluid. Liquids and gases are fluids.

Fluid Density

The ratio of mass to the volume of a body is called its density. (i.e. mass present in its unit volum(e). It is a scalar quantity having SI unit kg/m^3. The density of water is 1000 kg/m^3. The density of water is maximum at 4°C.

Hydrometer - It is an instrument used to measure density or relative density of liquid. Its working is based on law of floatation.

Fluid Pressure

Thrust (the normal forc(e) exerted by a liquid per unit area of the surface in contact at rest, is called fluid pressure.

Fluid pressure (p) = $\frac{F}{A}$. Its unit is Nm^{-2} or Pascal (P(a).

Atmospheric Pressure

The pressure exerted by the atmosphere, is called atmospheric pressure.

Aneroid barometer is used to measure atmospheric pressure and height of a place.

Other units of atmospheric pressure are torr and bar.

Pascal's Law

The pressure exerted anywhere at a point of confined fluid is transmitted equally and undiminished, in all directions throughout the liquid.

Hydraulic lift, hydraulic press hydraulic brakes works on the basis of Pascal's law.

Buoyancy

When a body is partially or wholly immersed in a liquid, an upward force acts on it, which is called buoyant force or upthrust and this property of fluids is called buoyancy.

Buoyant force is equal to the weight of the liquid displaced by the submerged part of the body.

The buoyant force acts at the centre of gravity of the liquid displaced by the submerged part of the body, which is called 'centre of buoyancy'.

Archimedes Principle

When a body is partially or completely immersed in a quid, it loses some of its weight. The loss in weight is equal to the weight of the liquid displaced by the submerged part of the body.

Law of Floatation

A body will float in a liquid if weight of the body is equal weight of the liquid displaced by the immersed part of the body.

In floating condition, the centre of gravity (g) and the centre of buoyancy (B) of the floating body must lie on the same straight line.

Ice and large icebergs float on water surface as its density (0.92 g/cm3) is lesser than the density of water.

When a piece of ice floats on water, its $\left(\frac{11}{12}\right) th$ part submerged in water and (1/12) th part is outside the water.

In sea water, (8/ 9) th part of icebergs is submerged and (1/9) th part is outside the water during floating.

It is easier to swim in sea water than in a river as density of sea water is greater than the density of river water. In sea water, buoyant force is greater than that in river water.

The density of human body is less than the density of water but the density of human head is greater than the density of water. Therefore, during swimming a person displaces the liquid with hands and legs and total weight of displaced liquid becomes equal to the weight of the body.

Surface Tension

The property of a liquid by virtue of which it tries to minimise its free surface area is called surface tension. The minimum surface area of a given amount of liquid is for spherical shape. Therefore, rain drops are spherical.

Factors Affecting Surface Tension

Temperature -The surface tension of a liquid decreases with increase in temperature.

Soluble Impurities - If the impurities are less soluble in liquid, then its surface tension decreases. If impurities are highly soluble in liquid, then its surface tension increases.Surface tension of a liquid becomes zero at critical temperature.

- **Applications of Surface Tension**
- When soap, detergent, dettol, phenyl etc., are mixed in water then its surface tension decreases. When salt is added in water, its surface tension increases.
- When oil spreads over the surface of water, its surface tension decreases.
- When kerosene oil is sprinkled on water, its surface tension decreases. As a result the larva of mosquitoes floating on the surface of water die due to sinking.
- Warm soup is tasty because at high temperature its surface tension is low and consequently the soup spreads on all parts of the tongue.
- Antiseptics like dettol have low surface tension and therefore it reaches in the tiny cracks of the wound and cleans the germs and bacteria.
- The surface tension of soap solution in water is less than the surface tension of pure water. Therefore, soap solution cleans greasy strains of clothes better than pure water.

Capillarity

The phenomenon of rising or falling of liquid column in a capillary tube (glass tube of very fine bor(e) is called capillarity.

