**CHAPTER # 11**

**HEAT**

**DEFINITION: -**

Heat is a form of energy which is transferred from one body into another body by virtue of temperature difference between them.

Once it is transferred to the cold body it becomes a part of its internal energy.

**TEMPERATURE**

**DEFINITION: -**

Hotness or coldness of an object is expressed in terms of a quantity called Temperature.

According to Kinetic Molecular Theory:

“It is the average Kinetic Energy of the molecules of an object.”

Heat determines the direction of flow of heat from one body to another, when they are bought in thermal contact with each other.

**DIFFERENCE BETWEEN HEAT & TEMPERATURE**

|  |  |
| --- | --- |
| **HEAT** | **TEMPERATURE** |
| **Definition:**  Heat is a form of energy which is transferred from one body into another by the virtue of temperature difference between them. | **Definition:**  Hotness or coldness of an object is measured in terms of quantity called Temperature. |
| **In Terms of K.M.T:**  Heat is the measure of Total kinetic energy of molecules. | **In Terms of K.M.T:**  Temperature is the measure of average kinetic energy of molecules. |
| **Unit:**  The S.I unit for the heat is Joule. It is also measured in calories. | **Unit:**  The S.I unit for temperature is Kelvin. It is also a measured in and . |
| **Measurement:**  It is measured by a derive called Calorimeter. | **Measurement:**  It is measured by Thermometer. |

**THERMOMETRIC PROPERTIES**

**DEFINITION: -**

Property of a substance which changes uniformly with the change of temperature is named as thermometric property.

**Examples:**

1. The volume of liquid in a vessel.
2. The volume of fixed mass of a gas at constant pressure.
3. The electric resistance of metals.

**THEROMOMETER**

**DEFINITION: -**

The device which is used in the measurement of temperature is called as thermometer.

* An ordinary mercury thermometer is made up of glass capillary tube having a uniform bore.
* One end of the tube is closed while the other end is provided with a glass bulb filled with mercury. It works on the principle that “Mercury expand linearly on heating.”
* As the bulb of thermometer is placed in contact with a hot body, the mercury expands and rises higher in the capillary. Thus height of the mercury in the capillary can be used as a measure of temperature of a body.

**SCALES OF TEMPERATURE**

To select the scales of thermometer two fixed points are taken.

1. Ice point or lower fixed point.
2. Steam point or upper fixed point.

**CELSIUS SCALE OF TEMPERATURE**

In this scale the lower fixed point is taken at 0 (zero) and upper fixed point is taken as 100 at . The interval between these points is divided into 100 equal parts. Each part measures .

**KELVIN SCALE OF TEMPERATURE**

In this scale the lower fixed point is taken as . The upper fixed point is the temperature of the steam at one atmosphere pressure. It is marked at . The interval between these points is divided into 100 equal parts, each part measures .

* The zero of this scale marked starts from . This is the lowest temperature ever reached. That’s why this temperature is called absolute zero.

**FAHRENHEIT SCALE OF TEMPERATURE**

The lower fixed point on this scale is marked at and the upper fixed point is marked at , which is the temperature of the steam or boiling point of water at . The interval between these points is divided into 180 equal parts. Each part measures .

**CLINICAL THERMOMETER**

**DEFINITION: -**

A clinical thermometer is used to find the temperature of human body by placing the bulb under the tongue or in the armpit.

**CONSTRUCTION: -**

1. The clinical thermometer has a small bulb for convenience of use.
2. It has a limited range of calibration usually to .
3. The glass stem of the clinical thermometer has a narrow bend or constriction in its capillary bore near the mercury bulb.

Following figure illustrates the idea:

**WORKING: -**

When the patient’s body temperature warms the thermometer the mercury expands and rise into the capillary to indicate the temperature of the body. When the thermometer is removed from the patient it cools and mercury contracts. However the constriction prevent that part of the mercury from returning to the bulb. Therefore the mercury thread above the constriction, thus remain in the stem for reading the thermometer at leisure.

**THERMAL EXPANSION**

**DEFINITION: -**

“The expansion of a substance on heating is called thermal expansion.”

**OR**

“The increase in the dimensions of a substance by adding heat is known as thermal expansion.”

**MOLECULAR VIEW OF THERMAL EXPANSION**

When temperature is increased, the molecules of a substance vibrates with a greater amplitude. This increase the average distance between the molecules and consequently the object expands.

**LINEAR THERMAL EXPANSION**

**DEFINITION: -**

Increase in length due to rise in temperature is called linear thermal expansion.

**EXPLANATION: -**

Consider a metallic rod of original length “”. If there is change in length as a result of the change in temperature then it has been experimentally observed that the increase in length is directly proportional to the initial length or original length and change in Temperature i.e.

And

By combining (i) and (ii)

Here, is called a constant called “co-efficient of linear expansion”

and

may be written as:

**CO-EFFICIENT OF LINEAR EXPANSION**

Co-efficient of linear expansion is defined as:

“The change in length per unit original length per degree vise in temperature.”

**OR**

“It is also defined as the fractional change in length per degree vise in temperature.”

**UNIT OF CO-EFFICIENT OF LINEAR EXPANSION**

Other units are and

It depends upon the nature of substance.

**VOLUME THERMAL EXPANSION**

**DEFINITION:**

Increase in volume due to increase in temperature is called volume thermal expansion.

**EXPLANATION: -**

Consider a metallic body of original volume . If there is a change in volume as a result of the change in temperature, then it has been experimentally observed that change in volume is directly proportional to the initial or the original volume and change in temperature i.e.

By combining (i) and (ii)

Here,

is the constant called the co-efficient of volumetric expansion.

**CO-EFFICIENT OF VOLUMETRIC EXPANSION**

Co-efficient of volume expansion is defined as:

“The change in volume per unit original volume per degree vise in temperature.”

**OR**

“fractional change in volume per degree vise in temperature.”

**UNIT: -**

Other units are

* It depends upon nature of substance.

**RELATION BETWEEN AND**

**DERIVATION: -**

Consider a block of dimensions, , and . The volume of the block at intial temperature is given as:

When the temperature of the block is raised by , then its new dimension are given by:

The new volume of block is given by:

**or**

**CONCLUSION: -**

From the above relation it is clear that “The co-efficient of volume expansion is three time the coefficient of linear expression.”

**BIMETALLIC STRIPS**

**DEFINITION: -**

When two metallic strips are whose co-efficient of linear expansion differ widely from one another are rigidly fixed with one another, then this constitutes a bimetallic strips.

**WORKING: -**

When such a strip is heated it bends in such a way that the metal having a larger co-efficient of linear expansion lies on the outside of the curved bend as shown in the figure.

**APPLICATIONS OF BIMETALLIC STRIPS**

Bimetallic strips are used in many devices some of which are:

1. Bimetallic thermometer.
2. Bimetallic thermostat.
3. Bimetallic five alarm.

**BIMETALLIC THERMOMETER**

**CONSTRUCTION: -**

1. It consists of a bimetal strip in the form of a long spiral.
2. One end of the spiral is kept fixed while a light pointer is attached to the other following figure illustrates the idea.

**WORKING: -**

When the temperature rises, the bimetal strip coils itself into an even tighter position due to different expansion rates of the two metals which forms the bimetal strip and the pointer moves across the temperature scale.

**THERMOSTAT**

Thermostats are devices which control temperature in a certain space e.g. in refrigerators, electric ovens etc.

**CONSTRUCTION: -**

The essential parts of a thermo met are shown in the diagram.

**WORKING: -**

1. As the temperature of the air inside the room rises, the bimetal strip bends and the electric contact is disconnected. This switches off the heater.
2. When the room temperature falls the bimetal strip cools and straightens.
3. As the contacts touch each other, the heater is switched on again. In this way the thermostat switches the heater on and off to keep the room at a more or less steady temperature.

**FIRE ALARM**

It is used to warm about the fire due to temperature rise.

**CONSTRUCTION: -**

1. One end of a bimetal strip is firmly fixed while the other end is free.
2. One terminal of a battery is connected to the fixed end of the bimetal strip through a bulb or an electric bell.
3. The other terminal of the battery is connected with a metallic contact which is just above the free end of the strip.

**WORKING: -**

1. When a fire starts heat energy released raises the temperature of the bimetallic strips.
2. The free end of the strip bends towards the contact, and on touching it electric current flows through the circuit.
3. The bulb therefore, lights up or in case of a bell it rings to signal a warning about fire.

**GAS LAWS**

**Introduction: -**

The behavior of a gas can be described with the help of four variables i.e. the pressure, volume, temperature and mass. The laws which tells us how these variables are related are known as gas laws.

**BOYLE’S LAW**

**Statement: -**

“The volume of a fixed mass of a gas is inversely proportional to its pressure provided that the temperature is kept constant.”

**Mathematically: -**

For initial state of a gas

For final state of the gas

Comparing eq. (i) & (ii)

**Statement in terms of mass: -**

“Pressure of the gas is directly proportional to the mass of the gas provided that the temperature and volume of the gas are kept constant.”

**Mathematically: -**

The above equation can be also be written as:

**Graphical Representation: -**

**CHARLE’S LAW**

**STATEMENT:**

“For a fixed mass of a gas at constant pressure, the volume of the gas is directly proportional to its absolute temperature.”

**MATHEMATICALLY:**

For initial state of a gas,

For final state of a gas

Comparing eq. (i) & (ii)

**Graphical Representation:**

* Volume of the gas is directly proportional to the absolute temperature.

∴ The graph between V and T is a straight line.

* If the line of graph is extra platted to lower temperature, it meets the temperature axis at . It means that if a gas is cooled to its volume becomes zero. [Practically it is not possible]

∴ is considered as “Absolute zero”.

**GENERAL GAS EQUATION**

**DEFINITION: -**

The combined form of Boyle’s law and Charle’s law in which neither Temperature nor pressure is constant is called General Gas Equation.

**DERIVATION: -**

According to Boyle’s law:

And according to Charle’s law:

Combining eq. (i) & (ii)

For initial state of a gas

For final state of a gas

Comparing (a) & (b)

The value of constant depends on the no. of moles of the gas. For one mole of a gas, the constant particular name called Universal gas constant it is denoted by ‘R’. For ‘n’ mole of a gas.

This equation is called **General Gas Equation**

Here,

For ‘n’ moles of a gas for initial state.

For final state

**HEAT CAPACITY**

**DEFINITION: -**

Heat capacity of a substance is defined as:

“The quantity of heat required to produce unit temperature change.”

**MATHEMATICALLY:**

Here,

**UNIT: -**

The unit of heat capacity is or .

**SPECIFIC HEAT CAPACITY**

**DEFINITION: -**

“Amount of heat required to raise the temperature of unit mass of a substance through .”

**EXPRESSION: -**

If is the amount of heat added to raise the temperature of of a substance through , then

And,

Combining above two equations

Here,

C is a constant, known as specific heat capacity.

**UNIT OF SPECIFIC HEAT CAPACITY**

As we know that

**LAW OF HEAT EXCHANGE**

This law was first put forward by Prevost. According to this law:

“When two bodies at different temperature are mixed or brought in thermal contact with each other than the quantity of heat lost by hot body is equal to the quantity of heat gain by the cold body.”

**Mathematically:**

Here,

And,

**DETERMINATION OF SPECIFIC HEAT OF A SOLID SUBSTANCE**

**CALORIMETRY:**

The branch of physics which is concerned with the measurement of heat is called calorimetry.

**CALORIMETER:**

Calorimeter is an instrument which is used to measure the specific heat.

**MEASUREMENT OF SPECIFIC HEAT (METHOD OF MIXTURE)**

**PROCEDURE:**

Some water is taken in calorimeter and the substance whose specific heat is required heated to unknown temperature and dropped into the water of calorimeter. The hot substance loses some heat, while the water and calorimeter gain some heat. The masses if water, calorimeter and the given substance should be measured previously initial and final temperature of water, calorimeter and the given substance noticed correctly. By these measurement specific heat of given substance can be determine by using following calculations.

**CALCULATIONS:**

**Heat gained by water:**

Let,

mass of water =

Initial temperature of water =

Final temperature of water =

rise in temperature of water =

specific heat of water = =

**Heat gained by calorimeter:**

Let,

mass of calorimeter =

Initial temperature of calorimeter =

Final temperature of calorimeter =

rise in temperature of calorimeter =

specific heat of calorimeter =

**Heat lost by Given Solid:**

Let,

mass of given solid =

Initial temperature of given solid =

Final temperature of given solid =

fall in temperature of solid =

specific heat of given solid =

According to law of heat exchange:

**TRANSMISSION OF HEAT**

Heat transfer from hot body to cold body or from one place to another because of difference of temperature. There are three different modes of heat transfer,

1. Conduction
2. Convection
3. Radiation

**CONDUCTION**

“Conduction is the process in which heat is transferred from one part of the body to the another part by the interaction of electrons and molecules.”

**EXPLANATION: -**

When the body is heated by using heating source, its temperature rises at the heating place. Due to this rise in temperature, the average kinetic energy of atoms increases. The atoms in the body begin to vibrate with greater amplitude with the rise in temperature about their mean positions. This results in the collision of atoms and the heat absorbed by an atom is transferred to the neighboring atoms through collision.

**EXPERIMENT: -**

A long metal bar is covered with a thin layer of wax at one end of bar. The wax coated end is heated by placing it under a thin layer of wax at one end. The wax coated end is heated by placing it under a flame. This end absorbs heat energy and as a result wax begins to melt. As the time passes on, the melting starting at the hot end goes further and further along the wax coated length of the rod.

**CONCLUSION: -**

This experiment of wax coated bar shows that the heat is carried continuously from the hot end towards the cold end of the rod.

**GOOD CONDUCTORS OF HEAT**

The rate of transmission of heat depends on the nature of the substance. Some substances are quickly heated by this process.

All metallic solids except mercury which is liquid are good conductors of heat. As metallic solids have pressure of free electrons which move throughout the body of the metal therefore, conducts heat. For example Iron, aluminum, copper etc.

**POOR CONDUCTORS OF HEAT**

The substances which do not conduct heat easily from one point of the body to another are termed as poor conductors of heat.

For example: Glass, wood, asbestos, rubber and plastic etc.

**BAD CONDUCTORS OF HEAT**

Bad conductors are the substances which do not conduct heat from one end of the body to another. They are also called thermal insulators. A wooden stick can burn at one end leaving the other end relatively cold.

**EXPERIMENT SHOWING THE ABILITY OF DIFFERENT SUBSTANCES TO CONDUCT**

Water is heated in a container which have various types of rods supported by cork, initially coated with a thin layer of wax. The mode of heat transfer is mainly conduction, downwards along the rods. The melted length of the coated wax along a rod gives its ability to conduct.

