

PHYSICS

- Physics is that branch of physical science in which the matter and energy mutually interact to each other.

MATTER -

- That substance which occupies space and possesses mass, that which we can experience from our senses.

MASS -

- Quantity of matter in a substance is called mass.

WEIGHT -

- Weight is that force through which earth attracts a thing.
- Its unit is Newton.

$$W = mg$$

- Value of weight is dependent of gravitational acceleration,
- Hence mass of a thing always remain unchanged

But its weight changed.

- Weight is less at the equator and when we move towards poles weight of a thing increases

FORCE -

- Force is that factor which brings changes in the state of a thing.
- Force is pull or push which brings changes in the state of a thing.

$$\mathbf{F = ma}$$

- It is a vector quantity
- Its SI unit = Newton (Kg.m/sec²) and CGS Unit = Dyne
- 1 N = 10⁵ Dyne
- There are four types of fundamental forces in our nature
 - i. Gravitational Force
 - ii. Weak Force
 - iii. Electromagnetic Force
 - iv. Nuclear Force

Gravitational Force:-

- Attraction force between two bodies having mass is called Gravitational Force.
 - This force is negligible in bodies of very less mass.
 - It's range is infinite
 - It increases as mass increases.
 - It is weakest among all existing forces.
-
- Gravitational Force:- Every body in the universe attracts another body with a force whose magnitude is directly proportional to the product of the masses of those bodies and inversely proportional

to the square of the distance between those bodies. this force of attraction is called gravitational force.

➤ $\vec{F} \propto \frac{M_1 M_2}{R^2}$

➤ $\vec{F} = \frac{GM_1 M_2}{R^2}$

➤ Where:-

➤ M_1 and M_2 are the masses of both the bodies

➤ R = distance between the two bodies.

➤ G = gravitational constant, whose value is $6.673 \times 10^{-11} \text{ NM}^2\text{Kg}^{-2}$

➤ This is called the universal gravitational constant.

Importance of universal law of Gravity:-

➤ The force that binds us to the earth.

➤ The motion of the moon around the earth.

➤ motion of planets around the sun.

➤ Tides due to the moon and the sun.

Characteristics of Gravitational force:-

➤ Gravitational force is attractive in nature.

➤ Gravitational force does not depend on nature of medium

➤ Gravitational force is a conservative force is nature.

➤ It is a central force, acting along the line joining the centers of mass of two bodies and it obeys the law of inverse square.

Earth's Gravitational force and changes in it:-

- The gravitational pull exerted by the earth is called gravitational force. So when objects fall towards the earth due to this force alone, we say that the objects are in free fall.
- In free fall, there is no change in the direction of velocity of the object as it always falls towards the earth. But the magnitude of the velocity of the object changes.
- The change in velocity or acceleration of an object due to the gravitational force of the earth is called gravitational acceleration. It is denoted by 'g' and its unit is M/S².
- Calculation the value of gravitational acceleration 'g'.
- force on a body by the earth -
 - $F = \frac{GM_e \cdot M}{R^2} \dots \dots \dots [1]$
 - Where,
 - M_e = Mass of the earth.
 - M = mass of the body
 - R = radius of the earth
 - The acceleration produced due to the F will be gravitational acceleration then.
 - $F = m \times g \quad (2)$
 - Substituting the value of F in eq (i)
 - $m \times g = \frac{Gm_e \cdot m}{R^2}$
 - $g = \frac{Gm_e \cdot m}{R^2 m} = \frac{Gm_e}{R^2}$

➤ $\therefore G = 6.673 \times 10^{-11} \text{ NM}^2/\text{kg}^{-2}$

➤ $M_e = 6 \times 10^{24} \text{ kg}$ (mass of earth)

➤ $R = 6.4 \times 10^6 \text{ m}$ (radius of the earth)

➤ $\therefore g = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{[6.4 \times 10^6]^2}$

➤ $g = 9.8 \text{ ms}^{-2}$

➤ Hence the value of gravitational acceleration of the earth is 9.8 ms^{-2}

Difference between Gravitational acceleration and Gravitational Constant.

Gravitational acceleration:-	Gravitational Constant.
1. Its value is 9.8 M/S^2 .	1. Its value is $6.673 \times 10^{-11} \text{ NM}^2/\text{Kg}^2$
2. Its value is different at different places.	2. Its value is same at different places.
3. It's unit is m/s^2 .	3. It's unit is NM^2/kg^2
4. It is a vector quantity	4. It is a scaler quantity

Change in gravitational acceleration:-

Due to height (h).

➤ The value of gravitational acceleration decreases with increase in height (h).

Due to depth-

- With increasing depth the value of gravitational acceleration is also decrease and becomes zero at the centre of the earth.

Due to the earth's rotation on its axis-

- Due to the rotational speed of the earth, the value of gravitational acceleration increases as we move from the equator to the poles.
- If the earth stop rotating around its axis then the value of g will increase everywhere except the poles but if the rotation speed of the earth is increased then the value of g will decrease at all the places except the poles.

Gravitational Field (E) :-

- It is the area around a body in which that body experiences the gravitational pull of another body
- Consider a particle of mass M, then the magnitude of the resultant gravitational field strength, at a distance of r, from M, is given by the formula,

- $E = \frac{GM}{R^2}$

Gravitational Potential (V) :-

- The value of gravitational potential at a location is equal to the work per unit mass that would be needed to move an object to that location from a fixed reference location.

- $V = \frac{-GM}{R}$

- $E = \frac{-dV}{dR}$

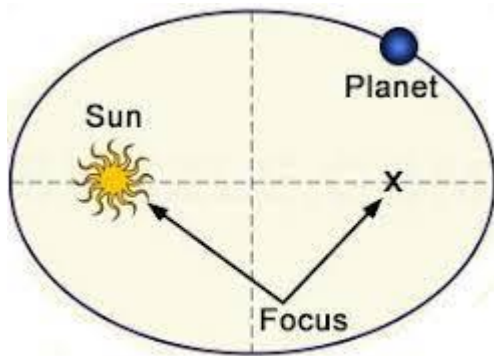
- Note:- The gravitational potential (V) is related to the gravitational field (E).

Motion of the objects under the effect of earth's gravitational force:-

- Since the value of g is constant near the earth, all the equations of uniform acceleration will be valid even if the acceleration a , is substituted by g . This is the equation
- $v = u + at \dots\dots (1)$
- $S = ut + \frac{1}{2}at^2 \dots\dots (2)$
- $v^2 = u^2 + 2as \dots\dots (3)$
- Here u = initial velocity, v = final velocity
- s =distance covered by the object in time t .
- While using these equations, if the acceleration (a) is in the direction of velocity i.e., in the direction of motion, then we will take +Ve and if it is opposite to the direction of motion then we will take -Ve.