Examples of Capillarity -

1. A piece of blotting paper soaks ink because the pores of the blotting paper serve as capillary tubes.
2. The oil in the wick of a lamp rises due to capillary action of threads in the wick.
3. The root hairs of plants draws water from the soil through capillary action.
4. To prevent loss of water due to capillary action, the soil is loosened and split into pieces by the farmers.
5. If a capillary tube is dipped in water in an artificial satellite, water rises up to other end of tube because of its zero apparent weight, how long the tube may be.
6. Action of towel in soaking up water from the body is due to capillary action of cotton in the towel.
7. Melted wax, in a candle rises up to wick by capillary action.

Cohesive and Adhesive Forces

The intermolecular force of attraction acting between the molecules of same substance is called **cohesive force.** e.g., Intermolecular force of attraction acting between the molecules of water, mercury etc.

The intermolecular force of attraction acting between the molecules of different substance is called **adhesive force.** For e.g., Intermolecular force of attraction acting between the molecules of paper and gum, paper and ink, etc.

Viscous force: The force which opposes the relative motion between different layers of liquid or gases is called viscous force.
Viscosity: Viscosity is the property of a liquid by virtue of which it opposes the relative motion between its different layers. Viscosity is the property of liquids and gases both. The viscosity of a liquid is due to cohesive force between its molecules.
The viscosity of a gas is due to diffusion of its molecules from one layer to other layer.
Viscosity of gases is much less than that of liquids. There is no viscosity in solids.
Viscosity of an ideal fluid is zero.
With rise in temperature, viscosity of liquids decreases and that for gases increases.
Viscosity of a fluid is measured by its coefficient of viscosity. Its SI unit is decapoise (kg/ms) or pascal second. It is generally denoted by η.

Stoke's Law
According to this law, the viscous force depends upon the coefficient of viscosity, velocity of the moving object and its size.

Terminal Velocity
When a small spherical body falls through a long liquid column its velocity increases gradually but later on it becomes constant, called terminal velocity.
The radius of spherical rain drops is very small therefore their terminal velocity is also small, with which they strike the earth's surface. When a liquid flow through a pipe, its speed i maximum near axis and minimum near the walls of the pipe.

Bernoulli's Theorem
If a non-viscous and incompressible liquid is flowing in stream-lined flow then total energy, i.e., sum of pressure energy, kinetic energy and potential energy, per unit volume of the liquid remains constant. Venturi tube and aspirator pump works on Bernoulli's theorem.
According to Bernoulli's theorem, with increase in velocity of liquid its pressure decreases and vice-versa.
During storms or cyclones, the roofs of the huts or tinned roofs blown off because wind blows with very high speed over the top of the roof and therefore pressure of air decreases. Due to the pressure difference of air above and below the roof, a lifting force acts on the roof. If it is sufficient to balance the weight of the roof it start to fly off.
Magnus Effect : Motion of a Spinning Ball
When swing bowlers deliver the ball, the ball changes its plane of motion in air.

LIGHT

REFLECTION OF LIGHT (Law of Reflection)
(i) The angle of incidence is equal to the angle of reflection.
(ii) The incident ray, the normal, the point of incidence and the reflected ray, all lie in the same plane.

Spherical Mirrors & their Uses

Uses of concave mirrors
- Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
- They are often used as shaving mirrors to see a larger image of the face. The dentists use concave mirrors to see large images of the teeth of patients.
- Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

Uses of convex mirrors
Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles, enabling the driver to see traffic behind him/her to facilitate safe driving. They always give an erect, though diminished, image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view much larger area than would be possible with a plane mirror.

REFRACTION OF LIGHT
The refraction of light when it passes from a fast medium to a slow medium bends the light ray toward the normal to the boundary between the two media. When a thick glass slab is placed over some printed matter, the letters appear raised when viewed through the glass slab the bottom of a tank or a pond containing water appears to be raised seen a pencil partly immersed in water in a glass tumbler. It appears to be displaced at the interface of air and water.
A lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides.

The following are the laws of refraction of light :
(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.
(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction. If i is the angle of incidence and r is the angle of refraction, then,
Sin i/Sin r = constant.

The one with the larger refractive index is optically denser medium than the other. The other medium of lower refractive index is optically rarer. The speed of light is higher in a rarer medium than a denser medium.

DISPERSION OF WHITE LIGHT BY A GLASS PRISM

The prism has probably split the incident white light into a band of colors. The sequence of colors VIBGYOR . The splitting of light into its component colors is called dispersion.