* **OBSERVATION:**

The melted portion of wax is maximum along copper rod and minimum along the wooden and glass rods.

* **CONCLUSION:**
* Wood and glass are good insulators.
* Copper is the best conductor of heat.

**CONVECTION**

“Convection is the transmission of heat due to actual movement of molecules of the substance from one place to the other.”

**EXPLANATION:**

The fluid receives heat directly from the source and gets heated. It expands, become lighter and therefore rises up. The circulation of fluid sets up convention current. The same process holds in the boiling of water which is taken in electric kettle. The heater of the kettle is normally placed near the bottom of the kettle so that as the water lying at the bottom of kettle is heater, it expands and get lighter there by rises up and the cooler section of water being denser moved down and heated. This process is repeated due to convection set up until the whole water reaches the boiling point.

**EXAMPLES SHOWING TRANSFER OF HEAT IN CONVECTION:**

* Take flask containing water. Now add a large crystal of of the water. The flask is heated colored streaks of water rise up. It is because the fact that the water at the bottom gets heated expands and becomes lighter and hence goes up along the sides of vessel. Water from the sides of the flask being somewhat denser reaches the bottom, gets heated and rises up, thus forming colored streaks.
* Take a candle and fix it at the bottom of a cylinder as shown in figure. Light the candle. It will found that the flame becomes weaker and weaker and finally gets extinguished. It is due to the fact that by burning of the candle, the air in the cylinder gets heated, expands and is pushed out. Now take a card board and hold it inside the cylinder dividing the space above the candle into two parts. Again light up the candle. It will continue to burn. Here, the air above the flame gets heated and goes up through one of the sides of the cards board. The fresh air moves in through the other side, forming convection currents and so the candle continues to burn.

**RADIATION**

Radiation is the process of heat transmission in which heat energy is transferred from one place to the other in the form of waves without affecting the medium.

**EXPLANATION: -**

All the objects emit energy at all temperatures from their surfaces.

**RADIANT ENERGY**

The energy emitted and carried through radiation is called radiation energy. The radiant energy is carried by electromagnetic waves.

**Example:**

A hot piece of metal gives off light. Its color depends on the temperature of the metal, going from red to yellow to white as it becomes hotter and hotter. The light emitted corresponding to different colors is a part of electromagnetic waves. At room temperature most of the radiation is found in infrared region.

Light of every color (from infrared to ultraviolet), radio and TV waves, microwaves and x-rays are all electromagnetic waves. The difference lies in their frequencies and wave length.

**THERMAL CONDUCTIVITY**

“The ability of a substance to conduct heat is called thermal conductivity.”

This ability is the measure of thermal conductivity of a substance, which is a thermal property of a substance.

**EXPERIMENT:**

Consider a slab of thickness with opposite faces each of area A maintained at temperature and so that .

Heat is conducted in the direction of fall of temperature across the thickness of the slab. It is found experimentally that the heat conducted across the two faces varies as:

Where, is the time interval of heat flow and is the constant called the co-efficient of thermal conductivity.

**VALUE OF CO-EFFICIENT OF THERMAL CONDUCTIVITY**

It is numerically equal to the amount of heat flowing per second across the opposite faces of a cube of unit size whose faces are maintained at a difference of temperature equal to or .

Following are the factors on which coefficient of thermal conductivity depends:

**NATURE OF SUBSTANCE:**

Coefficient of thermal conductivity depends upon nature of substance.

* It is large for metals and small for non-metallic solids, liquids and gasses.

**UNIT:**

In S.I unit of system, the unit of thermal conductivity is .

**PRACTICAL APPLICATION OF CONDUCTION OF HEAT**

1. **ICE BOX:**

Ice box has a double wall, made of tin or iron. The space between the two walls is filled with cork or felt which is poor conductor of heat. They prevent the flow of outside heat into the box, thus keeping ice away from melting.

1. **WOOLEN CLOTHES:**

Woolen clothes have fine pores filled with air. Air and wool are bad conductors of heat. Thus the heat from the body does not flow out to the atmosphere. Thus the woolen clothes keep the body warm in winter.

1. **DOUBLE DOORS:**

In cold countries windows are provided with double doors. The air in the space between the two doors forms a non-conducting layer and so heat cannot flow out of room.

1. **TIGHTLY FITTED STOPPER:**

When a stopper, fitted tightly to the bottle is to be remained, the neck of the bottle is gently heated. It expands slightly on heating. Since glass is bad conductor of heat, the heat does not reach the stopper. Thus it can be removed safely and easily.

1. **DAVY’S SAFETY LAMP:**

It is one of the most important applications of conduction of heat. The principle of Davy’s Safety lamp can be understood by following simple example.

* The wire gauze is placed over a Bunsen burner. The gas coming from the burner is lit above the wire gauze. A flame appears at the top surface of wire gauze. The gas coming out of the burner below the wire gauze does not get sufficiently heat for ignition. The reason is that the wire gauze conducts away the heat of the flame above it and so the temperature at the lower surface of the gauze does not reach the ignition point.
* In Davy’s safety lamp, cylindrical metal gauze of high thermal conductivity surrounds the flame as show in figure (b). when this lamp is taken inside a mine, the explosive gases present in the mine are not ignited because the wire gauze in the form of cylinder conducts away the heat of the flame of the lamp. The result is that the temperature outside the gauze remains below the ignition point of the gasses. In the absence of the wire gauze, the gases outside can explode.

**PRACTICAL APPLICATION OF CONVECTION OF HEAT**

1. **Ventilation: -**

From health point of view energy living room of a building should be provided with ventilators near the ceiling. Due to respiration of the persons sitting or sleeping in the room, the air in the room gets warmer and hence is less dense. If rises up and goes outside through the doors and windows. Thus a convection current of air is warm trained.

1. **Trade Winds: -**

At the equator the surface of the earth gets heated more than at the poles. These results in the movement of the warm air from the equator to the poles the cold air from poles moves towards the equator. Because of the rotation of Earth (from west to east) the air in the Northern Hemisphere seems to be coming from north-east instead from north. In the south Hemisphere the air from the South Pole appears to be coming from north, in the South Hemisphere. These winds are called trade winds because in old days these winds were used by traders for sailing their ships.

1. **Land and Sea Breezes: -**

Land is better conductor of heat than water. Hence in day time land gets hotter in the sea. The air above the land becomes warm and rises up being lighter and somewhat cold air above sea surface moves towards the sea shore. This is known as sea breeze thus convection current fair our set up.

During night land becomes cooler than water and so the warm air over the surface of water in the sea rises up. The air on the land near the sea shore begins to move towards sea side and is called land breeze.

**APPLICATION OF HEAT RADIATION**

Differential air Thermo scope is an important application of radiation of heat.

**CONSTRUCTION: -**

* It consists of two identical glass bulbs A and B, which are connected by a narrow glass tubing having the shape of U-tube.
* The space above the levels of tube contains air.
* When the bulbs are at the same temperature there is no difference in the level of the acid in the limbs.
* The bulb A is coated with lamp black so that it may completely absorb the heat radiation falling on it.

**WORKING: -**

Now the bulb ‘A’ is exposed to heat radiation. It absorbs whole of the radiation falling on it, as a result the air in the bulb A gets heated, expands and passes down the acid in the limb. Thus we have a difference in the level of the liquid in the two limbs.

**ADVANTAGES OF THERMO SCOPE**

It is very sensitive and can detect radiation of very weak intensity for example radiation coming from a distant candle.

**BOY’S RADIO MICROMETER**

It is also a very sensitive device, used as an application of radiation.

**CONSTRUCTION: -**

It is a combination of a moving coil galvanometer and a thermo couple. It consists of a single loop of silver or copper wire A. the lower ends the wire are soldered to a copper disc which is coated with lamp black.

**WORKING: -**

The disc is exposed to heat radiation and as a result thermoelectric current is produced in the couple made of bismuth and antimony and beings to flow in the wire A. hence we get a current in the galvanometer. The deflection product in the galvanometer can be measured by using lamp and scale arrangement.

**ADVANTAGE OF BOY’S RADIO MICROMETER**

It can detect heat radiation of very weak intensity for example radiation coming from a distant candle.

**LATENT HEAT**

“The amount of heat supplied, or removed from (to) a matter, changing its state thereby maintain constancy of temperature is called Latent Heat.”

**OR**

“The amount of energy (Heat) in transit that changes the state of matter at constant temperature is called Latent Heat.”

**EXPLANATION: -**

* In general, when heat is added to a material, it’s temperature rises.
* If, ice cube is heated from , its temperature rises as a result, but at . Further increase in heat supply does not raise the temperature, until it liquefies.
* This is known as Melting point for ice. This amount of heat added to the ice at constant temperature is called Latent heat of Fusion.
* **LATENT HEAT OF FUSION**

“it is the amount of heat Energy needed to melt of ice at completely to of water at . (i.e. without changing its temperature) is called Latent Heat of Fusion.”

* Experimental value of Latent Heat of Fusion of ice is .

**MATHEMATICAL EXPRESSION:**

* The same amount of heat is required to be removed, if water at is being converted to of ice.
* For, water, further addition of Heat would again raise its temperature. But, at , further addition of heat would rather convert water state to gaseous state without changing its temperature.
* This amount of heat is called Latent Heat of Vaporization, and is said to be the boiling point of water.
* **LATENT HEAT OF VAPORIZATION**

“The amount of heat required to change water at its boiling point to steam without changing temperature is called Latent Heat of Vaporization.”

* Experimental value of Latent Heat of Vaporization for water is .

**LAWS OF FUSION**

1. Every substance changes its state form solid to liquid at a particular temperature (at normal pressure).
2. During the change of state, the temperature remains constant.
3. One kilogram of every solid substance needs a definite quantity of heat energy to change its state from solid to liquid. It is also called the latent heat of fusion of a substance.
4. Mostly substances shows an increase in their volumes on melting, while a few substance show decrease in volume on melting.
5. Melting points of those substances which show decrease in their volumes on melting are lowered with the increase of pressure whereas melting points of those substances which show an increase, their volume are increased with increase of pressure.

**CHAPTER # 12**

**WAVES AND SOUND**

**PERIODIC MOTION: -**

Any motion that repeats itself in equal intervals of time is called periodic motion.

**OSCILLATORY OR VIBRATORY MOTION**

When a body repeats its motion about its mean position then its motion is known as OSCILLATORY or Vibratory Motion.

**Examples: -**

* Motion of a swing
* Motion of a pendulum
* Atoms in solid
* Sitar’s string when plucked

**SIMPLE HARMONIC MOTION**

Simple harmonic motion is the particular type of periodic motion in which acceleration of the vibrating body is always directed towards its mean position (or equilibrium position) and also the acceleration of the vibrating body is directly proportional to the displacement of the vibrating body from its equilibrium position.

**MATHEMATICAL EXPRESSION:**

**COMMON TERMS**

**VIBRATION: -**

One complete round trip of the body is called vibration.

**TIME PERIOD: -**

Time required to complete one vibration is called time period.

**AMPLITUDE: -**

It is the maximum displacement of a body on either of its equilibrium position.

**OR**

The maximum distance of a vibrating body from its equilibrium position is known as Amplitude.

**Frequency: -**

it is the no. of vibration completed in one second. It is represented by .

**DISPLACEMENT: -**

The distance of the vibrating body from its equilibrium position at any instant is known as displacement.

**SIMPLE PENDULUM: -**

An ideal simple pendulum consist of a spherical bob suspended by a weightless, flexible and inextensible string tied to a rigid, fixed and frictionless support.

**TIME PERIOD OF A PENDULUM: -**

The time period of a pendulum is given by the formula:

Where,

**SECOND PENDULUM: -**

The pendulum which takes two seconds to complete one vibration is called second pendulum.

**RELATION BETWEEN TIME PERIOD AND FREQUENCY**

The Time period is related to the frequency by the relation.

**MASS ATTACHED TO THE SPRING PERFORMING SIMPLE HARMONIC MOTION**

Consider a block of mass ‘m’ attached to one end of the horizontal spring and placed on a smooth horizontal surface. When a block is given a small displacement to the right, applied force is given as,

Where,

The above expression is the mathematical form of HOOK’S LAW which states that,

Extension of an elastic solid is directly proportional to the applied force provided that the force remains below the elastic limit. But in the discussion of S.H.M we are usually interested in the restoring force which is defined as “The internal force of the system which returns or tends to return the system to its original shape or mean position.”

Restoring force is always equal and opposite to that of applied force.

When the block is released it performs vibratory motion under the influence of elastic restoring force.

The net force acting on the block is given by according to Newton’s second Law of Motion as,

Where,

The above relation is the mathematical form of Simple Harmonic Motion.

Hence by the definition the motion of the block is S.H.M.

Diagrammatical representation of mass attached to spring performing (S.H.M)

**SIMPLE HARMONIC OSCILLATOR**

The particle or object which performs simple harmonic motion is known as Simple Harmonic Oscillator.

**TIME PERIOD OF THE MASS ATTACHED TO THE SPRING**

The time period of the mass attached to the spring is given as:

Where,

**RESONANCE**

**DEFINITION: -**

When the frequency of the driving force is exactly equal to the natural frequency of the oscillator then the driving force impart the maximum energy to the oscillator resulting in considerable increase in amplitude of vibration such phenomena is called as resonance.

**OR**

It is defined as a phenomenon in which there is remarkable increase in the amplitude of a body when the period of the force applied to it is equal to its natural time period.

**EXAMPLES:**

1. **SWING:** An interesting example of Resonance is that of swing while enjoying a swing we apply force by the special movement of our body at a particular position in every vibration. The result is increase in the amplitude of the swing.
2. **SUSPENSION BRIDGE:** While crossing the suspension bridge soldiers are ordered no to march in steps but to break their steps. The reason is that the bridge receives periodic impulses by regular footsteps. If the time period of the periodic impulses become equal to the natural time period of the bridge then a vibration of dangerously large amplitude produced by which the bridge may collapse.

**WAVE**

**DEFINITION: -**

Travelling disturbance is called a wave.

**OR**

A wave motion is a means of transferring energy from one point to another without there being any transfer of matter between the points.

**OR**

The mechanism of energy transfer by the wave is known as wave motion.

**TRANSVERSE WAVES**

**DEFINITION: -**

These are the waves in which particles of the medium vibrate in a direction perpendicular to the direction of the propagation of the waves.

**DIAGRAMMATICAL ILLUSTRATION:**

**GRAPHICAL REPRESENTATION:**

**CREST: -**

The portion of the wave in which the particles of the medium are higher than their normal position is called CREST.

**TROUGH: -**

The portion of the wave in which the particles of the medium are lower than their normal position is called trough.

**LONGITUDINAL WAVES**

**DEFINITION: -**

These are the wave in which the particles of the medium vibrate in a direction parallel to the direction of the propagation of the waves.