Kepler's Law Of Planetary Motion

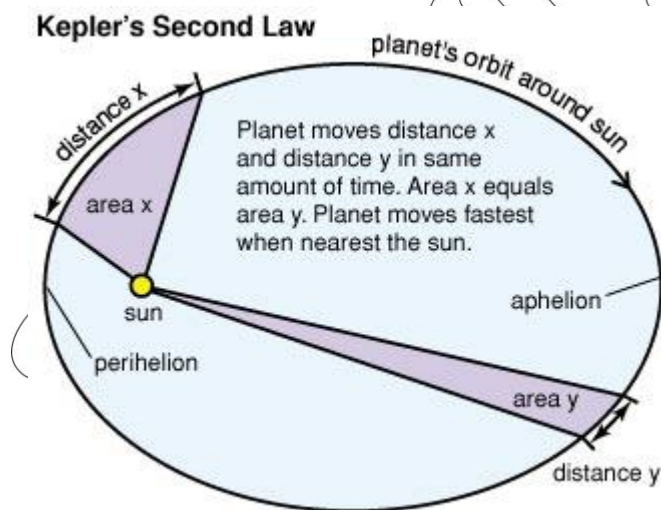
- Kepler propounded three laws related to the motion of planets.
- **First law/ Law Of Orbits:-** According to this law, every planet revolves around the sun in an elliptical orbit and the sun is located at a focal point of the planet's orbit.



Kepler's First Law

Second law / Law Of Areal Velocity :-

- The regional velocity of the each planet remains constant. Its effect is that when the planet is near the sun its velocity increases and when it is far away its velocity decreases.
- In other words , A line segment joining a planet and the sun sweeps out equal areas during equal intervals of time.



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Third law / Law Of Periods:-

- The square of a planet's orbital period is directly proportional to the cube of the length of the semi-major axis of its orbit.

- $T^2 \propto r^3$
- Its effect is that the planets located at a greater distance from the sun have a longer period of revolution. Like as:- revolution period of mercury is 88 days and revolution period of neptune is 165 years.

Orbital Velocity Of Satellite

- The minimum velocity required for the satellite to move in its orbit is called its orbital velocity.
- Let a satellite of mass (m) be revolving around the earth with velocity v_1 on a circular radius r_1 , then
- $V_0 = \sqrt{\frac{gR_e}{R_e+h}} [\because R_e + h = r]$
- Where,
- R_e = Radius of the earth
- h = height of the satellite from the surface of the earth.
- Note:- The value of the orbital velocity does not depend on the mass of the satellite.
- Q. A person whose weight is 1200 N on earth becomes 200 N on the moon. Find the mass of that person on earth and on the moon.
- What will be its gravitational acceleration on the moon ? [$g=10 \text{ m/s}^2$]
- The weight of the person on the earth = 1200 N (w_1)
- The weight of the person on the moon = 200 N (w_2)
- Gravitational acceleration of the earth = 10 m/s^2
- $w = m \times g$

➤ $1200 = m \times 10$

➤ $m = 120 \text{ kg}$

➤ Mass on the moon will remain the same as it is on the earth ,because mass remains same everywhere.

➤ Mass 120 Kg on the moon

➤ $w_2 = m \times g$

➤ $200 = 120 \times g$

➤ $g = \frac{200}{120} = \frac{10}{6} = \frac{5}{3} = 1.66 \text{ m/s}^2$

➤ *Q Find the mass of an object whose weight is 49 N.*

➤ $w = 49 \text{ N}$

➤ $g = 9.8 \text{ m/s}^2$

➤ $w = mg$

➤ $m = w/g = 49/9.8$

➤ $m = 5 \text{ kg}$

PRESSURE:-

➤ It is the amount of force applied perpendicular to the surface of an object per unit area.

➤ Unit = Pascal = N / m^2

$P = F/A$

ATMOSPHERIC PRESSURE:-

- The pressure applied on our body due to presence of air, dust particles, water vapor is called Atmospheric Pressure.
- Atmospheric Pressure is measured through barometer.
- Pressure due to atmosphere is 760 mm Hg.
- Altimeter, Instrument used for measuring height from oceanic surface uses atmospheric pressure to calculate height.

Effect of Pressure on melting and boiling point:-

- Generally on increasing pressure melting point reduces. (Ice - Water).
- Boiling point always increases by increasing pressure (Water - Vapour).
- Food gets prepared very early in pressure cooker because of increase in boiling point.
- Food takes time in getting prepared at height due to less atmospheric pressure.

ESCAPE VELOCITY:-

- That minimum velocity with which if a thing is thrown in space than it never comes back and escapes gravitational field of earth.
- Earth's Escape Velocity = 11.2 km/sec
- Escape velocity is depends on the mass and radius of the celestial body.
- The escape velocity play an important role in the Presence or absence of atmosphere on any planet .

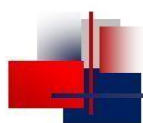
- Moon's escape velocity is 2.4 km/sec, that's why moon doesn't have atmosphere.
- Hydrogen molecule's normal velocity at 500 Kelvin is 2.6 km/sec which is greater than moon's escape velocity.

UPTHRUST:-

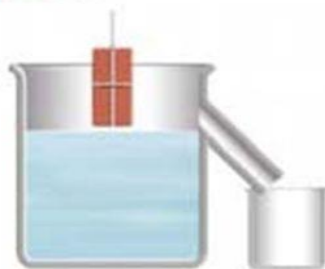
- When a thing is dipped in the liquid two forces apply on that thing.
- One pulls it downward and other pushes it upward.
- Force working upward is called Upthrust

ARCHIMEDES PRINCIPLE:-

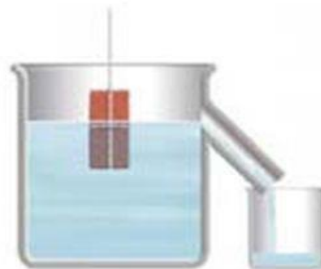
- When a thing is partially or completely immersed into a fluid at rest, the fluid exerts an upward force of buoyancy which is equal to the weight of the displaced fluid.



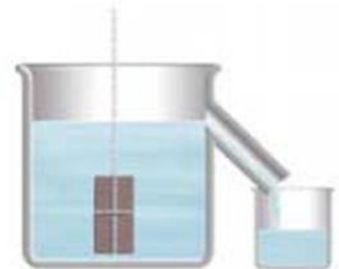
Archimedes' Principle



A An object is lowered into a container of water.



B The object displaces water, which flows into a smaller container.