Different colors of light bend through different angles with respect to the incident ray, as they pass through a prism. The red light bends the least while the violet the most. Thus the rays of each colour emerge along different paths and thus become distinct.It is the band of distinct colors that we see in a spectrum.

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colors reach the observer's eye.

ATMOSPHERIC REFRACTION

The air just above the fire becomes hotter than the air further up. The hotter air is lighter (less dens(e) than the cooler air above it, and has a refractive index slightly less than that of the cooler air. Since the physical conditions of the refracting medium (air) are not stationary, the apparent position of the object, as seen through the hot air, fluctuate. This wavering is thus an effect of atmospheric refraction (refraction of light by the earth's atmospher(e) .

Twinkling of stars

The twinkling of a star is due to atmospheric refraction of starlight.

Advance sunrise and delayed sunset

The Sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after the actual sunset because of atmospheric refraction.

SCATTERING OF LIGHT

Scattering of light is the phenomenon by which a beam of light is redirected in many different directions when it interacts with a particle of matter.

The blue colour of the sky, colour of water in deep sea, the reddening of the sun at sunrise and the sunset.

Total Internal Reflection

Total internal reflection is a phenomenon that occurs when light travels from a more optically dense medium to a less optically dense one, such as glass to air or water to air.

Examples of Total Internal Reflection -

(a) Mirage – Hotter air is less dense, and has smaller refractive index than the cooler air. On hot summer days, the air near the ground becomes hotter than the air at higher levels noticed that while moving in a bus or a car during a hot summer day, a distant patch of road, especially on a highway, appears to be wet. This is also due to mirage.

(b) Diamonds - Their brilliance is mainly due to the total internal reflection of light inside them.

(c) Optical fibres too make use of the phenomenon of total internal reflection.Light undergoes repeated total internal reflections along the length of the fibre there is no appreciable loss in the intensity of the light signal.

Tyndall Effect

The Tyndall effect is the scattering of light as a light beam passes through a colloid. The individual suspension particles scatter and reflect light, making the beam visible.

The earth's atmosphere is a heterogeneous mixture of minute particles like smoke, tiny water droplets, suspended particles of dust and molecules of air.When a beam of light strikes such fine particles, the path of the beam becomes visible.

Tyndall effect is seen when a fine beam of sunlight enters a smoke-filled room through a small hole. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest.

Power of Accomodation of Eye - The ability of the lens to change its shape to focus near and distant objects is called accommodation. A normal human eye can see objects clearly that are between 25 cm and infinity.

Defects of Vision and Their Correction

Nearsightedness: If the eyeball is too long or the lens too spherical, the image of distant objects is brought to a focus in front of the retina and is out of focus again before the light strikes the retina. Nearby objects can be seen more easily. Eyeglasses with concave lenses correct this problem by diverging the light rays before they enter the eye. Nearsightedness is called myopia.

Farsightedness: If the eyeball is too short or the lens too flat or inflexible, the light rays entering the eye — particularly those from nearby objects— will not be brought to a focus by the time they strike the retina. Eyeglasses with convex lenses can correct the problem. Farsightedness is called hypermetropia.

Astigmatism : Astigmatism is the most common refractive problem responsible for blurry vision. Most of the eyeball's focusing power occurs along the front surface of the eye, involving the tear film and cornea (the clear 'window' along the front of the eyeball). The ideal cornea has a perfectly round surface. Anything other than perfectly round contributes to abnormal corneal curvature– this is astigmatism. Cylindrical lens is use to correct astigmatism.

MAGNETISM AND ELECTRICITY

Electricity — Flow of Electrons is called Electricity.

- The electricity produced by friction between two appropriate bodies, is called static electricity, it is also called **frictional electricity.**

Coulomb's law - The electrostatic force of interaction acting between two stationary point charges is directly proportional to the product of magnitude of charges and inversely proportional to the square of the distance between them.

F= K(q_a-$q_{(b)}$/r^2 .