**DIAGRAMMATICAL ILLUSTRATION:**

**COMPRESSIONS: -**

The points where the crowding of particles of the medium is maximum are known as compressions.

**RAREFACTIONS: -**

The points where the distance between the particles is maximum are known as expansions or rarefactions.

For compressions and rarefactions following figure illustrates the idea.

**CHARACTERISTICS OF A WAVE**

**WAVE LENGTH**

**DEFINITION: -**

The distance between similar position of two consecutive crests or troughs is called wave length.

**OR**

The distance between similar position of two consecutive compressions or rarefactions is known as wavelength.

**SYMBOL: -**

It is denoted by a Greek Letter .

**UNIT: -**

It is measured in .

**AMPLITUDE (A)**

**DEFINITION: -**

The maximum displacement of a particle from its rest position is called the amplitude of the wave. It is denoted by A or .

**TIME PERIOD (T)**

**DEFINITION: -**

The Time period is the time taken for any particle to undergo a complete oscillation.

**OR**

The Time period is the time required for the wave to have travel a distance of one wavelength.

**FREQUENCY**

**DEFINITION: -**

The frequency ‘f’ of the waves is defined as the number of waves generated by a source in one second.

**OR**

Frequency is also defined as the number of vibrations completed by a vibrating particle in one second.

**UNIT: -**

Its unit is or

**DISPLACEMENT**

**DEFINITION: -**

The particular distance of the vibrating particle in any instant of time is known as displacement. It is denoted by ‘X’.

For wave length, time period and Amplitude following figure illustrates the idea.

**RELATION BETWEEN FREQUENCY, WAVE LENGTH AND VELOCITY**

Let the velocity of the wave be and the wave length be and the frequency of the wave be .

The Time required to complete one vibration is called time period and it is represented by . The no. of vibrations completed by a particle in one second is known as frequency of the wave. If the frequency of the wave is then the particle complete vibration in one second. Therefore one vibration is completed in second and this is the time period .

Since the wave travel a distance which is equal to the wave length during the time period then the velocity of the wave is given as:

By using relation,

Hence we have,

**CONCLUSION: -**

The above expression shows that the velocity of the wave is equal to the product of the frequency and wavelength.

|  |  |
| --- | --- |
| **TRANSVERSE WAVES** | **LONGITUDINAL WAVES** |
| **DEFINITION:**  These are the waves in which particles of the medium vibrate in a direction perpendicular to the direction of the propagation of the waves. | **DEFINITION:**  These are the waves in which particles of the medium vibrate in a direction parallel to the direction of the propagation of the waves. |
| **DIAGRAMMATICAL ILLUSTRATION:** | **DIAGRAMMATICAL ILLUSTRATION:** |
| **CREST:**  The position of the wave in which particles of the medium are higher than their normal position is called CREST. | **COMPRESSIONS:**  The points where the crowding of particles of the medium is maximum are known as compressions. |
| **TROUGH:**  The portion of the wave in which particles of the medium are lower than their normal position is called trough. | **RAREFACTIONS:**  The points where the distance between the particles is maximum are known as rarefactions. |
| **GRAPHICAL REPRESENTATION:** | **GRAPHICAL REPRESENTATION:**  These waves are represented in the same graphical fashion as the transverse waves. |
| **WAVE LENGTH :**  The distance between similar position of two consecutive crests or troughs is called wave length. | **WAVE LENGTH :**  The distance between similar position of two consecutive compressions or rarefactions is known as wave length. |
| **EXAMPLES:**   1. Wave along a rope 2. Water waves | **EXAMPLES:**   1. Sound waves |

**REFLECTION OF WAVES**

**DEFINITION: -**

The bouncing back of a wave from a surface is called reflection of the wave.

**EXPLANATION: -**

1. Waves coming from the source and hitting an obstacle are called incident waves.
2. The waves which seem to originate from the obstacle are termed as reflected waves.
3. Both incident and reflected waves have the same frequency because they are produced by the same source in the same medium.
4. The angle at which the wave is reflected is equal to the angle at which the wave is incident on the surface.

Following figure illustrates the idea

**INTERFERENCE**

**DEFINITION: -**

If two waves are in the same place at the same time. They produce an effect which is equal to the combined effect of the two waves in accordance with the principle of superposition which says that at those points where the waves meet the net amplitude of the combined wave will be the algebraic sum of the displacement of the two separate waves.

**EXPLANATION: -**

When ‘n’ waves travel through the medium simultaneously along the same line the net displacement of each particle is given by

Where,

are the individual displacement caused by each of the ‘n’ waves.

**ANOTHER DEFINITION OF INTERFERENCE**

When the particles of a medium are simultaneously disturbed by two waves then under suitable conditions, they enhance the effects of each other at some points and cancel at others. This phenomenon is known as interference.

**TYPES:**

There are two types of interference.

1. Constructive interference
2. Destructive interference

**CONSTRUCTIVE INTERFERENCE**

**DEFINITION: -**

The type of interference in which waves support each other is known as constructive interference. In constructive interference crest of one wave falls on the crest of another wave and trough of one wave falls on the trough of another wave. This is illustrated in the following figure:

**DESTRUCTIVE INTERFERENCE**

The type of interference in which waves cancel the effect of each other is known as destructive interference. In destructive interference crest of one wave falls on the trough of another wave and trough of one wave falls on the crest of another wave. This is illustrated in the following figure:

If a crest from one source is superposed on a trough of equal amplitude from the other source a region of zero resultant disturbance is created as shown.

**STATIONARY WAVES**

**DEFINITION: -**

These are the waves under the influence of which particles of the medium vibrates in such a manner so that the motion of the wave is not visible through the medium. Stationary waves are setup in a medium as a result of superposition of two exactly similar waves of same frequency, amplitude and wave length travelling along the same line but in opposite direction.

**EXPLANATION: -**

Consider a string which is kept stretched by clamping its two ends. When the string is plucked at its middle two transverse waves originate from this point. One wave travel towards the right and other one travel towards the left end of the string. After reflection from the clamps end and then super position stationary waves are formed as shown:

**ANTINODES**

The points where the particles of the medium vibrates with the greatest amplitude are known as Antinodes denoted by A.

These are the points of constructive interference.

**NODES**

The points where the particles of the medium do not vibrate (have zero amplitude) are known as Nodes denoted by ‘N’.

These are the points of destructive interference.

**SEGMENT OR LOOP**

It is the distance between any two consecutive nodes or antinodes, equal to half wave length .

**SOUND**

**DEFINITION: -**

Sound is usually defined as any longitudinal wave traveling through a material in such a way that it is capable of setting the human eardrum into motion thereby giving rise to the sensation of hearing.

**OR**

Sound is a form of energy which is produced by a vibrating body.

**THINGS NECESSARY FOR PRODUCING SOUND**

Two things are necessary for producing sound.

1. Vibrating body.
2. Some material medium (e.g. water, air etc.)

**TYPES OF SOUND WAVES ON THE BASIS OF FREQUENCY**

1. **AUDIBLE SOUND: -**

The sound waves which have frequency between to are able to produce sensation in the auditory system of human beings such sound waves are called as audible sound.

1. **INFRA SONIC SOUND: -**

The sound waves which have frequency below are called as infra sonic sound.

1. **ULTRA SONIC SOUND: -**

The sound waves which have frequency above are called as ultra-sonic sound.

**GENERATION OF SOUND WAVES**

A sound is produced when we strike a tuning fork with a rubber pad and its prongs start vibrating as shown below.

(For the sake of simplicity motion of one prong is shown)

Generation of sound waves is explained as consider the right prong of the tuning fork which is vibrating between the positions A and B when the prong moves from A to B it compresses the adjacent layer of air to the right thus creating a region of increased air pressure called compression. This compression travel outs through the air and a wave of compression moves forward.

When the prong moves from B to A. The pressure of the adjacent layer of air to right decreases. This region of decreased air pressure is called rarefaction. This disturbance travel outs through the air there fore sound waves producing by a vibrating body consist of alternate low and high air pressure region. Following figure illustrates the idea:

**MUSICAL SOUND**

The sound which produces pleasant effect on our ear is called as musical sound.

**OR**

A pleasing sensation in the ear due to sound waves is called a musical sound.

**FREQUENCY CURVE**

Musical sound with a regular symmetric fluctuation, periodic pattern which produces a smooth pleasant sensation as shown as:

**EXAMPLES: -**

1. Sound produced by a tuning fork.
2. Sound produced by blowing into an organ pipe.
3. Sound produced by plucking the string of a sitar and violin.

**NOISE**

The sound which produces unpleasant effects on our ear are called as noise.

**OR**

A unpleasing sensation in the ear due to sound is called a noise.

**OR**

Sound waves with an irregular, non-symmetric random fluctuations producing disagreeable sensation called noise.

**FREQUENCY CURVE**

**EXAMPLES: -**

1. Sound of hammering.
2. Clapping of hands.
3. Sound from a factory.
4. Sound of wheels on applying the brakes.

**CHARACTERISTICS OF MUSICAL SOUND**

Following are the characteristics of musical sound.

1. Loudness
2. Pitch
3. Quality

**LOUDNESS**

The characteristic of a sound through which a loud and a faint sound can be distinguished is called loudness.

**FACTORS ON WHICH LOUDNESS DEPEND**

The loudness of the sound depends upon the following factors.

1. Intensity of the sound waves.
2. Surface area of the vibrating body.
3. The amplitude of vibrating body.
4. Distance of the sounding body.
5. Direction of the wind.

**INTENSITY OF THE SOUND WAVES**

Loudness of sound depends upon the intensity of the sound waves. Intensity of sound waves is defined as “Energy transported by the sound waves each second through a unit area held perpendicular to the direction of sound waves is known as intensity of sound waves”.

**MATHEMATICAL EXPRESSION: -**

The S.I unit of Intensity is .

**SURFACE AREA OF THE VIBRATING BODY**

The larger the area of the vibrating object the louder the sound produced. For example the loudness of a school bell is large than that of a house bell because school bell has large surface area as compared to house bell.

**THE AMPLITUDE OF VIBRATING BODY**

The greater the amplitude of vibrating object the louder the sound produced. For example when we beat a drum force fully the membrane vibrates with large amplitude and a loud sound is produced.

**DISTANCE OF THE SOUNDING BODY**

Loudness depends upon the distance between the sounding body and the listener i.e. by increasing the distance of the sounding body from the listener the loudness is decreased and vice versa.

**DIRECTION OF WIND**

If you receive the sound travelling along the wind a louder sound is heard. But of sound is travelling against the wind a faint sound will be heard.

**PITCH**

The characteristic of sound by which a shrill sound can be distinguished from a grave one is called pitch of the sound.

**EXPLANATION: -**

Pitch of a sound depends upon frequency the greater the frequency the higher the pitch and lowers the frequency the lower the pitch. For example sound produced by a tuning fork of high frequency will be shrill while that by a fork of low frequency will be grave. Pitch is the sensation depending upon frequency.

**QUALITY OF SOUND**

It is that characteristic of sound by which we can distinguish between the two sound of the same pitch and loudness.

Dependence of quality of sound

1. It depends upon the resultant wave form.
2. Nature of the source of sound.

**EXPLANATION: -**

Our exact knowledge of sound quality is due to Helmholtz. According to him the difference in the sound produced by two notes of the same pitch and intensity is due to the difference in their resultant wave forms. The resultant wave form of any sound is obtained by combining the amplitudes of fundamental and over tones of the given sound.

Some of the wave forms are shown below.

**ECHO**

**DEFINITION: -**

The reflection of sound waves from an obstacle is called echo. **OR** The sound heard after reflection from a surface is called echo.

**CONDITION: -**

Echo can only be produced when the distance of the obstacle is at least .

**REASON: -**

It is because of a special characteristic of the human ear. When we hear a sound its impression remains in our ear for of a second. If the reflected sound reaches our ear in less than of a second the reflected sound merges with the original sound and no sound is heard.

**TO CALCULATE THE MINIMUM DISTANCE FOR THE PRODUCTION OF AN ECHO**

If the distance between the source and the obstacle is then the distance travel by the sound waves from the sound to an obstacle and back to the source is . Let be the time taken by the sound waves. If be the velocity of the sound waves then the relation b/w time, velocity and distance is given as:

As we know that:

And,

Put the value of S, t and V in eq. no (1)

Hence is the minimum distance required for the production of echo.

**INTERFERENCE OF SOUND WAVES**

**DEFINITION: -**

When two sound waves of the same frequency, wave length and amplitude superimpose on each other. They cancel the effect of each other at some point and reinforce the effect of each other at other points. This phenomenon is known as interference of sound waves.

**TYPES: -**

There are two types of interference.

1. Constructive interference.
2. Destructive interference.

**CONSTRUCTIVE INTERFERENCE**

The type of interference in which sound waves support each other so that the resultant sound is loudest is called constructive interference of sound waves.

In constructive interference compression of one wave falls on the compression of another wave and rarefaction of one wave falls on the rarefaction of another wave.

**DESTRUCTIVE INTERFERENCE OF SOUND WAVES**

The type of interference in which sound waves cancel the effect of each other so that no sound or a very faint sound is heard is called destructive interference of sound waves. In destructive interference compression of one wave falls on the rarefaction of another wave and rarefaction of one wave falls on the compression of another wave.

**BEATS**

**DEFINITION: -**

Beats is defined as the periodic variation in intensity at a given point due to superimposition of two waves having slightly different frequencies.

**OR**

When two sound waves that differ from one another in frequency by a very small number are heard together then sometimes we have a loud sound where the compressions (or rarefaction) of the two waves meet and at other time we hear a faint sound where the compression of one wave falls upon the rarefaction of the other wave. This phenomenon is called beats.

Following figure illustrates the idea

**BEATS FREQUENCY**

The number of beats per second is called beats frequency which is equal to the difference in the frequencies between the two sounds.

**MAXIMUM BEAT FREQUENCY FOR HUMAN EAR**

The maximum beat frequency that a human ear can defect is 7 beats per second.

**USES OF ULTRASONIC**

1. Ultra sonic waves can be used in echo- depth sounding devices to determine the depth of ocean floor. A since their wavelengths are much shorter than those of normal sound waves they penetrate deeper into the sea.
2. Radar cannot be used under the sea, as sea water absorbs micro waves “Sonar” (sound navigation and ranging) is used because it emits ultra-sonic waves and can be used to carry out the location of an object by its echo.
3. Ultrasonic sounds are also being used for cleaning purpose places and objects which cannot be cleaned in a normal way. Ultrasonic cleaned are especially popular with jewelers & material scientists for cleaning delicate instrument & materials.
4. These are also used to obtain cross-sectional pictures of patients in hospitals. Ultra so scans are often proffered to X-ray scans, because it is much safer than X-rays.
5. These are also used to make ultrasonic guiding devices for the blinds, to detect the cracks in metal structures, to kill bacteria and microorganism in liquids.