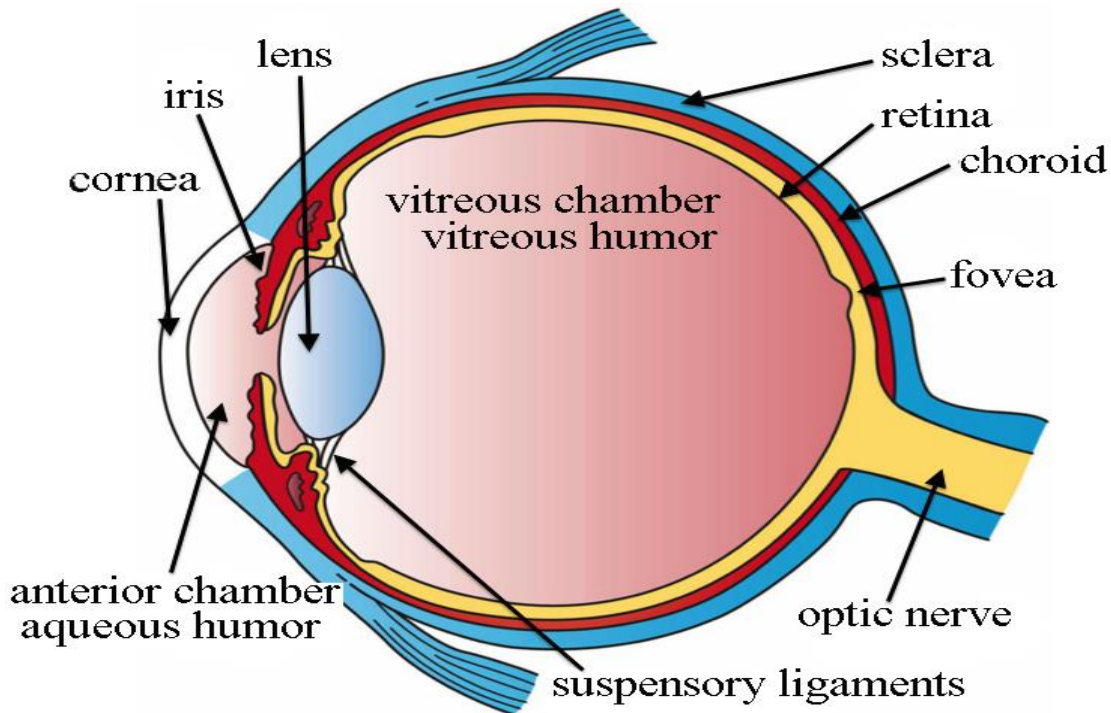


C When the object is completely submerged, the volume of the displaced water equals the volume of the object.



EYE (Photoreceptor)

- These are photosensitive organs.



Cornea :-

- It is the outer transparent visible part.
- Cornea transplantation is successful because it lacks blood vessels.

Sclera:-

- It is made up of white, hard, opaque thick fibrous connective tissue in human.
- It is also called "White of eye"

Iris :-

- There is present an aperture in the Centre of iris, it is called pupil. Light rays enter in the eyeball through pupil.
- In bright light the size of the pupil decrease while in dim light the size increase.

Retina:-

- This layer is made up specialized sensory cells.
- Rods and cones are found in this layer.
- Rods differentiate between light and dark. These are more sensitive than cones.
- Cones are thick and small cells which differentiate among different colours in full light

Lens :-

- A transparent, biconvex lens is present just after iris.
- Lens has the ability to adjust or power of accommodation so that the image of an object placed at any distance is formed on the retina.
- Lens divides the cavity of eyeball into two chambers.

1. Aqueous chamber

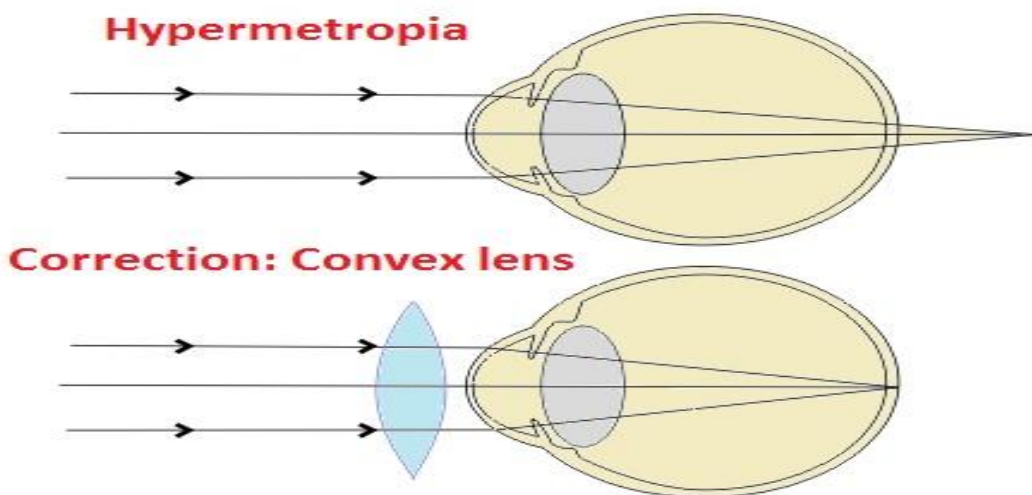
2. Vitreous chamber

- When amount of this humor is increased in the eye chambers then pressure is increased inside the eye ball. Thus retina damaged. This is known as glaucoma.