Electric Field

- The space in the surrounding of any charge in which its influence can be experience by other charge, is called electric field.
- **Electric field intensity (E)** at any point is defined as the electrostatic force **((F)** acting per unit positive test charge (q) at the point.
- $E = \frac{F}{q}$
- Its unit is newton/coulomb.
- Therefore, electric field intensity is inversely proportional to the square of the distance r from the point charge.

Electric Field Lines

- An **electric field line** is an imaginary line, so that its tangent at any point is in the direction of the electric field vector at that point.
- Two lines can never intersect. Electric field lines always begin on a positive charge and end on a negative charge and do not start or stop in mid-space.

Electric Potential

- **Electric potential** at a point in an electric field is equal to the work done per unit charge in carrying a test charge from infinity to that point. Its unit is joule/coulomb.
- Electric potential, V = $\frac{W}{q}$.
- Potential difference is that physical quantity which decides the direction of flow of charge between two points in electric field.
- Positive charge always tends to move from higher potential towards lower potential.

Electric Dipole and Capacitor

- An **electric dipole** consists of two equal and opposite point charges separated by a very small distance.
- **Electric dipole moment** of the dipole is product of charge and the separation between the charges.
- A **capacitor or condenser** is a device over which a large amount of charge can be stored without changing its dimensions.
- The **capacitance** of a conductor is equal to the ratio of the charge (q) given to the conductor to change in its potential (V) is given by C = $\frac{q}{V}$.
- Its unit is coulomb/volt or farad. Farad ((F) is a large unit of capacitance. Its practical unit is microfarad (μF).
- $1\mu F = 10^{-6}F$

Type of Materials

- **Conductors** are those type of materials which have number of free electrons to conduct the electricity. The metals are good conductors of electricity.
- **Insulators** are that type of materials which do not have the free electrons in its volume and hence, it does not conduct the electricity at all.
- **Semiconductor** is that type of materials which do not have free electrons at the normal temperature, but has the free electrons at the increased temperature and hence, behaves like a conductor. The materials such as silicon, germanium etc., are the semiconductor.

Electric Current

- An electric current whose magnitude and direction do not change with time is called direct current, and whose magnitude changes continuously and direction changes periodically is called alternating current.
- Inverter is a device which converts DC to AC.
- In solid conductors, electric current flows due to flow of electrons, in liquids due to flow of ions as well as electrons and in semiconductors due to flow of electrons and holes.
- Its S.I. unit is Ampere

Resistance

- Resistance is the opposition that a substance offers to the flow of electric current.
- It is represented by R.
- **Its S.I. unit is ohm.**

Conductance

- **Conductance and conductivity** is the reciprocal of resistance and the resistivity of the material respectively. The SI unit of conductance is Ω^{-1} i.e., mho and to that of conductivity is $\Omega^{-1}\text{m}^{-1}$.

Resistivity

- Resistivity of a material depends on the temperature and nature of the material depends on temperature and nature of the material. It is independent of dimensions of the conductor, i.e., length, area of cross-section etc.
- Resistivity of metals increases with increase in temperature.

Combination of Resistances

- It resistance R_1, R_2 and R_3 are connected in **series,** then their equivalent resistance is given by $R = R_1 + R_2 + R_3$
- In series combination, equal current flows through each resistors but Voltage varies.
- If resistances R_1, R_2, R_3 are connected in **parallel**, then their equivalent resistance is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- In parallel combination, potential difference across each resistor remains same but current varies.

Ohm's law

- It states that if physical conditions of any conductor such as temperature, pressure etc., remain unchanged, then electric current (I) flowing through it, is directly proportional to the potential difference (V) applied across its ends, i.e., I ∝ V or V = IR
- where, R is the electrical resistance of the conductor.

Electric Cell

- An electric cell is a device which converts chemical energy into electrical energy.
- Electric cell are of two types

Primary cell cannot be charged. Voltaic, Daniel and Leclanche cells are primary cells.

Secondary cell can be charged again and again. Acid and alkali accumulators are secondary cells.

- Working of electric cells is based on chemical effect of electric current.

Emf of a Cell

- The work done by the cell to bring a (+)ve charge from its own terminal to the other is known as its emf (electromotive forc(e). Electromotive force is work but not a force.