**CHAPTER # 13**

**PROPAGATION AND REFLECTION OF LIGHT**

**LIGHT**

**DEFINITION: -**

Light is the form of energy which enables us to see the surrounding objects.

**REFLECTION OF LIGHT**

**DEFINITION: -**

“The rays of light spreading from a source travelling through a medium strikes the surface of another medium a part of this light re bounce back in the same medium in a particular direction. This phenomenon of light is called REFLECTION OF LIGHT.”

**LAWS OF REFLECTION OF LIGHT**

1. The incident ray, the reflected ray, and the normal at the point of incidence all lie on the same plane.
2. The angle of incidence is equal to the angle of reflection i.e. .

**EXPLANATION: -**

1. In the above figure:
2. **INCIDENT RAY:** The ray of light which strikes the mirror at point of incidence is called incident ray.
3. **REFLECTED RAY:** The ray of light which reflects after striking the mirror at point of incidence is called reflected ray.
4. **POINT OF INCIDENCE:** It is the point at which the incident ray strikes and reflects.
5. **ANGLE OF INCIDENCE:** The incident ray makes an angle with normal or perpendicular to the reflecting surface at the point of incidence is called the angle of incidence.
6. **ANGLE OF REFLECTION:** The reflected ray makes an angle with normal or perpendicular to the reflecting surface at the point of incidence is called the angle of reflection.

**TYPES OF REFLECTION OF LIGHT**

* **REGULAR REFLECTION OF LIGHT:**

“When parallel light rays strikes the plane or smooth reflecting surface all of the rays reflect in the same direction such a reflection is known as the REGULAR REFLECTION OF LIGHT.”

**DIAGRAMMATIC ILLUSTRATION:**

**IMPORTANCE OF REGULAR REFLECTION OF LIGHT**

1. Formation of image in plane mirror is due to the regular reflection of light.
2. Due to regular reflection of light can converge or scatter by using the spherical mirrors.

**DIFFUSED (IRREGULAR) REFLECTION OF LIGHT**

“When parallel rays of light falls on an irregular surfaced body such as paper, the individual rays strikes it at different angles of incidence the rays therefore reflected in different directions from the surface such a reflection of light is considered as the IRREGULAR OR DIFFUSED REFLECTION OF LIGHT.”

**DIAGRAMMATIC ILLUSTRATION:**

**IMPORTANCE OF IRREGULAR REFLECTION OF LIGHT**

1. Due to irregular reflection of light we are able to see the non-luminous objects.
2. Due to irregular reflection of light sunlight reaches us before sunrise and persists for some time after the sunset.
3. Dust and another particles hanging in the atmosphere scattered sunlight in all the directions, so in this way we get sufficient amount of light in our rooms and other places where sunlight cannot reach directly.

**SPHERICAL MIRRORS**

**DEFINITION: -**

A part of a hollow sphere whose surface is smooth and polished is called spherical mirror.

**TYPES OF SPHERICAL MIRRORS: -**

Spherical mirrors are of two types

1. Convex mirror.
2. Concave mirror.
3. **CONVEX MIRROR: (DIVERGING MIRROR)**

The spherical mirror whose outer surface is light reflecting is called convex mirror.

**OR**

The spherical mirror whose reflecting surface is on side of centre of curvature is called convex mirror. It can diverge the parallel light rays, so also called diverging mirror.

1. **CONCAVE MIRROR: (CONVERGING MIRROR)**

The spherical mirror whose inner surface is light reflecting is called concave mirror.

**OR**

The spherical mirror whose reflecting surface is towards the centre of curvature is called concave mirror.

**TECHNICAL TERMS**

1. **Centre of curvature: -**

The centre of curvature is the centre of sphere from which a curved reflecting surface is obtained. It is denoted by ‘C’.

1. **Pole or Vertex: -**

The geometrical centre of the spherical mirror is regarded as vertex or pole, denoted by ‘P’.

1. **Radius of Curvature: -**

The distance between pole and centre of curvature is called radius of curvature. It is denoted by ‘R’.

**OR**

The radius of the sphere from which the spherical mirror is obtained is called radius of curvature.

1. **Principle Axis: -**

The straight line passing through the centre of curvature and the pole is called principle axis.

1. **Principle Focus: (Focal Point)**

* **In case of concave mirror:**

When the rays of light parallel to principal axis fall on concave mirror, after reflection passed through a point which is called Principal Focus or Focal Point or Simply Focus. As shown in the diagram:

* **In case of convex mirror:**

When the rays of light parallel to principal axis falls on a concave mirror, after reflection the rays are diverged and on backward plotting appears to come from a point. This point is called Principle focus. As shown in the diagram:

1. **Focal Length:**

The distance between the principal focus and pole of the mirror is known as its focal length. It is denoted as ‘f’.

**RELATION BETWEEN FOCAL LENGTH AND RADIUS OF CURVATURE**

The relation between focal length and the radius of curvature is given by:

Here,

**IMAGE FORMATION BY SPHERICAL MIRRORS**

**Rays Used For Image Formation:**

* **Ray # 1:**

A ray parallel to principle axis after reflection from concave mirror will pass through the focus of the mirror, as shown the diagram:

* **Ray # 2:**

A ray passes through the focus after reflection from concave mirror become parallel to the principle axis, as shown in the diagram:

* **Ray # 3:**

A ray which passes through centre of curvature after reflection from concave mirror retraces its own path, as shown in the diagram:

* **Ray # 4:**

A ray which strikes the mirror at pole, then the angle which it makes with principle axis before reflection is equal to the angle which makes with the principal axis after reflection, as shown in the diagram:

**GRAPHICAL CONSTRUCTION OF IMAGE BY CONCAVE MIRROR**

* **Case # 1:**

When the object is beyond the centre of curvature, ‘C’.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; The image is formed between ‘C’ and ‘F’.

Size; Diminished with respect to object.

Nature; Real and Inverted.

* **Case # 2:**

When the object is at centre of curvature, ‘C’.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; at centre of curvature ‘C’.

Size; same size as that of object.

Nature; real and inverted.

* **Case # 3:**

When the object is placed between centre of curvature ‘C’ and focus ‘F’.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; Beyond the centre of curvature.

Size; Enlarged with respect to object.

Nature; Real and inverted.

* **Case # 4:**

When the object is at principal Focus ‘F’.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; At infinity.

Size; Highly magnified.

Nature; inverted and real.

* **Case # 5:**

When the object is placed between ‘F’ and ‘P’ or when the object it’s within the focal length.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; Behind the mirror.

Size; Enlarged.

Nature; Virtual and erect.

* **Case # 6:**

When the object is at infinity.

**CHARACTERISTICS OF IMAGE FORMED:**

Position; at F.

Size; Real and inverted.

Nature; Extremely diminished.

**IMAGE FORMATION BY CONVEX MIRROR**

**CHARACTERISTICS OF IMAGE FORMED BY CONVEX MIRROR**

Size; diminished with respect to object.

Nature; Virtual and errect.

Position; Between P and F.

**IMPORTANT POINTS TO REMEMBER:**

1. When the object is at infinite distance from the convex mirror, the image is formed at focus. This image is virtual errect and extremely diminished.
2. As the object moves from infinity towards the pole of the mirror, the image in all cases is erect, virtual and is formed between P and F.

**IMAGE FORMATION BY PLANE MIRROR**

**CHARACTERISTICS OF IMAGE FORMED BY PLANE MIRROR**

1. Images are found to be laterally inverted i.e. the right side of the object appears as the left side of the image and vice versa.
2. Images are found to be of the same size as that of the object.
3. The image formed is found to be virtual, it cannot be obtained on a screen.
4. The image is as far behind the mirror as the object is in front of the mirror.

**USES OF SPHERICAL MIRRORS**

1. Concave mirrors are used in microscope.
2. Doctors used concave mirror for the examination for ear, nose, throat and of the patients.
3. Concave mirrors are used to focus the light in case of search light spot light also is head lights in automobiles.
4. Concave mirrors are used as a shaving mirror.
5. Convex mirrors are used in automobiles to have a rare view as back view mirrors.

**MIRROR EQUATION**

**DEFINITION: -**

It is an equation which relates the focal length ‘f’ of a mirror to the object distance ‘p’ and the image distance ‘q’.

**MATHEMATICALLY: -**

The reciprocal of focal length of a mirror is equal to the sum of the reciprocals of the object distance and image distance. i.e.

Where,

**DERIVATION: -**

In the above figure:

As the triangles and are similar to each other, therefore,

As,

Comparing eq. (ii) with eq. (iv)

Dividing both sides by ‘p’

Rearranging above equation

This equation is known as mirror equation or mirror formula

**SIGN CONVENTION:**

1. Focal length of concave mirror is taken as positive while focal length of convex mirror is taken as negative.
2. Real object distances and Real image distances are taken as positive.
3. Virtual object distances and virtual image distances are taken as negative.
4. All distances are measured from the pole ‘p’ of the mirror.

**MAGNIFICATION**

**DEFINITION: -**

“The ratio of the size of the image and the size of the object is called Magnification.”

**OR**

“The ratio of the image height and the object height is known as magnification.”

**OR**

“The ratio between the image distance and object distance is called magnification.”

**MATHEMATICALLY: -**

i.e.

**Or**

Comparing eq. (i) & (ii)

Here,

**CHAPTER # 14**

**REFRACTION OF LIGHT AND OPTICAL INSTRUMENTS**

**REFRACTION OF LIGHT**

**DEFINITION: -**

“When a ray of light enters from one medium into another medium obliquely, it undergoes a change, not only in direction, but in velocity as well. This change in velocity and direction as it enters from one medium into another medium is known as REFRACTION OF LIGHT.”

**DIAGRAMMATIC ILLUSTRATION:**

**EXPLANATION: -**

1. **Angle of incidence:** It is the angle between incident ray and the normal at the point of incidence. It is represented by .
2. **Angle of refraction:** It is the angle between refracted ray and the normal at the point of incidence. It is represented by .

**NOTE: -**

* When light enters from a rarer medium to a denser medium, it bends towards the normal i.e. .
* When light enters from denser to rarer medium, it bends away from the normal i.e. .

**LAWS OF REFRACTION OF LIGHT**

**INTRODUCTION: -**

In 1621, Willebrord Snell, Professor of Mathematics at Leyden University, discovered the exact relationship between the angle of incidence and angle of refraction after performing various experiments on this phenomenon (i.e. refraction of light).

**Law # 1:**

The incident ray and the refracted ray are on the opposite sides of normal at the point of incidence and all three are lie on the same plane.

**Law # 2:**

Second law which is also known as Snell’s law states that:

“The ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant for a given pair of media.” It is denoted by .

**MATHEMATICALLY: -**

Where,

is a constant and is called the refractive index of the second medium w.r.t the first medium.

**REFRACTIVE INDEX**

**DEFINITION: -**

“The value of constant for a ray passing from one medium to another medium is known as refractive index of the second medium. It is represented by .”

**OR**

“It is the ratio between the velocity of light in air and velocity of light in the medium.”

**MATHEMATICALLY: -**

**TOTAL INTERNAL REFLECTION**

When a ray of light passes from a denser medium to a rarer medium, refracted ray bends away from the normal. As the angle of incidence increases, the angle of refraction also increases. When the value of angle of incidence becomes greater than the critical angle, the ray of light no longer suffers refraction, but whole of it is reflected back in the same medium such a reflection is known as “TOTAL INTERNAL REFLECTION.”

**ESSENTIAL CONDITIONS FOR TOTAL INTERNAL REFLECTION**

1. The ray of light should travel from a denser medium to a rarer medium.
2. The angle of incidence should be greater than the critical angle.

**CRITICAL ANGLE**

Whenever light enters from denser medium, the angle of incidence for which the angle of refraction is is called critical angle.

**DIAGRAMMATIC REPRESENTATION: -**

**TOTALLY REFLECTING PRISM**

A totally reflecting prism has one of its angle is equal and each of the remaining two angles equals to .

**WORKING PRINCIPLE: -**

Totally reflecting prism works on the principle of total internal reflection.

**DIAGRAMMATIC ILLUSTRATION:**

**WORKING: -**

If a ray of light strikes one of its faces perpendicularly, it enters the prism without any change of direction and meet the hypotenuse at an angle of . As the critical angle of glass is , the ray striking the hypotenuse suffers total internal reflection. The reflected ray thus strikes the other face perpendicularly and comes out of the prism without any further change of direction.

**USE: -**

Totally reflecting prisms are used in periscopes.

**PERISCOPE**

**CONSTRUCTION: -**

In a periscope, two right angled prisms are used to total internal reflect lenses are also used in periscope to achieve a clear image.

**DIAGRAMMATIC ILLUSTRATION:**

**Working: -**

The rays iron distant objects are reflected at right angle by the upper prism into the vertical tube the rays pass through a system of lenses and fall on the second right angled prism. This prism bends light rays.

**REFRACTION OF LIGHT THROUGH PRISM**

**PRISM: -**

“A prism is a transparent refracting body which is bounded by three refracting rectangular and two triangular surfaces.”

**ANGLE OF PRISM: -**

The angle between the two refracting rectangular surfaces opposite to the base is called angle of prism.

* **REFRACTION THROUGH PRISM:**

1. The light ray strikes the face of the prism.
2. On entering the prism this ray bends towards the normal at the point of incidence ‘F’. (i.e. it bends towards the base of the prism.)
3. The refracted ray on emerging out of the prism further bends away from the normal at the point of incidence ‘G’. (i.e. the emergent ray bends further towards the base of the prism.)
4. The angle is the angle of incidence, .
5. The angle is the angle of refraction, .
6. If the incident ray is further extended up to the point and the emergent ray is traced back up to the point M, then the angle is called the angle of deviation, represented by .
7. The angle of deviation is least when the incident ray and emergent ray make equal angles with the normal, i.e. when the refracted ray is parallel to the base of the prism.
8. The minimum value of angle of deviation is called the angle of minimum deviation.

**REFRACTIVE INDEX OF PRISM**

The index of refraction of a material of the prism can be determined by the relation.

Where,

**LENSES**

**DEFINITION: -**

“A lens is a piece of transparent material, such as glass or plastic that refracts light rays in a regular way bounded by one or two spherical surfaces.”

**TYPES OF LENSES**

1. Convex lens or converging lens.
2. Concave lens or diverging lens.
3. **CONVEX LENSE:**

A lens which is thicker at the middle and thinner at the edges and which converges parallel beam of light at a point is called convex lens or converging lens.

1. **DOUBLE CONVEX OR BICONVEX LENS: -**

Both sides of the convex lens are convex in the biconvex lens.