Defects of eye

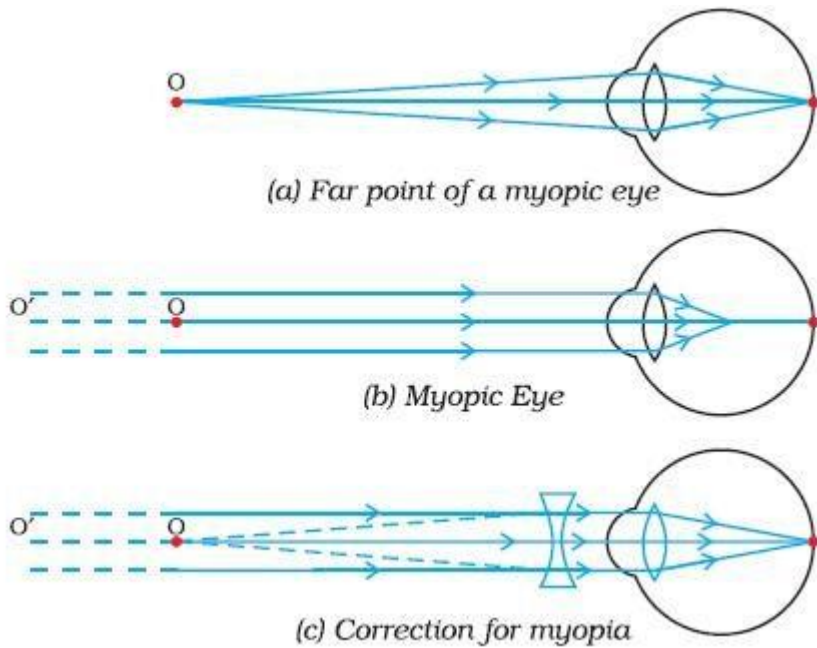
1. Hypermetropia (far sightedness) :-

- In this defect of eye, person is able to see objects placed at far distance but is unable to see objects close to him or her.
- In this defect image is formed behind the retina.
- To cure this defect person should wear convex lenses in spectacles.
- Sometimes in old age this defect may occur due to reduction in the flexibility of lens or ciliary body, then it is known as presbyopia.



2. Myopia or Nearsightedness:-

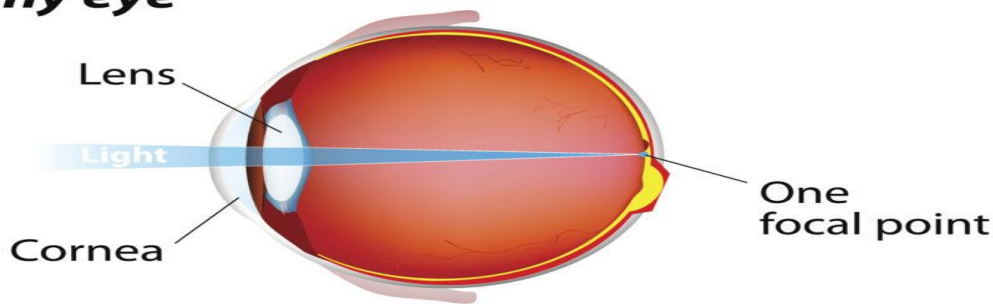
- In this defect of eye, person is able to see objects near/close to him or her but is unable to see objects placed at far distance.
- In this defect image is formed before the retina.
- To overcome this defect person should wear concave lenses in spectacles.



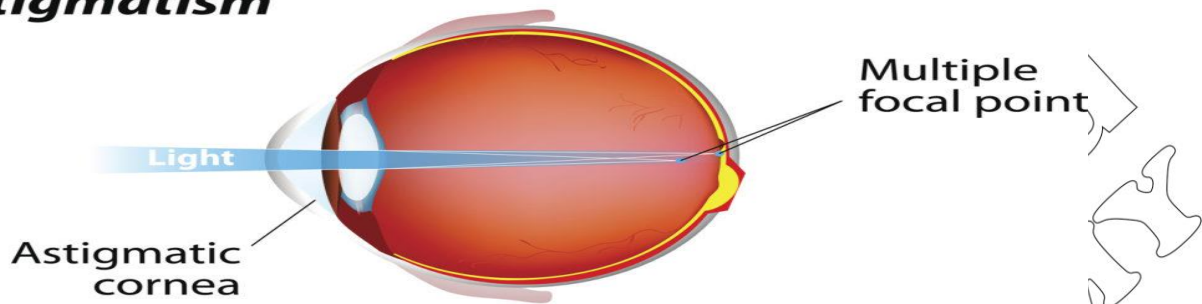
3. Astigmatism :-

- In this defect curvature of cornea is changed.
- As a result of that light rays do not focus on macula lutea but somewhere else, causing incomplete and blurred vision.
- This defect may be cured by cylindrical lenses.

Healthy eye



Astigmatism



4. Trachoma:-

- It is caused by a microbe *Chlamydia trachomatis*.

5. Strabismus :-

- It is due to loosening or contraction of the any of 6 skeletal muscles which give the proper position to the eye ball in its orbit. Thus eye ball inclines towards one side of orbit. It is strabismus or squint eyes
- This defect is prevented by curing the related muscle by operation.

6. Cataract:-

- In this defect, lens becomes more solid, brown or more flat.
- It occurs in old age mostly.

- The lens becomes opaque, and reduces its power of accommodation.
- At this stage person can not see.
- A new lens is administered in place of defective lens by operation.

TEMPERATURE AND HEAT

Temperature-

- Temperature is degree of coldness and hotness. It is the Thermal State.

Heat -

- Heat is a form of energy which gets transmitted from higher temperature to lower temperature.
- Heat can be converted into work.
- Unit of heat is calorie.
- 4.2 Joule work can be done in 1 calorie.

CALORIE -

- Heat required to raise temperature of 1 gram water by 1°C is one Calorie.

INTERNATIONAL CALORIE -

- Heat required to raise temperature from 14.5°C to 15.5°C is called International Calorie.

BRITISH THERMAL UNIT -

- Heat required to raise temperature of 1 pound water by 1°F is called British Thermal Unit.

- Thermometer is used to measure temperature.
- Generally mercury is used in Thermometer.
- Mercury expands after getting heated, it is used because of shining quality.
- Freezing point of mercury is -39°C and its boiling point is 356.7°C which means it can be used for temperature range from -39°C to 357°C .
- Alcohol thermometer is used for lower temperature .

Gas thermometer

- Gas thermometer is used for higher temperature. In it H_2 gas (500°C) and N_2 gas (1500°C) is used.(Charles's law)

Platinum resistant thermometer-

- Along with rising temperature resistance of the conductor also increases.
- Platinum resistance thermometer works on this principle only.
- Its range is -200°C to 1200°C .
- Digital Thermometer used these days are based on resistance thermometer.

PYROMETER:-

- Extreme Temperatures are measured by Pyrometer.

- Every physical body emits radiation after being heated.
- These radiations are proportional to fourth power of temperature of that body.

$$R \propto T^4$$

- Pyrometer works on the basis of above principle.
- The temperature of all stars including the sun is determined with the help of a pyrometer.
- Minimum temperature for this should be 800°C

SCALES OF TEMPERATURE:-

1. Celsius ($^\circ \text{C}$):-

2. Fahrenheit ($^\circ \text{F}$) –

3. Kelvin –

1. Celsius ($^\circ \text{C}$):-

- If freezing point of water is taken as 0° and boiling point as 100° and this range is divided in 100 equal parts then each part would make 1°C .