Joule's Law of Heating

- Current can produce three effects: heating effect, magnetic effect and chemical effect.
- Heat is produced in conductor in time t is given by

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

- This is known as **Joule's law of heating.**
- Electric bulb, electric kettle, heater etc., devices work on the basis of heating effect of electric current.
- To protect the domestic appliances from sudden change in electricity, fuses are used. It is made of tin, lead, alloy (63% + 37%).
- It should have high resistance and low melting point always connected in series.

Electric power

- The electrical energy produced or consumed per unit time is called electric power.
- Electric power, P = VI = $I^2R = \frac{V^2}{R}$
- 1 kWh = 3.6 × 10^6 J

Chemical Effect of Electric Current

- When an electric current is passed through an acidic or basic solution, it decomposes into its positive and negative ions. The positive ions collect at negative electrode (cathod(e) and the negative ions collect at positive electrode (anod(e).
- This phenomenon is called electrolysis. It is chemical effect of current. The process of coating of a base metal with a layer of more expensive metal, is called **electroplating**.

Domestic Electrification

- From the distribution, the two terminals are supplied to the houses named as live and neutral (neutral is earthed at local substation). The third terminal is introduced as the earth for the safety in the building.

Lightning Appliance

- The electric discharge occurring between two charged clouds or between a charged cloud and earth can damage the houses or buildings. To protect this lightning conductors are used.

Magnetism

- A magnet is a material which can attract iron objects.
- A natural magnet is an ore of iron (Fe_3O_4) called magnetite or lodestone.
- A magnet which is prepared artificially, is called an **artificial magnet**.
- A freely suspended magnet always aligns itself into North-South direction. Like magnetic poles repel and unlike magnetic poles attract each other.
- A current-carrying coil containing a soft iron core, is called an **electromagnet.**
- An electromagnet is utilised in electric bell, telegraph receiver, telephone diaphragm, transformer, dynamo etc.
- Permanent magnets are made of steel and temporary magnet or electromagnets are made of soft iron because steel cannot magnetised easily but when it is magnetised one time, cannot be demagnetised easily. The soft iron can be magnetised or demagnetised easily.

Properties of Magnet

- **Attractive property:** A magnet can attract small pieces of magnetic substances like iron, steel, cobalt, nickel etc. The attraction is maximum at poles. Unlike poles attract and like poles repel.
- **Directive property:** A magnet, when suspended freely, aligns itself approximately along geographical N-S line.
- **Magnetic poles exist in pairs:** If a magnet is cut into two equal parts transverse to its length, then N and S-poles of the magnet do not get separated.

Magnetic Field

- The space in the surrounding of a magnet or a current carrying conductor in which its magnetic effect can be experienced, is called magnetic field.
- **Magnetic lines of force** is an imaginary line drawn in magnetic field at which a magnetic North pole will move, if it is free to do so.
- A tangent drawn at any point of an magnetic line of force represents the direction of magnetic field at that point.
- The **magnetic flux** linked with a surface is equal to the total number of magnetic lines of force passing through that surface normally. Its unit is weber.

Earth's Magnetism

- The earth has its own magnetic field. The pole near the geographic North of the earth is called the magnetic North pole. Similarly, the pole near the geographic South pole is called the magnetic South pole.
- The Earth's magnetic field diverts charged particle coming from space towards its poles and saves living beings from being severely harmed.
- **Magnetic compass** A magnetic needle which always direct in North-South (N-S) direction.

Magnetic storm

- Local disturbances in the earth's magnetic field which can damage telecommunication which are probably caused by lump of charged particles emanating from the sun is known as magnetic storm.
- In the Arctic Circle, they are known as Aurora Borealis or the northern lights, while in the Antarctic Circle they are called Aurora Australis or the southern lights.
- **Moving Coil Galvanometer**
- A moving coil galvanometer is used to detect the presence of current and the direction of current in any circuit.

Ammeter and Voltmeter

- An ammeter is an instrument used to measure electric current. It is always connected in series. The resistance of an ideal ammeter is zero.
- A **galvanometer** can be converted into an ammeter by connecting a low resistance in parallel.
- A voltmeter is a device used to measure potential difference between two points in an electric circuit.
- The resistance of an ideal voltmeter is infinity. It is always connected in parallel.
- A galvanometer can be converted into a voltmeter by connecting a high resistance in series.
- A small resistance connected in parallel with the load resistance to reduce amount of electric current through resistor is called shunt.