1. **PLANO CONVEX LENS: -**

One of the two surfaces of such a lens is plane and the other is convex.

1. **CONCAVO-CONVEX LENS: -**

One of the two surfaces of such a lens is concave and the other is convex.

1. **CONCAVE LENS:**

A lens which is thinner in the middle and thicker at the edges and which diverges the light is called concave lens.

Concave lens are also of the three types:

1. **BI-CONCAVE LENS: -**

Both surfaces of a bi-concave lens are concave.

1. **PLANO CONCAVE LENS: -**

One of the two surfaces is plane and the other is concave.

1. **CONVEXO-CONCAVE LENS: -**

One of the two surfaces as a convexo-concave lens is convex while other is concave.

**TECHNICAL TERMS**

1. **OPTICAL CENTRE:**

The central point of the lense situated on the principal axis between the two spherical surfaces is known as the optical centre. It is represented by .

1. **APERTURE:**

The diameter of the lens is called as it aperture. In the following figure represents aperture.

1. **PRINCIPLE AXIS:**

An imaginary line passing through principal focus and optical centre is called principle axis. In the following figure represents the principal axis.

**PRINCIPAL FOCUS OR FOCAL POINT**

1. **IN CASE OF CONVEX LENS:**

The light rays parallel to the principal axis, after refraction from the convex lens meet at a point this point is known as focus or focal point.

1. **IN CASE IF CONCAVE LENS:**

When the rays of light parallel to the principal axis falls on a concave lens after refraction from concave lense, the rays are diverged and on backward plotting appear to come from a point. This point is called Principal focus.

**FOCAL LENGTH**

The distance between focus and optical centre is called focal length and is denoted by .

**GRAPHICAL CONSTRUCTION OF IMAGES THROUGH LENSES**

**RAYS USED IN IMAGE FORMATION:**

**Ray # 1:**

A ray which is parallel to the principle axis after refraction from a lens passes through the principle focus of the lens.

**Ray # 2:**

A ray which passes through the focus, after refraction from a lens becomes parallel to the principle axis.

**Ray # 3:**

A ray which passes through the optical centre of the lens remains unchanged in the direction.

**IMAGE FORMATION BY A CONVEX LENS**

**CASE # 1:**

When the object is placed beyond .

**CHARACTERISTICS OF IMAGE FORMED**

Position; Between .

Size; Diminished w.r.t object.

Nature; Real and inverted.

**CASE # 2:**

When the object is at .

**CHARACTERISTICS OF IMAGE FORMED**

Position; at .

Size; Same in size.

Nature; Real and inverted.

**CASE # 3:**

When the object is placed between .

**CHARACTERISTICS OF IMAGE FORMED**

Position; Beyond .

Size; Magnified w.r.t object.

Nature; Real and inverted.

**CASE # 4:**

When the object is placed at principal focus .

**CHARACTERISTICS OF IMAGE FORMED**

Position; At infinite distance.

Size; Highly magnified.

Nature; Real and inverted.

**CASE # 5:**

When the object is placed between .

**OR**

When object is within the focal length.

**CHARACTERISTICS OF IMAGE FORMED**

Position; At the same size of object.

Size; magnified.

Nature; virtual and errect.

**CASE # 6:**

When the object is at infinity.

**CHARACTERISTICS OF IMAGE FORMED**

Position; At Principal focus.

Size; Extremely diminished.

Nature; Real and inverted.

**THIN LENS FORMULA**

**DEFINITION: -**

It is the equation which relates the focal length of a lens with the object distance and the image distance .

**SIGN CONVERSION: -**

1. All distances are taken from the optical centre .
2. Focal length of convex lens is taken as , while focal length of concave lens is taken as .
3. Real image distance and Real object distances are taken as .
4. Virtual image distance and virtual object distances are taken as negative.

**POWER OF A LENS**

**DEFINITION: -**

The reciprocal of the focal length of the lense is called power of the lens.

**MATHEMATICALLY: -**

**DIOPTER**

The unit of power of a lens used by the opticians is DIOPTER and is defined as:

“One diopter is the power of a lens whose focal length is one metre .”

**SIGN CONVERSION: -**

1. The power of convex (converging) lens is taken as .
2. The power of concave (diverging) lens is taken as .

**EXAMPLES:**

**HUMAN EYE**

Eye is one of the five senses of the human beings. The structure of human eye is nearly spherical and its diameter is . Its main parts are given below:

**CONSTRUCTION OF HUMAN EYE**

1. **SCLEROTIC:**

The outermost layer of the human eye is called sclerotic.

1. **CORNEA:**

The front portion of sclerotic is called the cornea. It is transparent.

1. **CHOROID:**

Inside the sclerotic there is a black pigmented layer called the choroid.

1. **IRIS:**

The front portion of the choroid is known as Iris.

1. **PUPIL:**

In the center of the iris, there is an opening called pupil.

1. **LENS OF THE EYE:**

In the back of iris, there is a transparent body called lens of the eye.

1. **AQUEOUS HUMOUR:**

The water like fluid between the cornea and the lens of the eye is called aqueous humour.

1. **RETINA:**

The rays of light form an object are focused and converged by the lens on to the sensitive internal layer of the eye-ball called the Retina.

1. **CILLIARY MUSCLES:**

These are the thin nerves which are along the lenses, called cilliary muscles. They controlled the lens in its adjustment.

**WORKING OF AN EYE**

1. **WHEN EYE IS LOOKING TOWARDS A NEAR OBJECT:**

When eye is directed towards a near object, the eye lens bulges out by action of cilliary muscles and its focal length decreases in such a way that a clear and distinct image is formed on the photosensitive layer called RETINA.

1. **WHEN EYE IS LOOKING TOWARDS A FAR OBJECT:**

When eye is looking towards the distant object the cilliary muscles are relaxed and the focal length of eye lens is increased and a clear and a distinct image is formed at retina.

**DEFECTS OF VISION**

**SHORT SIGHTEDNESS: (MYOPIA)**

The defect of an eye in which the distant object cannot be seen clearly is called short sightedness or MYOPIA.

**CAUSE:**

The eye lens of such an eye is too converging or the eye ball is too elongated as shown in the diagram:

**REMEDY:**

The defect of an eye can removed by using concave lens of suitable focal length, as shown in the diagram:

**LONG SIGHTEDNESS: (HYPEROPIA)**

The defect of an eye in which the near objects cannot be seen clearly is called far sightedness or hyperopia.

**CAUSE:**

In this defect the eye lens of such an eye is less converging or the eye ball is too short, as shown in the diagram:

**REMEDY:**

This defect is removed by using convex lens of suitable focal length as shown in the diagram:

**ASTIGMATISM**

**CAUSE:**

If the cornea or the surface of the eye is not perfectly spherical the eye has different focal planes and an object is not focused on clearly on the retina.

**REMEDY:**

Astigmatism is corrected by asymmetrical lenses which have different radii or curvature in different planes.

**LACK OF ACCOMMODATION (PRESBYOPIA)**

**CAUSE:**

At old age the eye lens loses its elasticity and ability to change in shape and the ciliary muscles weaken resulting in a lack of accommodation. This kind of long sightedness is called presbyopia.

**REMEDY:**

This defect of eye can be corrected by using spectacles with bifocal lenses i.e. the convex part in the lower side to see the near objects and concave part in upper side to see the far objects.

**FAR POINT:**

The farthest distance at which an eye can see an object clearly is called far point.

**NEAR POINT:**

The point closest to the eye at which objects can be seen clearly is called near point.

**LEAST DISTANCE OF DISTINCT VISION:**

A normal human eye can see an object clearly it is at from the eye this distance is known as least distance of distinct vision. It is denoted by .

**PERSISTENCE OF VISION:**

When an object is seen by an eye its image formed on the retina. If the object is removed the impression of the image persists in the eye for about to of the second. This lingering effect is called persistence of vision.

**MAGNIFYING GLASS (SIMPLE MICROSCOPE)**

**DEFINITION: -**

A convex lens which of short focal length which enables one to examine the details of a minute object is called Magnifying Glass.

**RAY DIAGRAM: -**

**PRINCIPAL:**

A convex lens produce a virtual, erect and enlarged image of an object placed with in its focal length.

**MAGNIFYING POWER:**

Magnifying power of a magnifying glass is given by:

Where,

**COMPOUND MICROSCOPE**

**DEFINITION: -**

Compound microscope is an optical instrument by means of which a small object can be seen very much magnified.

**CONSTRUCTION: -**

It consists of two biconvex lenses.

**OBJECTIVE:** The objective is the lens which is near the object. It has smaller focal length as compared with eye-piece.

**EYE-PIECE:** The eye-piece is the lens which is near the eye. It has comparatively longer focal length as compared to that of objective.

**RAY DIAGRAM: -**

**WORKING: -**

1. An object is placed very closed to objective which forms its real, inverted and magnified image in front of the eye piece.
2. The position of eye piece is adjusted in such a way that this image should fall within its focal length.
3. The eye piece now works like a magnifying glass and forms a virtual, erect and highly magnified image .

**ASTRONOMICAL TELESCOPE**

**DEFINITION: -**

“An astronomical telescope is an optical instrument which is used to see the heavenly bodies (like stars, planets etc.) clearly.”

**CONSTRUCTION: -**

It consists of two biconvex lenses.

1. **OBJECTIVE:** The lens which is near the object or towards the object is called objective. It has larger focal length and aperture so that it should receive maximum light from the object.
2. **EYE-PIECE:** The lens near the eye is known as eye-piece and it has focal length smaller than that of objective.

**RAY DIAGRAM: -**

**WORKING:**

1. Objective forms a real inverted and diminished image of distant object .
2. The position of the eye piece is adjusted in such a manner that this image should fall within its focal length.
3. The eye piece now forms a virtual, erect and magnified image of the real image formed by the objective. This image is inverted w.r.t the object.

**CHAPTER # 15**

**NATURE OF LIGHT AND ELECTROMAGNETIC SPECTRUM**

**THE DRIES ABOUT LIGHT**

In order to explain the properties and nature of light various theories were put forward by the scientists, some very important theories are as follows:

1. Newton’s Carpuscular Theory of light.
2. Wave theory of light.
3. Plank’s Quantum theory of light.

**NEWTON’S CARPUSCULAR THEORY OF LIGHT**

**BASIC POSTULATES:**

1. Newton proposed that light consists of minute particles called carpusclar.
2. When these particles are emitted from the source of light, travel in straight line with great speed.
3. When these particles enter the eyes, they create a sensation of sight on the retina of the eye.

**IMPORTANCE:**

1. This theory explains the formation of shadows and propagation of light along a straight path.
2. It also explains the reflection of light particles from a surface.

**DRAWBACK:**

It could not explain the phenomenon of refraction of light.

**WAVE THEORY OF LIGHT**

**INTRODUCTION:**

This theory was proposed by a famous contemporary scientist of Newton, Huygens in 1680 and is known as wave theory of light.

**BASIC POSTULATES:**

1. According to Huygens, light is a form of energy (not particle) and travels in the form of waves.
2. Since for the propagation of waves medium is necessary, so in order to explain how light reaches to earth from sun he suppose a medium ether in the space.

**IMPORTANCE:**

On the basis of this theory formation of image, Reflection and refraction, interference, also Diffraction phenomenon all can easily be explained.

**DRAWBACK:**

1. Huygens could not explain the presence of the medium ether. In beginning of 20th century Mosley’s and Michelson proved experimentally that the ether did not exist.
2. This theory could not explain the phenomenon of Compton’s effect and photoelectric effect.

**QUANTUM THEORY OF LIGHT**

**INTRODUCTION:**

This theory was proposed by Max Plank in 1901 and is known as Plank’s Quantum theory of light.

**BASIC POSTULATES:**

1. According to Plank’s Quantum theory of light, light consists of packets or bundles of energy Plank’s named these packets of energy as Photon.
2. The Photons are highly energetic particles and the energy of photons depend upon the frequency.
3. Photons have dual nature, they behave as particles as well as waves.

**IMPORTANCE:**

1. This theory explains the phenomenon of Compton effect and photo electric effect.
2. It also explains how light moves in the space.

**DISPERSION OF LIGHT**

**DEFINITION:**

When a beam of light falls on a prism after refraction from prism light decompose into a band of colours. This colour band is called the spectrum and the phenomenon of decomposition of white light into different colours is called the dispersion of light.

**DIAGRAMMATIC ILLUSTRATION:**

**EXPLANATION:**

1. The colours obtained have their own frequencies. The amount of refraction of waves depends upon frequencies.
2. The waves of higher frequency bend more than the waves of lower frequency.
3. The shortest wavelength visible to the human eye is violet at its deviation is the greatest. The longest visible wavelength i.e. red colour with about and its deviation is the least.

**RAINBOW**

**DEFINITION: -**

The rainbow is an arc of colours formed across the sky during or after rainfall in the morning or evening.

**REASON FOR RAINBOW FORMATIN: -**

The reason for the formation of the rainbow is that the rain drops behave like prism and white light entering the rain drops is split up into colours on refraction.

**THE ELECTROMAGNETIC SPECTRUM**

The electromagnetic spectrum consists of the following types of rays.

**RADIO WAVES:**

These are the electromagnetic waves with a large range of wavelength from a few millimeters to several meters.

**MICRO WAVES:**

These are radio waves of shorter wavelengths between and . Microwaves are used in radar and microwave ovens.

**INFRARED WAVES:**

These waves are of wavelengths having a mean value of or . These waves are radiated by hot bodies at different temperatures.

**VISIBLE WAVES:**

These waves have a wavelength range between . The peak of the solar radiation is at a wavelength of about .

**ULTRA VIOLET WAVES:**

Their wavelengths, ranges from down to . These are emitted by hotter stars having a mean temperature greater than .

**GAMMA RAYS:**

Their wavelength is less than . They are emitted by nucleus of certain radioactive substances.

**GREEN HOUSE**

**CONSTRUCTION: -**

A green-house is constructed to provide a stable warm environment for plants to encourage their proper growth. The roof and walls of the green house are built with glass or plastic sheets to let the heat of the sun in and trap it. This results in the air inside the green house to become warm.

**EFFECT ON ATMOSPHERE:**

Infrared waves are coming from sun after passing from sheets of greenhouse absorbed by plants and earth rises the temp of the greenhouse. The soil and plants become warmer and emit infrared radiation of longer wavelengths. These rays are now to passed back out of atmosphere but dust carbon dioxide and water Vapour are opaque to infrared radiation. This results in the trapping of Heat energy in the atmosphere causing.

1. The rising of atmosphere temperature.
2. Rising sea-level.
3. Climatic changes, such as floods, draughts and cydones are predicted.
4. Ecological changes.