2. Fahrenheit ($^\circ \text{F}$) –

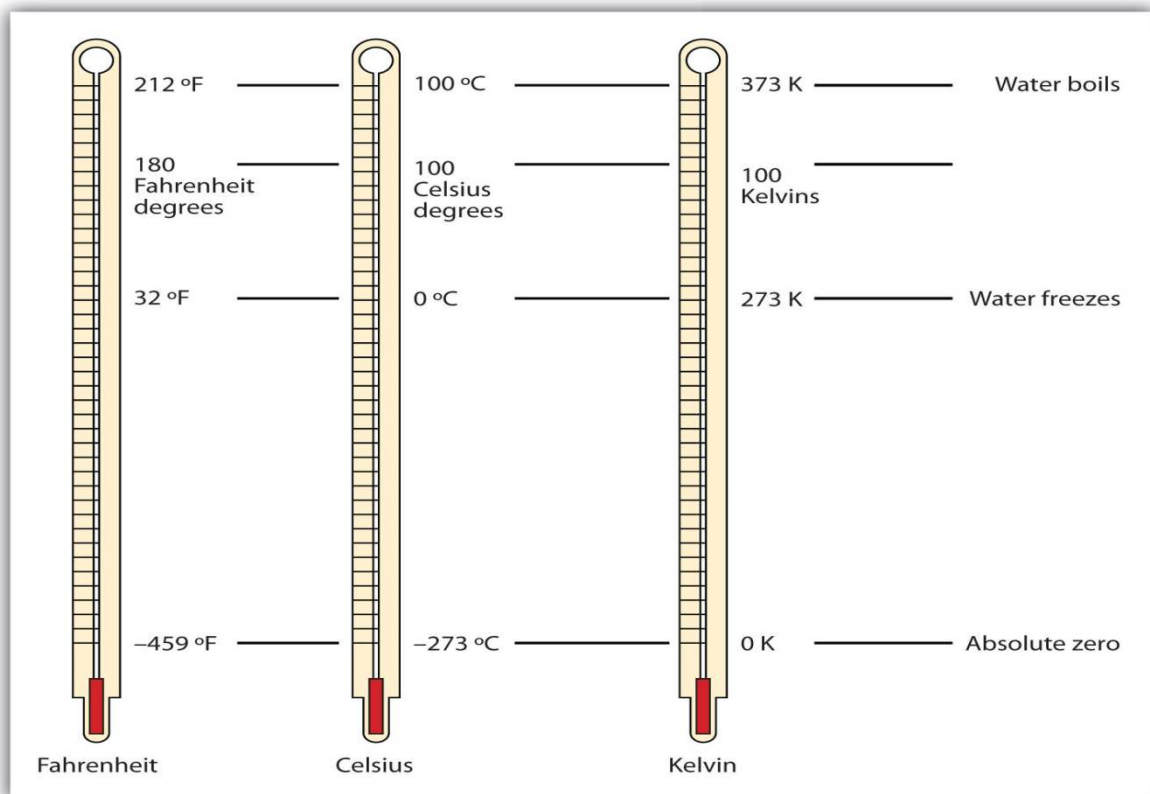
- If freezing point of water is marked 32°F and boiling point as 212°F and this range between two marks is divided in 180 equal parts then each part would make 1°F .

3. Kelvin –

- Freezing point of water is marked as 273 K and boiling point as 373 K and range between two marks is divided in 100 equal part then each part would make 1 Kelvin.

Relation between various scale of Temperature

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



THERMAL EXPANSION:-

- Generally every substance expands after receiving heat and their volume is increased.
- Solid expands after getting heated because of this reason space is left between rail lines joints, wires are loosened on electricity poles.

- Liquid also expands after heating but water behaves differently between 0° to 4° C. At 4° C water has maximum density and its volume is minimum.
- This behavior of water is very important in day to day activities.

Transmission of Heat:-

- There are three methods of heat transmission

1. Conduction:-

- By the process of conduction the heat is transferred from one place to another by the particles vibrations of the substance but these particles doesn't leave their occupied position.
- transmission of heat in solid take place by this method.
- On the basis of conductivity substances are classified in three types.

Good conductor –

- Heat is transmitted easily through them.
- example metals, acidic water, human body.

ii. Bad conductor –

- Only a few amount of heat transfers.
- Example wood, fiber, glass, rubber, air.

iii. Thermal Insulator –

- Heat is not transmitted by any means.
- Example Ebonite, Asbestos etc.

2. Convection:-

- Method of heat transmission in which particles of the substance leave their place and transfers heat.
- In liquid and gas heat is transmitted through this method.

- In liquid and gas heat is transmitted through convectional currents.

3. Radiation:-

- Method of heat transmission which do not need any medium.
- Light energy is transmitted from one place to another through radiations.

Emission of Heat -

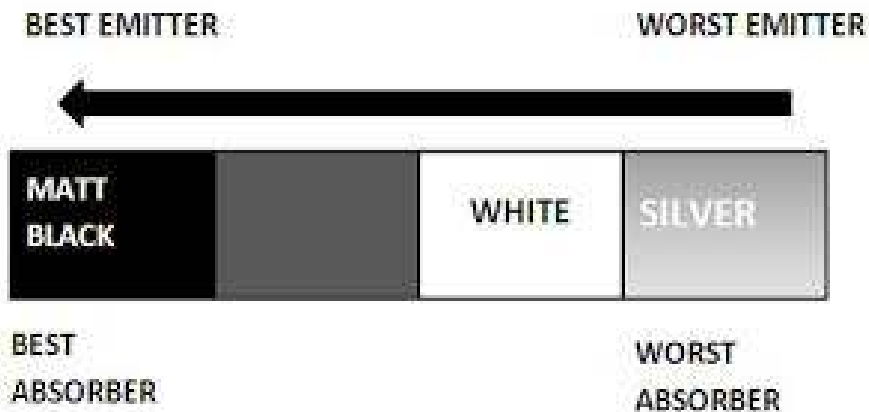
- All substances at different temperature emits heat in the form of radiations.
- This emission depends on temperature of substance, their area and nature of the substance.
- White and smooth surface emits less energy that is why cups for tea with light colours and smooth are preferred.
- Black and hard surface emits more energy.

Absorption of heat -

- When heat radiations strikes a body then some radiations reflects back and some are absorbed and some pass through the body.
- Absorption of heat depends on nature of that substance.
- Black and hard things absorb more heat.

BLACK BODY:-

- A perfectly black body is one which absorbs completely all the radiations.
- Example- Kajal.



KIRCHHOFF'S LAW:-

- According to it bodies which are good emitters are also good absorbers.
- Black and hard bodies are good emitter as well as good absorber.

NEWTON'S LAW OF COOLING:-

- It states that the rate of loss of heat energy of any hot body by the process of Thermal energy is proportional to the difference between the mean temperature and the temperature of surroundings.
- A body temperature falls from 80° to 70° C in less time compared to fall from 60° C to 50° C.