Magnetic Substances

- There are three types of magnetic substances Paramagnetic, Diamagnetic and Ferromagnetic.

Paramagnetic Substances

- Those substances which are feebly magnetised in the direction of magnetic field when placed in strong magnetic field, are called **paramagnetic substances.**
- For examples—Aluminium, platinum, chromium, manganese, solutions of salts of iron, nickel, oxygen etc.
- These substances are attracted towards strong magnetic field in a non-uniform magnetic field.
- The magnetism of these substances decreases with increase in temperature.

Diamagnetic Substances

- Those substances which are feebly magnetised in the opposite direction of magnetic field when placed in strong magnetic field are called diamagnetic substances.
- For examples— Gold, silver, zinc, copper, mercury, water, alcohol, air, hydrogen etc.
- These substances are attracted towards weak magnetic field in a non-uniform magnetic field.
- The magnetism produced in these substances does not change with increase or decrease in temperature.

Ferromagnetic Substances

- Those substances which are strongly magnetised in the direction of magnetic field when placed in it, are called ferromagnetic substances.
- For examples —Iron, nickel, cobalt etc.
- The magnetism produced in these substances decreases with increase in temperature and at a particular temperature, called Curie temperature.
- At the **Curie temperature**, a paramagnetic substance becomes diamagnetic.
- Curie temperature for iron is 770°C and for nickel is 358°C.

Electromagnetic Induction (EMI)

- Whenever the magnetic flux linked with an electric circuit changes, an emf is induced in the circuit. This phenomenon is called electromagnetic induction.

Faraday's Laws of EMI

- Whenever the magnetic flux linked with a circuit changes, an induced emf is produced in it. The induced emf loses as long as the change in magnetic flux continues.

Lenz's Law

- The direction of induced emf or induced current is always in such a way that it opposes the cause due to which it is produced.

Eddy Current

- If a piece of metal is placed in a varying magnetic field or rotated with high speed in a uniform magnetic field, then induced current set up in the piece is like whirlpool of air, called eddy current, also known as **foucault's current.**

Uses

- Eddy currents are used in dead beat galvanometer, induction furnaces, induction motor, speedometers of automobiles etc.
- Eddy currents are used in diathermy for deep heat treatment of the human body.

Self and Mutual Induction

- The phenomenon of production of induced emf in a circuit due to change in current flowing in its own, is called **self induction.**
- The unit of self induction is Henry (H).
- The phenomenon of production of induced emf in a circuit due to change in magnetic flux in its neighbouring circuit, is called **mutual induction.**
- Its unit is Henry (H).

Alternating Current

- An electric current whose magnitude and direction changes continuously is called alternating current. The frequency of alternating current in India is 50 Hz.
-
- Mean or average value of AC is zero for one complete cycle.
- **Root mean square value** of AC is given by
- $I_{rms} = \frac{I_0}{\sqrt{2}}$
- An AC ammeter and AC voltmeter read root mean square value of alternating current and alternating voltage respectively.

AC Generator or Dynamo

- It is a device which Inverts mechanical energy into alternating current.
- Its working is based on electromagnetic induction.

DC Motor

- It is a device which converts electrical energy into mechanical energy.
- Its working is based on the fact that when a current carrying coil is placed in uniform magnetic field, a torque acts on it.

Transformer

- It is a device which can change a low voltage current into a high voltage current and vice-versa.
- Its working is based on mutual induction.

Step-up Transformer

- It converts a low voltage current into a high voltage current.
- **Step-down Transformer**
- It converts a high voltage current into a low voltage current.
-

NUCLEAR REACTOR

A nuclear reactor is a device that contains and controls sustained nuclear chain reactions. In nuclear reactors, the nuclear fission is controlled by controlling the number of neutrons released during the fission. The energy liberated in a controlled manner is used to produce steam, which can run turbines and produce electricity.