**CHAPTER # 16**

**ELECTRICITY**

**CHARGE: -**

It is the basic property of the elementary particles by which they attract or repel in an electric field.

**POSITIVELY CHARGED BODY: -**

The body which loses electrons consider as positively charged body.

**NEGATIVELY CHARGED BODY: -**

The body which gains electrons consider as negatively charged body.

**ELECTROSTATIC: -**

The behavior of charges at rest is called electrostatic.

**INSULATOR OR NON-CONDUCTOR: -**

**INSULATOR: -** Those material objects which do not allow the charge to pass through them are known as Insulator.

**EXAMPLE: -** Wood, plastic, rubber etc belong to this category.

The electron in an atom of an insulator are bound tightly with the nuclei and thus charge cannot pass through them.

**CONDUCTOR: -**

Those material objects which allow the charge to pass through them are known as Conductor.

**EXAMPLE: -** Copper, Iron, Aluminum, Silver, Gold

In conductor some electrons are loosely bound and can move freely within the medium.

**FREE ELECTRON: -**

The electron of outermost orbit in an atom is called free electron which is not attached to a particular atom and it moves atom to atom in a substance.

**SOUND ELECTRON: -**

The electron in the innermost orbit of an atom is called Bound electron which is attached to a particular atom and does not move atom to atom in a substance.

**COULOMB’S LAW**

**STATEMENT: -**

“Two unlike charges attract each other, and two like charges repel each other with a force which is directly proportional to the product of the magnitude of charges and is inversely proportional to the square of the distance between them.”

**EXPLANATION: -**

Suppose are two point charges and ‘r’ is the distance between them.

According to the coulomb’s law the force between the charges is directly proportional to the product of their magnitudes.

And,

The force between the charges is inversely proportional to the square of the distance between them.

By combining eq. (1) and (2)

Where ‘K’ is the constant of proportionality which is called as Coulomb’s constant and its value depends upon the space between the charges.

Value of ‘K’ is taken as

In S.I system it is a common conversion to write the constant ‘K’ as:

∴ Eq. (3) may be written as:

Where is called permittivity of free space and it has a value:

If the medium in which the charges are placed is not vacuum but a material medium then eq. (4) may be written as:

Where,

**UNIT OF CHARGE: -**

The unit of charge is coulomb.

**COULOMB**

**DEFINITION: -**

Coulomb of charge being that quantity of charge which when placed / meter from an identical charge in a vacuum repels it with a force of .

**ELECTRIC FIELD**

**DEFINITION: -**

Electric field due to charge is defined as the space around a charge in which its influence would be felt by another charge.

**ELECTRIC FIELD INTENSITY: -**

The strength of an electric field is known as electric field intensity or electric field strength which is defined as:

“Electric Intensity ‘E’ at any point surrounding the charge (Q) is defined as the force per unit positive charge.”

As ‘E’ is a vector quantity therefore its direction is same as that of the force that will act on a unit positive charge.

**MATHEMATICAL EXPRESSION: -**

According to the definition,

Where is the unit positive charge

According to the coulomb’s law:

∴ The equation of the Electric Intensity may be written as:

**Or**

**UNIT: -**

The unit of Electric Intensity is

**TEST CHARGE: -**

Ideally the test charge is small that it does not disturb other field of the charge in which it is present. The test charge is standardized as a unit positive charge.

**ELECTROSTATIC INDUCTION**

**DEFINITION: -**

When a charged body is brought close to a neutral body, charge distribution takes place either in the body or in its surface. This phenomenon is termed as Electrostatic Induction.

**EXPLANATION: -**

1. Take two brass sphere A and B which are placed together that they touch one another and thus form in effect, a single conductor.
2. A negatively charged rod is now brought near to A. As a result a positive charge is induced on A and a negative charge on B as shown in the figure.
3. Still keeping the charged rod in position sphere B is moved a short distance from A as shown in the figure.
4. The charged rod is now removed and A & B are tested for charge by electroscope.

**RESULT: -**

It is found that A is positively charged and B is negatively charged.

**ELECTRIC POTENTIAL**

**DEFINITION: -**

The amount of work done to move a unit positive charge against the electric field is called “Electric Potential”.

**MATHEMATICALLY IT CAN BE EXPRESSED AS:**

**EXPLANATION: -**

There is a unit positive charge which has to move against the electric field as shown.

The work per unit charge required to move the charge between the points B and A is appears as difference in electrostatic potential energy V and is called potential difference or the voltage between the points.

**MATHEMATICALLY IT CAN BE EXPRESSED AS:**

**UNIT: -**

The unit of potential difference is volt.

**VOLT**

**DEFINITION: -**

When of work is required to move a charge of between two points then potential difference is represented by i.e.

**CAPACITOR**

**DEFINITION: -**

“A device which is designed to store the charge is called capacitor.”

**PRINCIPLE: -**

When an amount of charge is given to one plate of the capacitor another amount of charge is induced due to electric field of this charge or due to force of attraction of this charge i.e. by means of electrostatic induction.

**CONSTRUCTION:**

A simple capacitor consists of two parallel metallic plates having a distance between them. It has insulating material between them which is dielectric.

**WORKING: -**

When an amount of positive charge is supplied to one plate of the capacitor (this can be done by rubbing a glass rod against silk cloth and touching it with plate) it produces an electric field due to which negative charge is attracted and they are stored in other plate. In other words a potential difference is developed across the capacitor.

**EXPRESSION: -**

Suppose the magnitude of charge which is stored in a capacitor is Q. A potential difference ‘V’ appears across the plates.

As we know that potential difference ‘V’ is directly proportional to the magnitude of charge stored in a capacitor therefore we have:

Where C is the constant of proportionality which is known as capacitance or capacity of the capacitor.

**UNIT OF CAPACITANCE: -**

The unit of capacitance is Farad.

**FARAD**

**DEFINITION: -**

The unit of capacity of the capacitor or capacitance is far which is defined as:

“If the capacitor requires one coulomb of charge to raise the potential difference to one volt. The capacity of the capacitor is said to be or Farad.”

**FACTORS AFFECTING THE CAPACITANCE**

1. **MEDIUM BETWEEN THE PLATES: -**

If an insulator such as glass (mica) etc. is introduced to the plates its capacity to store charge increases.

1. **AREA OF THE PLATES: -**

Increase in area of the plates of the capacitor and capacity of the capacitor.

1. **DISTANCE BETWEEN THE PLATES: -**

The reduction in the distance between the plates also increases the capacity of the capacitor.

**CURRENT**

**DEFINITION: -**

The rate of flow of electric charge through a certain cross-section is called current.

**EXPLANATION: -**

There is a substance which consist of free electron. When a battery is connected across it electron move from the region ‘A’ towards the region ‘B’. This amount of charge which passes through the cross-section area in a unit time is known as the “Rate of flow of charge” and this rate of flow of charge is known as current.

**EXPRESSION: -**

If a charge a flows for ‘t’ second through given cross-section area then electric current ‘I’, passing through the area is given by:

**UNIT: -**

The unit of electric current is Ampere.

**AMPERE**

**DEFINITION: -**

“If 1 coulomb of charge is flowing through any cross-section of a conductor in 1 sec. the amount of current is said to be one ampere.”

**IMPORTANT POINTS TO REMEMBER**

* Actual flow of current is the motion of the electrons from the negative terminal to the positive terminal.
* Conventionally electric current is taken as electric fluid which flows from the positive terminal to the negative terminal i.e. (from the positively charged body to the negatively charged body). This type of current is termed as Conventional current.

**OHM’S LAW**

**STATEMENT: -**

“The potential difference between two ends of a conductor is directly proportional to the current passing through it, provided that there is no change in the physical state of the conductor.”

**EXPRESSION: -**

Consider a conductor which is connected to the battery and a current passes through it as shown:

According to Ohm’s law the potential difference is directly proportional to the current passing through it.

Where is the Resistance

**RESISTANCE**

It may be defined as:

“The hindrance in the flow of current.”

**OR**

“The properly of the substance which opposes the flow of current through it.”

**OR**

“Resistance is an opposition to the motion of electrons.”

**REASON: -**

Resistance arises as a result of collisions of moving electron with one another and the neighboring ohms.

**UNIT: -**

The unit of resistance is ohm.

**Ohm**

**DEFINITION: -**

The unit of resistance is ohm which is defined as:

“If a current of one ampere is passing through a conductor when a potential difference of is applied across its ends then the resistance of a conductor is .”

**FACTORS ON WHICH RESISTANCE “R” DEPENDS**

**LENGTH OF THE CONDUCTOR: -**

As length of the conductor increases, resistance also increases.

**AREA OF CROSS-SECTION OF THE CONDUCTOR: -**

As the area of cross-section increases the resistance decreases.

**NATURE OF THE CONDUCTOR: -**

Different substances have different resistance. Resistance offered by copper is less than that of German silver.

**TEMPERATURE: -**

As the temperature of conductor increases, resistance also increases.

**ELECTRIC CIRCUIT: -**

A path through with an electric current flows is called “Electric Circuit”.

**DEPEND AND CLOSED CIRCUIT: -**

An electric circuit is said to be opened if no current flows from it.

An electric circuit is said to closed if current flows from it.

**COMBINATION OF RESISTANCE**

**SERIES COMBINATION: -**

The combination of resistors in which a single path is provided to flow the current is called series combination of resistors.

Following figure illustrates the idea

**CHARACTERISTICS OF SERIES COMBINATION**

1. **TOTAL RESISTANCE: -**

The total resistance of the circuit is equal to the sum of the individual resistance i.e.

Where is the equivalent resistance

1. **CURRENT: -**

The current passing through resistors connected in series is same i.e.

**POTENTIAL DIFFERENCE: -**

The sum of potential difference across each resistor is equal to the potential difference of the battery. i.e.

OR

Where is the equivalent resistance of the circuit.

**PARALLEL COMBINATION OF RESISTORS**

**DEFINITION: -**

The combination in which more than one path are provided to flow the current is called Parallel Combination.

Following figure illustrates the idea

**CHARACTERISTICS OF PARALLEL COMBINATION**

1. **TOTAL RESISTANCE: -**

The reciprocal of total resistance of the circuit is equal to the sum of reciprocal of individual resistance i.e.

1. **CURRENT: -**

The current of the circuit is equal to the sum of the current flowing through each resistor i.e.

**POTENTIAL DIFFERENCE: -**

The potential difference of each resistor is same i.e.

**DIRECT CURRENT (D.C)**

**DEFINITION: -**

A current which doesn’t change its direction in the circuit with time is called “Direct Current” and it is abbreviated as D.C.

**ALTERNATING CURRENT (A.C)**

**DEFINITION: -**

A current which changes its direction many times in a sec is called “Alternating Current” and it is abbreviated as A.C.

The current used in our houses in A.C and its frequency is 50 cycles per second.

The above graph shows that during the interval , the current increases from 0 to a certain maximum value and then again falls to zero. In this manner, during time interval the electric current varise in the similar way but in the opposite direction. Such a flow of current is called Alternating current (A.C).

**PEAK VALUE: -**

The maximum amount of the electric current flowing in a given direction is called its Peak value.

**FREQUENCY: -**

The number of cycle completed by A.C in one second is called its frequency.

**TIME PERIOD: -**

The time required to complete one cycle is called time period.

**FUSE**

**DEFINITION: -**

Fuse is a small wire that allows only a current of certain value to pass through a circuit.

**OR**

Fuse is a safety device for breaking the circuit in case the current exceeds a certain limit.

* It consists of thin wire of low melting point.
* Fuse wire is always connected in series with the live wire after the electric meter.

**ADVANTAGES: -**

1. It saves the costly electrical appliance like air-conditioner, T.V, Refrigerator etc. from damage.
2. It prevents the wiring from getting hot and prevents catching of fire.
3. Fuse prevents the electric meter from damage.

**JOULE’S LAW**

**STATEMENT: -**

“When a current passes through a resistance for a certain time then the heat in the resistance is equal to the product of square of current, resistance and time.”

i.e.

**OR**

**EXPLANATION: -**

Suppose charge coulombs is passing through a resistance in time second. When potential difference Volts is maintained across its ends then work done in moving Q positive charge through the resistor is given by:

If current amperes flow for seconds between these two points then the charge Q is given as:

So that the above equation becomes

According to Joule’s law

Work done by the current using Ohm’s law:

**POWER**

**DEFINITION: -**

The rate of doing work is called power.

**OR**

Power is the amount of work done in unit time.

**OR**

The amount of energy obtained from an electric current in unit time is called electric power.

**MATHEMATICALLY: -**

As we know that

∴ The expression of the power becomes

According to Ohm’s law

But,

**UNIT OF POWER: -**

In M.K.S system the unit of power is watt which is equal to .

**WATT**

**DEFINITION: -**

“If one joule of electrical work is done in one second then the power is called one watt.”

When electrical energy is used for commercial purpose its unit is called “KILOWATT HOUR (kwh)”.

“kwh is the quantity of energy which is obtained by the power of 1 kilowatt in one hour.”

**Chapter # 17**

**MAGNETISM AND ELECTROMAGNETISM**

**NATURAL MAGNET:**

Natural magnet is a dark coloured are called magnetic was discovered in Magnesia (Also) this one is a compound of iron and oxygen and had a property of attracting small pieces of iron.

**PROPERTIES OF NATURAL MAGNET**

1. It attracts pieces of iron, Nickel and Cobalt.
2. The force of attraction is greater at its ends i.e. poles than in the middle.
3. If a bar magnet is suspended in such a way that it is free to rotate about a vertical axis in a horizontal plane, it arranges its poles in north and south direction.
4. Like poles of two magnets repel and unlike poles attract each other.

**MAGNETISM: -**

All the physical properties which are related to magnets are known as magnetism.

**MAGNETIC FIELD: -**

The space surrounding a magnet in which its magnetic effect is felt is known as magnetic field.

**POLES: -**

Magnet has maximum power of attraction or repulsion on its end. These ends are called poles of magnet.

**SOUTH POLE: -**

If a magnet is suspended freely then it points towards north and south automatically. The south pointing end is called South Pole.

**MAGNETIC LINES OF FORCE**

Magnetic lines of forces are simply curves along which single North Pole moves when placed in the field. They indicate the direction of magnetic field.

The Tangent at any point on the gives the direction of the resultant magnetic force at the point.

**PROPERTIES OF MAGNETIC LINES OF FORCE**

1. Magnetic lines of force start from North Pole and ends at South Pole.
2. Two lines of forces cannot intersect at a point.
3. The magnetic lines of forces can pass move easily through the iron than air.

**MAGNETIC FORCE**

Magnetic force between two magnets is directly proportional to the strength of two poles and inversely proportional to the square of distance between them.