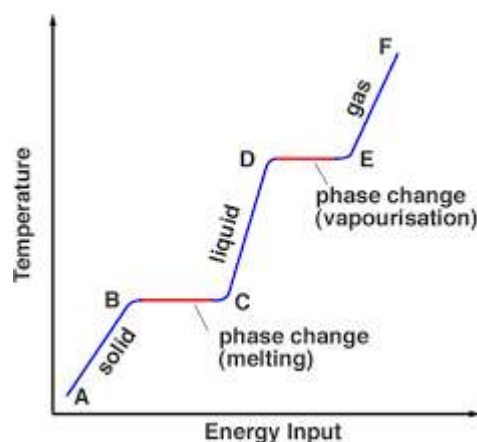
SPECIFIC HEAT:-

- The amount of heat required to raise temperature of 1 gram of a thing by 1° C is called specific heat of that body.
- Specific heat of water is 1 calorie.
- Mercury has lowest specific heat.

- Soil's specific heat is less than water that's why soil get easily heated and cooled.

LATENT HEAT:-

- At a certain temperature heat required by a body to change its state is called latent heat.
- Steam produces more warmth because of latent heat.

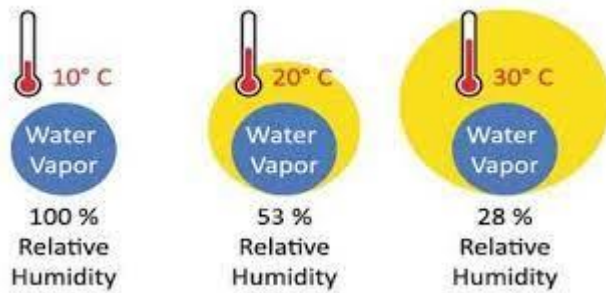
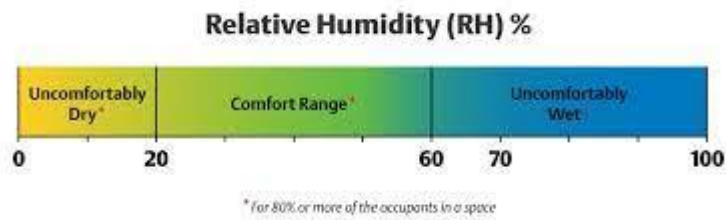
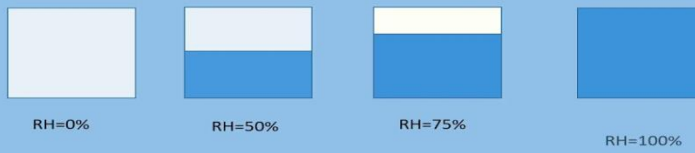


RELATIVE HUMIDITY:-

- At a given temperature, ratio of water vapor present in a certain volume and total water vapor needed to saturate air present in that volume is called Relative Humidity.
- $$\text{Relative Humidity} = \frac{\text{Water Vapor present}}{\text{Maximum quantity of water Vapor}}$$
- It is expressed in %.
- Measured by **hygrometer**.

RELATIVE HUMIDITY

- RH represents amount of water in air in percentage
- For example if we have a air



Static and current Electricity

- The electricity in which the charges remain at rest on the surface of the substance is called the static electricity.
- The static electricity generates by rubbing the two static objects.
- Every object made of tiny particles called atoms. The atom consists the nucleus and free electrons.
- Generally the nucleus has an equal number of neutrons and protons. The electrons of the atom move across their orbit.
- The free electrons of some of the substance are weakly bounded.
- While rubbing the two objects, the electrons having weak bond jump from one object to another.
- The objects which lose the electrons becomes positively charged and the object which gains electrons becomes negatively charged. Unit of charge is coulomb.
- The potential develops between the static objects which cause the static electricity.
- When we rubbed the balloon on hair, negative charges transfer between them.
- Let the negative charge moves from the atom of hair and adds on the atom of the balloon.
- Thus, the atoms of hairs become positively charged, and that of balloon becomes negatively charged.
- The force of attraction induces between the hair and balloon.

- The positive and negative charges develop the potential difference between the hair and balloon. Thus the static electricity induces between them.
- The property of electricity in an object is due to the generation of charge.

Difference Between Static & Current Electricity

Basis for Comparison	Static Electricity	Current Electricity
Definition	The electricity which is build up on the surface of the substance is known as the static electricity.	The current electricity is because of the flow of electrons.
Causes	It induces because of the movement of the negative charges from one object to another	The current electricity is because of the movement of the electrons.
Material	The static electricity develops both in the conductor and insulator.	The current electricity develops only in conductor.
Magnetic Field	Not induces the magnetic field.	It induces magnetic field.
Time Period	Exist for short time.	Exists for long time.
Measuring Device	Gold leaf electroscope	Analog and digital meter.
Examples	Lightning strokes, it develop by rubbing the balloons on hair, etc.	The current electricity is used for running the fan, light, T.V etc.

According to flow of charges substances are divided in Three types:-

1. Conductor –

- The substances in which charges flows easily are called conductor.
- Example- metal, human body, acidic water etc.
- Conductivity sequence in metals Silver, copper, gold, Aluminum, Zinc, Nickel, Brass, Bronze, Iron, Platinum.

2. Insulator –

- Substances in which there is no flow of charges are called insulator.
- Example – Wood, Plastic, Rubber distilled water etc.

3. Semi-conductor –

- Substances which has properties of both conductor and insulator.
- Example- Silicon, Germanium .
- Conductivity of semi-conductor increases by increasing temperature and decreases by decreasing temperature.
- At absolute zero temperature (0K) semi-conductor becomes insulator.
- Conductivity increases by adding impurities to the semi-conductor.
- Conductor have free electrons which helps in flow of electric current but semi-conductor do not have free electrons at normal temperature.

ELECTRIC CURRENT:-

- Flow of electrons or charges is called electric current.
- Unit- Ampere
- It is measured through Ammeter.