Fuel (Uranium - 235 , Plutonium-239)
The fissionable material is used in the reactor along with a small neutron source.The solid fuel is made into rods and is called fuel rods.

Role of extra neutron -
These neutrons in turn can initiate fission processes, producing still more neutrons, and so on. This starts a chain reaction. Slow neutrons (thermal neutrons) are much more likely to cause fission in $^{235}U_{92}$ than fast neutrons. Fast neutrons liberated in fission would escape instead of causing another fission reaction. If the chain reaction is uncontrolled, it leads to explosive energy output, as in a nuclear bomb or Atom bomb. Each time an atom splits, it releases large amounts of energy in the form of heat.

Moderators -(water, heavy water (D_2O) and graphit(e)
Light nuclei called moderators are provided along with the fissionable nuclei for slowing down fast neutrons.

Core - The core of the reactor is the site of nuclear fission. It contains the fuel elements in suitably fabricated form.

Reflector-The core is surrounded by a reflector to reduce leakage. The energy (heat) released in fission is continuously removed by a suitable coolant.

Coolant - (water, heavy-water, liquid sodium, helium,Liquid oxygen)
The coolant transfers heat produced during fission to a working fluid which in turn may produce steam. The steam drives turbines and generates electricity.

Control rods- (cadmium,Boron)
The reactor can be shut down by means of rods (made of, for example, cadmium,Boron) that have high absorption of capacity of neutrons.cadmium and boron can absorb neutrons to form the corresponding isotopes, which are not radioactive.

Shield - The whole assembly is shielded with heavy steel or concrete to check harmful radiation from coming out.

WORK, POWER AND ENERGY

Work

Work is a scalar quantity. Its SI unit is joule and CGS unit is erg. 1 joule = 10^7 erg.
Work done by a force is zero when
-Body is not displace actually, i.e. s = 0
-Body is displaced perpendicular to the direction of force i.e. θ = 90°.

Work done by a variable force

If we throw a ball upward, work done against gravity is given by,
W = mgh
where, m = mass of the body,
g = acceleration due to gravity and
h = height through which the ball is raised.

The centripetal force acts on a body perpendicular to the direction of motion. Therefore, work done by or against centripetal force in circular motion is zero.
If a coolie is carrying a load on his head and moving on a horizontal platform, then work done by force of gravity is zero as displacement is perpendicular to the direction of force of gravity.

Energy

Energy of a body is its capacity of doing work. It is a scalar quantity and its SI unit is joule.
Energy can be transformed into work and vice-versa with the help of some mechanical device.
There are two types of Mechanical Energy, which are as follows

Kinetic Energy

The energy possessed by a body by virtue of its motion is called its kinetic energy.
Kinetic energy of the body of mass m moving with velocity v is given by K = $\frac{1}{2}mv^2$.

Potential Energy

The energy possessed by any object by virtue of its position or configuration is called its potential-energy.
Gravitational potential energy, U = mgh.

Einstein's Mass-Energy Relation

According to this relation, the mass can be transformed into energy and vice-versa.
When Δm mass is disappeared, then produced energy
E= Δmc^2
where, c = speed of light in vacuum .

Law of Conservation of Energy

Energy can neither be created nor be destroyed, only one type of energy can be transformed into other form of energy.
Only for conservative forces, (total mechanical energy) initially = (total mechanical energy) finally.

Some Equipment used to Transform Energy		
S.	Equipment	Energy Transformed
1.	Dynamo	Mechanical energy into electrical energy
2.	Candle	Chemical energy into light and heat energy.
3.	Microphone	Sound energy into electrical energy.
4.	Loud Speaker	Electrical energy into sound energy.
5.	Solar Cell	Solar energy into electrical energy.
6.	Tube light	Electrical energy into light energy.
7.	Electric Bulb	Electrical energy into light and heat energy.
8.	Battery	Chemical energy into electrical energy.
9.	Electric motor	Electrical energy into mechanical energy.
10.	Sitar	Mechanical energy into sound energy.

Gravitation

Each and every massive body attracts each other by virtue of their masses. This phenomenon is called gravitation.