**SIMILARITY BETWEEN ELECTROSTATIC AND MAGNETISM**

1. There are two types of charges, positive and negative similarly there are two types of magnetic poles North and South.
2. Like charge and like poles repel each other, opposite charges and opposite poles attract each other.
3. Charged objects setup electric fields of force the magnetic objects setup magnetic field of force.
4. Certain substance may be electrically charged by rubbing together, certain magnetic substance may be magnetized by rubbing with another magnet.

**ELECTROMAGNETISM**

The branch of physics in which we study about the relation between electricity and magnetism is known as electromagnetism.

**MAGNETIC FIELD OF A STRAIGHT WIRE**

“When a current passes through straight conductor a magnetic field is created around it.”

The direction of the magnetic field produced by a current carrying straight conductor is determined by “RIGHT HAND RULE.”

**RIGHT HAND RULE**

“If a wire carrying a current is gripped with the right hand and with the thumb pointing along the wire in the direction of the current, the fingers points in the direction of the magnetic field around the wire.”

Following figures illustrates the idea

It is clear from the figure that the magnetic field is formed due to current carrying wire in the form of circular lines of force.

**MAGNETIC FIELD DUE TO A COIL OR SOLENOID**

**SOLENOID: -**

A coil of insulated copper wire in the form of a long cylinder is called solenoid.

Following figures illustrates the idea

When an electric current is passed through a solenoid the magnetic field produced due to current in a solenoid is very much similar to that of a bar magnet. One end of the solenoid acts like a North pole and other ach like a South pole. The magnetic field inside the solenoid is very strong and uniform because lines of force are parallel and close to one another.

Following figures illustrates the idea

“If the solenoid is gripped with the right hand such that the finger curl around it in the direction of the current then the thumb points towards the north pole of the solenoid.”

**ELECTROMAGNET**

The magnet produced by a current in a solenoid with a soft iron core is called as electromagnet.

**CORE:**

A bar of soft iron inside a solenoid is called its core.

**EXAMPLE:**

U-shaped soft iron bar which has coils of insulated wire wound in opposite directions on each of its arms as shown in the following figure is the example of electromagnet.

By examining the direction of the current we find that P has a N polarity while Q has a south polarity.

The magnetic strength of electromagnet increases by two factors.

1. Amount of Current.
2. Number of turns.

**TYPES:**

1. Straight electromagnet.
2. Horse shoe or U-shaped electromagnet.

**ELECTRIC BELL**

**CONSTRUCTION: -**

1. An electric bell consists of an electromagnet in front of which there is a soft iron strip. This strip is called armature.
2. Along rod attached to one end of the armature.
3. The free end of the rod carries a small hammer which can strike against a bell (gong).

Following figure illustrates the idea

**WORKING: -**

1. When the push button switch is closed there is a complete circuit.
2. A current flows through the electromagnet so magnetizing the iron core.
3. The electromagnet induces magnetism in the soft iron armature which is attracted to the pole of the electromagnet.
4. The hammer strikes the gong.
5. The spring strip contact moves away from the screw contact and breaks the circuit, switching off the current.
6. The electromagnet no longer magnetized releases the armature which springs back to its starting position.
7. The spring strip contact now touches the screw again, remakes the circuit and switches on the current.

The cycle repeats rapidly from (i) to (vi) for as long as the push button switch is closed. The hammer strikes the gong repeatedly making a continuous ringing sound.

**FORCE ON A CURRENT CARRYING CONDUCTOR**

If the current carrying conductor is placed normally to the magnetic field then the conductor experience a force which is normally to the magnetic field and the current.

Following figure illustrates the idea how a current carrying conductor experienced a force in a uniform magnetic field.

The force acts to push the current carrying conductor. From the stronger field region towards a weaker field region. The direction of the force is at right angle to both the field lines and the direction of the current.

**DIRECTION OF THE FORCE:**

The direction of the force on a current carrying conductor due to uniform magnetic field is determined by right hand rule according to which

“If the thumb is placed in the direction of current and the fingers are placed in the direction of the magnetic field then the direction of the force experienced is then given by the direction in which the palm of hand would push.”

The magnitude of force produced is directly proportional to the current and the field strength .

**MOVING COIL GALVANOMETER**

**DEFINITION: -**

A Galvanometer is a delicate and sensitive device used to measure the magnitude and direction of small current.

**CONSTRUCTION: -**

It consist of a horse shoe magnet and a soft iron cylinder. Coil is wounded on a thin and light frame of aluminum alloy and is placed between the north a south pole of a horse shoe magnet without touching it. A hard steel pivot or needle with pointed edges is passed through the upper and lower side of the frame which rests on a bearing. There are two connection for the current. One for the entering current and other for the current leaving path. Two hair springs are used to bring the coil to zero position. Following figures illustrates the idea:

**WORKING: -**

When current passes through the coil the two opposite forces cause the coil to rotate against the opposing force of the control spring. At one point the electromagnetic force and the controlling force of the spring balance each other and the coil comes to rest. The amount of rotation measured on the scale depends on the amount of current flowing through the coil. When the pointer moves to the end of the scale we call it a FULL SCALE DEFLECTION and the amount of current causing the full scale deflection is called the FULL SCALE DEFLECTION CURRENT.

This instrument is very sensitive because of frictionless bearing lightness of frame and spring. Even a small amount of current produces a note able deflection of the needle.

**SENSITIVITY OF A GALVANOMETER**

1. The sensitivity of a Galvanometer increases with increase in the no. of turns of the coil.
2. The sensitivity of Galvanometer increases with the strength of the magnetic field of the permanent magnet.

**AMMETER**

A galvanometer having a low resistance in parallel with the coil is used to measure the electric current is termed as Ammeter.

**CONSTRUCTION: -**

To measure the current a low resistance is connected parallel to the galvanometer. This resistance is called shunt resistance.

Following figure illustrates the idea:

**CONNECTION IN THE CIRCUIT: -**

An ammeter is always placed in series with other circuit components through which the current is to be measured.

**VOLTMETER**

A galvanometer having high resistance in series is used to measure potential difference is termed as volt meter.

**CONSTRUCTION: -**

To convert galvanometer into voltmeter a high resistance is connected in series with it.

**CONECTION IN THE CIRCUIT: -**

In order to measure the potential difference across a resistor the volt meter is connected in parallel to it as shown.

**FERROMAGNETIC SUBSTANCE:**

A substance which behave like a magnet in the presence of a strong field is called Ferromagnetic substance.

**SOFT FERROMAGNETIC SUBSTANCE:**

The ferromagnetic substances which become magnets in the presence of a magnetic field and lose their magnetism when removed from the magnetic field are called as soft Ferromagnetic substance.

**For example:** soft iron.

**HARD FERROMAGNETIC SUBSTANCE: -**

The ferromagnetic substances which become magnets in the presence of a magnetic field and do not lose their magnetism when removed from the magnetic field are called hard ferromagnetic substance.

**DEMAGNETIZATION: -**

1. The best way of demagnetizing a magnet is to place it inside a solenoid through which an alternating current is flowing.

While the current is still flowing the magnet is withdraw slowly to a distance of several meters from the solenoid in a W-E direction.

The magnet is held in an E-W direction so that it will not be left with some residual magnetism owing to induction in the earth’s magnetic field.

1. Another method to destroying magnetism is to heat the magnet to redness.
2. Magnet also be partially demagnetized by hammering.

**SIMPLE ELECTRIC MOTOR**

A device which converts electric energy into mechanical energy is called motor.

**CONSTRUCTION: -**

1. **ROTOR:**

In a motor the rotating coil can be called the rotor or the armature.

1. **COMMUTATOR:**

The device which supplies the current to the rotor is called a commutator the commutator would be made from two insulated halves of a of a copper ring. The commutator also acts as an automatic current reversing switch for d.c motor.

1. **CARBON BRUSHES:**

Two carbon brushes are caused to press lightly against the commutator by means of spring. Carbon is chosen for the brushes because it is soft compared with the copper commutator worn carbon brushes are easy to replace, but a worn commutator would be expensive to replace.

**WORKING: -**

Suppose the coil is in the horizontal position. When the current is first switched on current will flow through the coil in the direction shown, and by applying right hand rule it will be seen that side ‘ab’ of the coil experiences an upward force and the side ‘cd’ a downward force. These two forces form a couple which causes the coil to rotate in clockwise direction until it reaches the vertical position. When the coil comes to a vertical position both the brushes will be at the gaps between the ring segment and no current will flow. However the coil will continue to move due to its inertia and the ring pieces will come in contact with the brushes again. This time the terminal reverses the direction of the current flow in the coil and causes the side “ab and cd” to experience a force downward and upward respectively. Hence the coil continues to rotate in the clockwise direction as long as the current passes through it.

The speed of rotation depends on the following factors.

1. The magnitude of the current through the rotor.
2. The magnetic field strength of the permanent magnet.
3. Numbers of turn in the coil of rotor.

**MAGNETIZING A STEEL BAR BY MAGNETIC INDUCTION**

1. Stroke the bar with one pole of a permanent magnet so that the pole passes along the bar in the same direction many times. Between strokes the magnet should be raised high above the bar.
2. Test the poles induced in the steel bar by bringing them close to a magnetized compass needle. The pole which repels the N pole of the compass will also be a N-pole.
3. We find that the pole produced at the end of the bar where the strokes ends is of the opposite kind to the one used on the permanent magnet.

Following figure illustrates the idea

**CHAPTER # 18**

**ELECTRONICS**

**ELECTRONICS**

The branch of physics which deals with the development of electron emitting devices with their utilization and controlling of electron flow in the electrical circuit is known as ELECTRONICS.

**SEMI-CONDUCTORS**

A semiconductor is a material that has a conductivity level somewhere between the extremes of an insulator and a conductor.

**N-TYPE SEMI-CONDUCTOR**

The n-type semiconductor is created by introducing those impurity elements that have five valence electrons (Pentavalent). Such as antimony, arsenic and phosphorus. So when pure silicon (14 orbiting electron with 4 electron in the outer most shell valence) and Germanium (32 orbiting electron with 4 electron in the outer most shell) which are normally bad conductor of electricity are doped with a Pentavalent atom for e.g. with a arsenic then Silicon or Germanium become good conductor of negative charges and is known as N-type semiconductor where N stands for negative.

Following figure illustrates the idea

**p-TYPE SEMI CONDUCTOR**

When pure Silicon and Germanium which are normally bad conductor of electricity are doped with a trivalent atom. For example: Boron or Indium, then Silicon or Germanium becomes good conductor of positive charges (holes are created) and is known as p-type substance where p stands for positive.

Following figure illustrates the idea

**DOPING**

The process of adding very small calculated amount of other substances or impurities (e.g. Arsenic, phosphorous, Boron and Indium etc.) to the insulators crystal of Silicon or Germanium to increase the numbers of free electron or the number of holes i.e. to make the N-type or p-type conductor is known as doing.

**HOLE**

The departing electron leaves a vacancy in the outer or hit. We call this vacancy as a hole.

**p-n JUNCTION DIODE**

When a manufacturer dopes a crystal so that one half of it is p-type and the other half is n-type something new comes into existence which is known as p-n Junction or Diode.

Its symbol is:

Where,

Since the diode is a two terminal device, the application of a voltage across its terminals leaves three possibilities.

1. no bias
2. forward bias
3. reverse bias
4. The diode is no baised or unbiased which means that no external voltage is applied to it.
5. **FORWARD BIAS:** if voltage is applied to a PN-JUNCTION that is it is baised such that the positive potential to p-type region and negative potential of the battery to n-type region then positive holes from p-type will drift to n-type and electron from n-type will move to p-type region across the junction. Hence diode conducts an electric current and is called Forward bias.

Following figure illustrates the idea

**REVERSE BIAS**

In reverse bias the terminal of the battery is reversed with respect to forward bias its means that p-type connected with the –ve terminal of the battery and “n” type is connected with the +ve terminal of the battery due to this bias the holes in the p-type material and the electrons in the n-type material will be attracted by the negative and the positive terminals of the battery and will therefore move away from the junction so the flow of charge across the junction will therefore be zero.

Following figures illustrates the idea

**RECTIFICATION**

The process of converting alternating current into unidirectional current is known as rectification.

**RECTIFIER:**

Rectifier is a device that converts A.C current to D.C current.

**DIODE AS A RECTIFIER:**

As the diode allows current to pass in one direction hence it is used to convert A.C into D.C i.e. as a rectifier.

**HALF WAVE RECTIFICATION:**

In half wave rectification we use a diode with any specific resistance; both diode and resistance are in series as shown

If A.C is applied to a diode, then during the positive half of the cycle of A.C voltage the diode is forward baised, current flows through the junction from 0 to its peak value and then again to 0. During the negative half of A.C voltage the diode is in reversed bias and hence no current flows through the junction. This is called half wave rectification.

**TRANSISTOR**

The Transistor is a three layer semi-conductor device consisting of either two n-type and one p-type layer of material or two p-type and one n-type layers of material.

There are two types of Transistor.

1. npn
2. pnp

**npn TRANSISTOR:**

When a p-type substance is sandwiched between two pieces of n-type substance then it is known as npn Transistor.

Following figure illustrates the idea

**pnp TRANSISTOR**

When a n-type substance is sandwiched between two pieces of p-type substance then this type of Transistor is known as pnp Transistor.

Following figure illustrates the idea

**MERITS OF TRANSISTOR**

1. Transistors are very small in size and light weight.
2. They are more efficient since less power was absorbed by the device itself.
3. They produce little heat.
4. They can be used with very small potentials.
5. They are instantly for use.
6. A Transistor circuit is generally simpler than its equivalent tube circuit.

**IMPORTANCE OF TRANSISTOR:**

Importance of a Transistor is due to the fact that of the base emitter potential of base current is changed by a small amount then the collector current changes by a large amount.

**OPERATION OF TRANSISTOR:**

If the base emitter pn junction is toward baised by applying a potential difference of about . Electron flow from the n-type emitter into the p-type base. The loss of electrons in the emitter is compensated by electrons entering the emitter from the external circuit and form the emitter current , since the base is very thin and is lightly doped a small number of the electrons from the emitter combine with holes while most electrons pass through the base under the attraction of the positive collector. They cross the base collector junction and become the collector current in the external circuit. The loss of holes which occurs in the base is compensated by some holes flowing to it from the base power supply. This forms a small base current . Since the current leaving the transistor equals that entering.

**AMPLIFIER**

A device that increases an electrical signal applied to it as an input (device that increases the voltage, current or power level) is known as Amplifier.

**TRANSISTOR AS AN AMPLIFIER:**

A small change in the base current produce a large change in the collector current due to this characteristic a transistor is used as an amplifier.

**RADAR**

It is an abbreviation of the words “Radio detection and Ranging”.