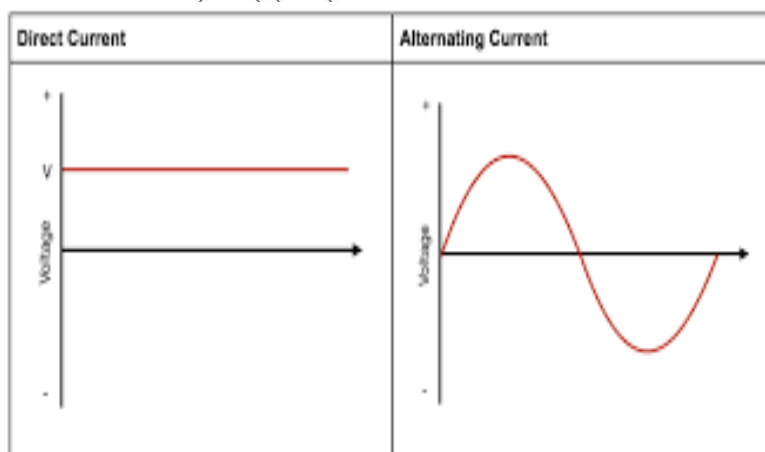
ELECTRIC CURRENTS ARE OF TWO TYPES:-

i. Direct Current:-

- If direction of electric current always remains same then such current is called direct current.
- Example: Electric battery, dry cell, Daniel cell, etc.

ii. Alternating Current:-

- If direction of electric current changes at regular interval in a circuit then it is Alternating current.
- Electric current in our house is alternating current of 5 Ampere and 15 ampere, 220 V and 50 Hz frequency.
- It reverses its polarity 100 times in second.





ELECTRIC POTENTIAL:-

- Work done to bring a unit charge from infinity to a point in electric field by an external agent.
- Its unit is volt, and measured by voltmeter.

RESISTANCE:-

- Obstructions in flow of electricity called resistance.

Its unit is Ohm.

OHM'S LAW:-

- At a fixed temperature the current passed through any conductor is proportional to the potential difference of any two-points.

$$V = IR$$

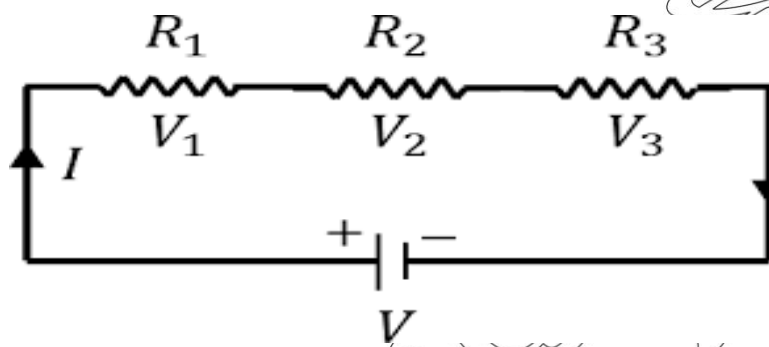
- Value of R depends on nature of the substance, temperature, length and cross section area.

Combination of resistance:- Resistances can be combined in two ways

i. Series Grouping:

- Resistances connected in such a way that components are placed one after another.
- Equal amount of electric current flows through all resistance.
- Ammeter and fuse wire are placed in series grouping in our house.
- Resultant resistance in this arrangement is sum of all resistances.

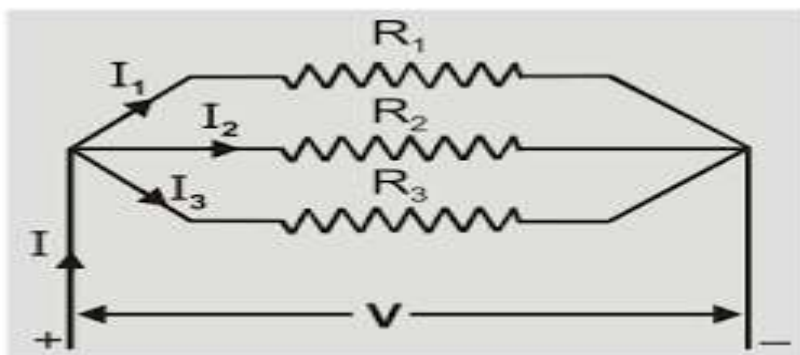
$$R = R_1 + R_2 + R_3$$



ii. PARALLEL GROUPING:-

- Resistances are connected in such a way that they are attached to same point.
- Potential difference between two points of the resistance is always same.
- All equipments in our household are in parallel grouping.
- Resultant resistance in this arrangement is less than minimum resistance.

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



ELECTRIC POWER:-

- Work done per unit time is called power.
- Rate of loss of electric energy in the electric circuit is called electric power

$$P = V \times I$$

Unit of power is Watt

In our household energy expenses are measured in units

$$\text{Unit} = \text{Kilo Watt} \times \text{hour}$$

Example -

- 40 Watt's 10 tube lights are switched on for 5 hours per day.
Calculate the energy expenses in a month.

ELECTRIC FUSE:-

- To prevent damage due to short circuit in an electric circuit electric fuse is used.

Electric fuse is placed in series.

An ideal fuse has minimum melting point and maximum resistance.

Electric fuse wire is made of alloy of lead and tin metal.

- MCB- miniature Circuit Breaker.



ELECTRIC BULB:-

- It was invented by Thomas Alva Edison.
- Tungsten wire is used in this which has melting point 3500°C .
- Inside temperature of bulb is 1500°C to 2500°C .
- Argon gas is filled inside the bulb.
- In it only 10% energy is converted into light energy rest is lost in form of heat.

Fluorescent Material –

- Those material which absorbs high frequency ultra violet radiations and emits low frequency light radiations are called Fluorescent Material.

TUBE LIGHT:-

- Inside wall of tube-light is coated with thin layer of fluorescent material.
- Two ends of the tube-light has tungsten wire which is coated by thin layer of barium oxide.
- When electricity passes through those tungsten wire electrons are emitted which causes flow of current in the tube-light.
- Because of this current mercury vapour inside the tube-light starts emitting ultraviolet rays.
- These UV rays are absorbed by the fluorescent material and it emits light energy.
- In tube-light starter is used to provide initial high current to filament and choke provide high voltage .

COMPACT FLUORESCENT LAMP (CFL):-

- It's a kind of tube-light which have been given shape of a bulb.
- Fluorescent material and mercury vapour are also used in this.
- It is more compact than tube-light.

LIGHT EMITTING DIODE:-

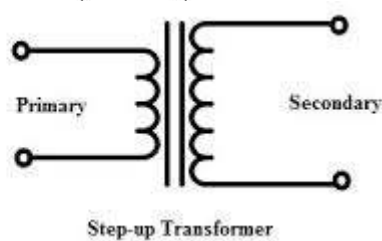
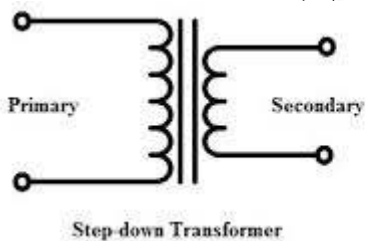
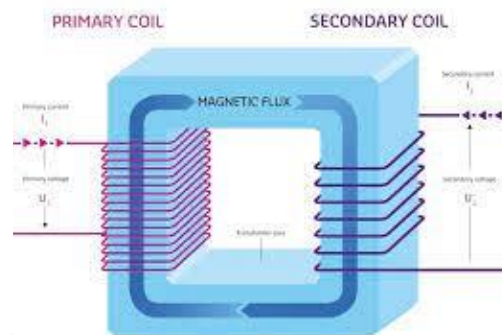
- It's a light source based on semi-conductor.
- P-n junction is used in it.
- Energy efficiency of it is greater than CFL.