Newton's Law of Gravitation

The gravitational force acting between two point objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.
Gravitational force ((F) = $\frac{Gm_1m_2}{r^2}$
where, G is universal gravitational constant.
Its value is 6.67 × $10^{-11}\ N-m^2\ kg^{-2}$.
Gravitational force is a central as well as conservative force.

Acceleration Due to Gravity of Earth

The uniform acceleration produced in a freely falling body due to the earth's gravitational pull, is called acceleration due to gravity, g = $\frac{GM}{R^2}$
where, M = mass of the earth, R = radius of the earth.
The value of g changes slightly from place to place but its value near the earth's surface is 9.8 ms^{-2}.

Gravitational force is the weakest force in nature. It is 10^{36} times smaller than electrostatic force and 10^{38} times smaller than nuclear force.

Factors Affecting Acceleration due to Gravity

Shape of Earth - Earth is not completely spherical its radius at equator is approximately 42 km greater than its radius at poles. The value of g is maximum at poles and minimum at equator. There is no effect of rotation of the earth at poles and maximum at equator.

Effect of Altitude - g decreases with altitude.

Effect of Depth - g decreases with depth and becomes zero at centre of the earth.

Mass and Weight

The mass of a body is the quantity of matter contained in it. It is a scalar quantity and its SI unit is kg.

Mass is measured by an ordinary equal arm balance.

Mass of a body does not change from place to place and remains constant.

The weight of a body is the force with which it is attracted towards the centre of the earth. Weight of a body (w) = mg

The centre of gravity of a body is that point at which the whole weight of the body appears to act.

The centre of gravity of a body can be inside the material of the body or outside it.

It is a vector quantity and its SI unit is newton (N). It is measured by a spring balance.

Weight of a body is not constant, it changes from place to place.

Weight of a Body in a Lift

When lift is rest or in uniform motion The weight recorded in spring balance (i.e. apparent weight) is equal to the real weight of the body w = mg.

When lift is accelerating upward The weight recorded in spring balance is greater than then real weight of the body w' = m(g + (a)

When lift is accelerating downward The weight recorded in spring balance is smaller than the real weight of the body w' = m(g – (a).

When lift is falling freely under gravity The apparent weight of the body

w' = m (g – g) (∵ a = g)

w' = 0

Therefore, body will experiences weightlessness.

Weight of a Body at the Moon

As mass and radius of moon is lesser than the earth, so the force of gravity at the moon is also less than that of the earth. It's value at the moon's surface is $\frac{g}{6}$.

Satellite

A heavenly body revolving around a planet in an orbit is called a satellite. Moon is a natural satellite of the earth. The satellite may be artificial. Artificial satellites are of two types.

Geostationary Satellites

It revolves around the earth in equatorial orbits which is also called Geostationary or Geosynchronous orbit. The time period of these satellites is 24 hour.

Polar Satellites

These satellites revolve around the earth in polar orbits at a height of approximately 800 km.

Weather monitoring which is predicted on the basis of information about moisture present in air, atmospheric pressure etc, obtained through a **polar satellite.**

We are able to see a live telecast of cricket world cup match or other programme with the help of a communication satellite which is a geostationary satellite.

Launching vehicles – PSLV & GSLV.

Time Period of a Satellite

It is the time taken by a satellite to complete one revolution.

If satellite is near the earth's surface, then T = $2\pi\sqrt{\frac{R}{g}} \approx 84.6$ min.

Escape Velocity

Escape velocity: Escape velocity is that minimum velocity with which a body should be projected from the surface of earth so as it goes out of gravitational field of earth and never return to earth. Escape velocity is independent of the mass, shape and size of the body and its direction of projection.

Escape velocity is also called second cosmic velocity. For earth, escape velocity = 11.2 km/s.

For moon, escape velocity = 2.4 km/s.

Orbital Velocity

Orbital velocity of a satellite $V_0 = \sqrt{gR}$ and escape velocity $V_e = \sqrt{2gR}$ where R = Radius of earth. i.e. $V_e = \sqrt{2}V_0$ i.e. escape velocity is $\sqrt{2}$ times the orbital velocity.

There if the orbital velocity of a satellite is increased to $\sqrt{2}$ times (increased by 41%), the satellite will leave the orbit and escape