**USES: -**

1. It helps the pilot in landing a plane even in low visibility due to fog or at night.
2. It also helps the captain of a ship to be wave of other ships in the surroundings, ice bergs and hidden rocks in the sea.
3. Due to the above reasons every modern airport is equipped with a radar system.

**CONSTRUCTION AND WORKING:**

Radar consists of a transmitter, a receiver and several indication devices.

The transmitter generates electromagnetic waves with frequency which are sent out in any desired direction in a narrow cone shaped beam with the help of a concave antenna. The radar waves travel out word with the velocity of light and arc reflected back when they strike a distant object. The reflected wave energy which returns and strikes the radar antenna is amplified in the radar receiver and these strong signals are fed to the derived indicating devices. These devices measure the time taken by the radar waves to strike the object and come back. By knowing the wave velocity the distance of the object from the radar can be found.

**CHAPTER # 19**

**NUCLEAR PHYSICS**

**ATOMIC NUMBER OR CHARGE NUMBER (Z)**

**DEFINITION: -**

The total number of protons or electrons in an atom is called its atomic number or charge number. It is represented by Z.

i.e.

**MASS NUMBER (A):**

**DEFINITION: -**

The total number of protons or neutrons in a nucleus of an atom is called its mass number or atomic mass number. It is represented by ‘A’.

i.e.

**SYMBOLIC REPRESENTATION:**

If ‘X’ is an element then its charge number (Atomic number) and mass number can be represented as,

**EXAMPLES:**

For examples, the symbolic representation of nuclei of some elements are:

Hydrogen (Z = 1 protons, A = 1 protons)

Helium (Z = 2 protons, A = 2 protons + 2 neutrons)

Carbon (Z = 6 protons, A = 6 protons + 6 neutrons)

Uranium (Z = 92 protons, A = 92 protons + 143 neutrons)

**MASS AND CHARGE NO ELECTRON AND PROTON**

1. The proton has a mass of and carries a charge of .
2. An electron has a mass of and carries a charge of .
3. The diameter of a nucleus is the order of , which is ten thousand times smaller than the diameter of an atom.

**ISOTOPES**

**DEFINITION: -**

Isotopes of an element are atoms have the same atomic number but different mass number.

**OR**

These are the atoms of same element having same charge number (Atomic number) but they are differ in mass number.

**EXAMPLES:**

1. **HYDROGEN HAS THREE ISOTOPES:**
2. “ORDINARY HYDROGEN” with one proton only.
3. “DEUTERIUM” with one proton and one neutron.
4. “TRITIUM” with one proton and two neutrons.

1. **URANIUM HAS THREE ISOTOPES:**

, ,

1. **OXYGEN HAS THREE ISOTOPES:**

, ,

**RADIO ACTIVITY**

**DEFINITION: -**

Elements which have a large atomic number are unstable and they emit radiations continuously such elements are called radioactive elements and the process of emitting radiation is known as radioactivity.

**OR**

It is the phenomenon by which atoms of unstable nuclei emit radiations and charge into atoms of stable nuclei. It is an irreversible process.

**PARENT ELEMENT:**

The element which is responsible for emitting radiations is called parent element.

**DAUGHTER ELEMENT:**

The element which is formed as a result of emission of radiation is called daughter element.

**SEPARATION OF RADIATION**

There are three types of radiations emitted from the radioactive elements.



These three types of radiation can be separated by following experiment.

**EXPERIMENT:**

A small quantity of radioactive substance for example “Radium” is placed in the cavity of the Lead block, a photographic plate is placed in front of the cavity as shown in the figure. The apparatus is placed in an evacuated chamber.

This chamber is then placed between the poles of a strong magnet so that the magnetic field is perpendicular to the plane of paper and is directed inwards.

Radiation coming out from the radioactive substance gives three separate images on photographic plate which are called Alpha , Beta and Gamma rays.

**PROPERTIES OF ALPHA , BETA & GAMMA RAYS**

**PROPERTIES OF ALPHA RAYS**

1. **MASS:**

The mass of each is nearly four times the mass of hydrogen nucleus.

1. **CHARGE:**

The particles which shows deflection like positive charge are termed as Alpha particles. The charge on each is positive and equal to twice the charge on proton.

1. **IONIZATION POWER:**

They are strong ionizing agent. They are 100 times better ionizing agent than and 10,000 times than .

1. **PENETRATING POWER:**

Penetrating power of is less than that of Beta and Gamma rays.

1. **FLUORESCENCE:**

They produce fluorescence in a solution like zinc sulphide.

1. **EFFECT ON HUMAN BODY:**

They produce burns on human body.

1. **ARTIFICIAL RADIOACTIVITY:**

They produce artificial radioactivity when absorbed by nuclei of certain elements.

**PROPERTIES OF BETA RAYS**

1. **CHARGE:**

The particles which show deflection like negative charge are termed as Beta particles. They are found to be high energy electron.

1. **IONIZATION POWER:**

Ionization power of is less than alpha particles but move than Gamma rays.

1. **PENETRATING POWER:**

Penetrating power of is greater than Alpha rays but less than Gamma rays.

1. **FLUORESCENCE:**

They produce fluorescence in Bariumplatinocynide.

1. **Velocity:**

The velocity of is from to .

1. **KINETIC ENERGY:**

The kinetic energy of is less than that of .

**PROPERTIES OF GAMMA RAYS**

1. **CHARGE:**

They are not deflected by electric or magnetic therefore they have no charge.

1. **ELECTROMAGNETIC RADIATION:**

They are electromagnetic radiation similar to .

1. **VELOCITY:**

The velocity of Gamma rays is equal to the velocity of light i.e. .

1. **PHOTO ELECTRONS:**

These radiations eject electrons when incident on some metal. (The phenomenon is called photo electric effect.)

1. **PENETRATING POWER:**

penetrating power of is more than . The penetrating power of is about hundred times larger than that of .

1. **FLUORESCENCE:**

produce feeble fluorescent when incident on a screen coated with barium platinocyanide.

**HALF LIFE:**

The time required for the dis of one half of the original amount of radioactive substances is called Half Life.

**OR**

The half-life of a radioactive element is the time during which half of the parent elements decay into daughter element.

The half-life of different elements ranges from to years.

**FISSION REACTION**

**DEFINITION: -**

The process of breaking up a heavy nucleus into two nuclei of nearly the same size with the release of energy is known as nuclear fission reaction.

**EXPLANATION: -**

Hann and stransman made an important discovery. They found that when an isotope of uranium is bombarded by slow moving neutrons than fission takes place simultaneously. This discovery was important because no high energy particles were required to produce fission.

**EQUATION: -**

The fission reaction in case of can be represented by the following equation.

(Barium) (Krypton) (Neutrons)

**PRODUCTS OF REACTION**

The products of this fission reaction are barium and krypton. Beside these two or three neutrions are also emitted which can produce fission in other nuclei of uranium. The fission fragments are also radioactive and they decay in a number of steps by emitting to stable nuclei.

**ENERGY RELEASED**

About 200 Mega electron volt energy is released when one nucleus of uranium under goes fission.

**FISSION CHAIN REACTION AND CRITICAL MASS**

If the three fast neutrons produced in the fission of are slowed down, they can start nuclear fission in three more nuclei with the release of nine neutrons. These nine neutrons can be used to start fission in nine more nuclei with the production of twenty seven neutrons and so on. In this way the fission reaction started with a single neutron in uranium can proceed further by itself under suitable conditions. Such a fission reaction is called fission chain reaction.

It is found that chain reaction can be set up only when the amount of uranium is not less than a certain definite value. This quantity of uranium is known as its critical mass.

**DIAGRAMATIC REPRESENTATION OF NUCLEAR FISSION CHAIN REACTION**

**FUSION REACTION**

**DEFINITION: -**

The process in which two lighter nuclei are fused to form another heavy nucleus with releases of energy is called FUSION REACTION.

**EXPLANATION: -**

1. **FUSION OF TWO DEUTERIUM:**

In a fusion reaction two atoms of heavy hydrogen i.e. Deuterium are fused together to form helium atom along with large amount of energy.

1. **FUSION OF DEUTERIUM AND TRITIUM:**

When deuterium and tritium nuclei are brought together they also form a helium nucleus with the release of a large amount of energy and a neutron. The process is represented as

**ENERGY**

In this process the sum of the masses of the helium nucleus and neutron is loss than the sum of masses of the deuterium and tritium nuclei. This difference in mass according to Einstein’s mass energy relation released as energy.

One kilogram me of Deuterium when converted into helium the energy released is six times greater than the energy produced by fission of one kilogram me of Uranium.

The energy obtained in fusion of two heavy hydrogen nuclei is .

**REQUIRED TEMPERATURE**

It is difficult to produce fusion reaction because when two positively charged nuclei are brought closer together work has to be done against the electrostatic repulsion. It required great deal of energy. This energy for thermo nuclei reaction is possible only through high temperature. The required temperature is approximately equal to million . This temperature is not possible on the surface of the earth, but in Hydrogen bomb this much temperature is attained by using fission process to start the fusion reaction.

**ADVANTAGES OF FUSION REACTION**

1. Hydrogen is much easily available and also cheaper as compare to Uranium.
2. Fusion reactions do not produce any radioactive waste products.

**RADIO ISOTOPES**

**DEFINITION: -**

There are the atoms of same element having same charge number (Atomic number) but they are differ in their mass number. Some of these are unstable and radioactive such unstable and radioactive isotopes are called “RADIO ISOTOPES”.

**Examples:**

Some examples of naturally occurring radio isotopes are carbon , uranium , radium , radon .

**USES OF RADIO ISOTOPES**

* **INDUSTRY:**

1. Radio isotopes are used to detect leakages in pipes by introducing small quantities of radio isotope in to the fluid in the pipe. A radiation detector is used to check whether the radio isotope is leaking anywhere in the pipe or not so in this way indicating a fault in the pipe.
2. Gamma rays are helpful in finding the defects in welding and moulding. For example 60-60 is used to detect cracks in welded joints.
3. Radio isotopes are used for keeping the thickness of paper uniform in the paper mill.
4. Radio isotopes are used to locate and remove the faults and wear and tear in a machine.
5. Radio isotopes are used to maintain the thickness of metal sheets uniform.

* **AGRICULTURE:**

1. Radiation is used to kill bacteria and preserve food.
2. Radio isotopes are used to determine the optimum amount of fertilizers and other nutrient in take by plants.
3. Radio isotopes are used to improve the fertilizers and animal food.
4. New types of seeds have been developed by exposing them to radiation. This plant gives more production and they have more resistance against diseases.
5. Diseases of plants, insect harmful to plants are being eradicated by the use of isotopes.

**MEDICINE AND BIOLOGY**

1. Radio isotopes have played a vital role in determine the effectively and absorption of medicine in various parts of the body.
2. Iodine 131 is used for the study of thyroid glands.
3. Phosphorus -32 is used to locate the position of tumor in the brain.
4. Radio isotopes e.g. phosphorus has been found effective for treating leukemia. Radiation emitted by it destroys the excess production of white blood corpuscles.
5. Radio sodium has been useful in tracing the blood circulation in the body.
6. Radio cobalt -60 has been widely used to treat cancerous tumors inside the body.
7. Radiation in low dosages can also be used for sterilizing instruments and other surgical instruments.

**RADIATION HAZARDS**

Radioactive radiations are helpful in many ways but their wrong use or their accidently exposure can have harmful effects.

They can damage our body cells. Highly intensity radiation destroys large number of vital body cell. The destruction of the cell is caused by the ionizing properties of the radiations. The amount of ionization produced by them depends upon the intensity and energy of radiation.

A body, If strongly irradiated may suffer the following diseases.

1. Anemia
2. Leukemia
3. Tumors etc.

The air and water used in the atomic energy laboratories and reactors may become radioactive and of proper precautions are not taken then these can spread radioactivity in the surrounding areas.

During atomic fall out radioactive materials deposits in the field and so the vegetable produced in these fields are also become radioactive.

**PRECAUTIONS TO MINIMIZE RADIATION DANGER**

1. While giving treatment to a patient by radiation doctors should take minimum possible time for radiation exposure.
2. The radiations from a reactors are shielded by thick concrete walls.
3. Since lead is a high density material therefore it stops radiation falling upon it so in laboratories radioactive substance should covered in lead box.
4. In radioactive laboratories and atomic reactors person should use a plastic clothes as a safety from radiation.
5. Since the source emits radiations in all directions and its. Falls according to the relation therefore one should keep a safe distance away from the radiation emitting source.

**MASS ENERGY EQUATION**

According to Einstein mass and energy are mutual convertible under certain conditions and the energy E produced by mass ‘m’ is given by,

The above relation is called mass energy relation where,

**SOLAR ENERGY**

The energy obtained from the sun is called solar energy. It is due to the fusion. The fusion reaction is possible in the sun due to very high temperature. The temperature inside the sun is about . Hydrogen isotopes serve as the fuel for fusion reaction in the sun. during each second millions of ions of this fuel are consumed.

**NUCLEAR REACTOR**

**DEFINITION: -**

A system used to obtain a controlled amount of heat from nuclear fission is called a nuclear reactor.

**PARTS:**

There are four parts of a nuclear reactor.

1. Fuel
2. Moderator
3. Control rods (Neutron absorber)
4. Coolant
5. **FUEL**

Uranium is usually used in the nuclear reactor as a fuel. It is fabricated in the form of cylindrical rods.

1. **MODERATOR & MODERATION**

Fast moving neutrons leaving the surface of uranium rod will be slowed down by graphite or Heavy water. The process of slowing down the neutrons is called moderation and the material used for this purpose is called moderator.

1. **CONTROL RODS (NEUTRON ABSORBER)**

To control the chain reaction Boron or cadmium rods are used. These rods are termed as control rods. The function of these rods is to absorb the neutron.

1. **COOLANT**

The heat produced in a nuclear reactor is carried away by the circulation of or pressurized water inside the core of the reactor. These fluids are termed as coolants.

The coolant transfers the heat energy from the core to boiler for producing high temperature steams.

The steam produced is used for driving turbine generator for the production of electricity.

|  |  |
| --- | --- |
| **FISSION REACTION** | **FUSION REACTION** |
| **DEFINITION:**  The process of breaking up a heavy nucleus into two nuclei of nearly the same size with the release of energy is known as nuclear Fission reaction. | **DEFINITION:**  The process in which two lighter nuclei are fused to form another heavy nucleus with release of energy is called Fusion reaction. |
| **EQUATION:** | **EQUATION:** |
| **ENERGY RELEASED:**  In fission reaction less energy is released. | **ENERGY RELEASED:**  In fusion reaction more energy is released for example when one kg. of Deuterium is converted to helium the energy released is six times greater than the energy produced by fission of one kilogram me of uranium. |