TRANSFORMER:-

- Transformer is used to increase and decrease the voltage.
- It works on the principle of electromagnetic induction.
- They are of two types:-

1. Step - up Transformer:

- They convert low voltage to high voltage.



2. Step - down Transformer:

- It converts high voltage into low voltage.
- In power plants low voltage electricity is produced which is converted into high voltage with the help of step-up transformer.
- Due to high voltage less electricity is lost in transmission.

- Before supply in households electricity is again converted from high voltage to low voltage.

GENERATOR:-

- That equipment which converts mechanical energy into electric energy.
- It works on principle of electromagnetic induction.
- There are two types of :-
 1. AC Generator
 2. DC Generator

Magnetism:-

- 600 year before christ, at a place called magnesia in Asia minor (present day - turkey), such stones were found which attracts small pieces of iron, that was called magnet.
- These stones are actually oxides of iron called magnetite (Fe_3O_4), which are found in all regions of the earth.
- Later on, it was observed that when hanging freely, they always stay along the north - south direction and attracts or repel other magnets. These properties of magnets are called magnetism.

Types of magnet:-

- Natural magnets:- They are naturally occurring magnets example - magnetite.
- Artificial magnet:- magnet which are made from different components of iron in various shape and sizes for different uses are called artificial magnet.

- They are in different shapes. For example:- Bar magnet, horse shoe magnet, magnetic compass, etc.

Characteristics of magnets:-

- 1. Magnet has property of attracting metals like iron, nickel, cobalt etc.
- 2. Magnet has two poles, (North pole and south pole)
- 3. Magnetism is highest near the poles and lowest in the middle.
- There is no magnetism in the centre of the magnet, it is called neutral point.
- 4. When a magnet is broken, each piece of it again becomes a new magnet, which again has two poles. So that, poles cannot be separated from the magnet.
- 5. There is repulsion between similar poles and attraction between two opposite poles of the magnet.
- 6. Iron also behaves like a magnet when it is brought near a powerful magnet.

Types of magnetic materials :-

- Materials can be divided into three categories on the basis of magnetic tendency-
 1. Para-magnetic materials.
 2. Dia-magnetic materials.
 3. Fero-magnetic materials.

Para-magnetic materials :-

- The materials which are not strongly attracted to a magnet.
- Those substance which when placed in an external magnetic field, acquire weak magnetism in the direction of the field are called

paramagnetic substances. for example - Platinum, aluminium, sodium, oxygen, manganese etc.

Note:- The property of Para-magnetism is often found in those substances whose atoms have an odd number of electrons.

Dia-magnetic materials :-

- The materials which are repelled by a magnet.
- Those materials which when placed in an external magnetic field, acquire weak magnetism in the opposite direction of the field are called dia- magnetic materials.

for example - Bismuth, Lead, Water, Gold, Silver, Nitrogen, Diamond, Hydrogen etc.

Ferromagnetic materials :-

- The materials which are strongly attracted to a magnet.
- Those materials which, when placed in an external magnetic field, becomes strongly magnetized in the direction of the field, and when brought near the end of a magnet, are strongly get attracted towards the end are called ferromagnetic materials

For example - Iron, Cobalt, Magnetite, Aqueous solution of ferric chloride etc.

Domains Theory:-

- Domain theory has been given to explain why any substances has the property of magnetism.
- Domain in a substance is a small local region in which all the magnetic dipoles align parallel to each other giving rise to certain magnetisation within the domain.
- The direction of magnetisation within a domain is different from that in the neighbouring domain, as a result the net magnetisation of the specimen as a whole is almost zero.

When the substance is magnetised, the domains expand in space such that all the arrows align parallel to each other in a single direction.

For an ideal magnet, there would be a single domain with all molecular magnets pointing in one direction.

Every substance is made up of atoms. Each atom has nucleus and electrons revolving around it. Electrons have electric charges.

The spinning motion of electron generates an electric current and because of this electron acts like a microscopic magnet.

Depending on the spin of electron, their magnetic orientation may change.

In an atom if few electrons are spinning clockwise and the same number spinning anti-clockwise, then the magnetic moments of both the electrons cancel out. And atom has no net magnetic moment.

But, if there are unpaired electrons, then atoms will have a net magnetic field and react to external magnets.

So, we can say that magnetic field around an atom depends upon the number of unpaired electrons in an atom.

Explain ferromagnetism on the basis of domain theory

Each atom in a ferromagnetic material behaves like a miniature magnet

Some complex and reciprocal actions takes place in these atoms which results in formation of numerous microscopic effective field in the material the magnetic axis of these effective fields aligns unidirectional and these field are called domain.

Each domains also behaves like a strong magnet.

Each domain consists of 10^{18} to 10^{21} atoms.

The magnetic properties of ferromagnetic materials are due to the mutual substitution and rotation of these domains.

Since all these domains are scattered randomly in the materials in such a way that their resultant magnetic moment in any direction is zero.

When the ferromagnetic material is placed in an external magnetic field, the external magnetic field force it to align in its own direction. This force mobilise the domain and they arranged themselves in the direction of applied external magnetic field. It result in formation of a large single domain with magnetism in direction of the external magnetic field. Thus the ferromagnetic material gain the properties of a permanent magnet.

Note:- When we heat a magnet / substance having ferromagnetic property, the domain structure gets disturbed, which destroys it's magnetic property.

Curie Temperature:-

The magnetic characteristics of a ferromagnetic material is inversely proportional to its absolute temperature, this is called curie's law.

On increasing the temperature, a point comes at which due to thermal disturbance, its ferromagnetic property get vanished and the substance turns into a para - magnetic substance, this temperature is called curie temperature.

The curie temperature for iron is 770°C and for nickel it is 358°C .

Uses of magnets:-

In the identification of ferrous materials.

In the manufacturing of computer memory.

In a strip of magnetic material on the back of ATM cards. Credit cards as well.

Magnetic materials are coated on the tapes used in sound recording and playing pre-recorded sound.

Magnetic materials are used in the video tape on which movies are recorded.

Magnetic field is also used to accelerate charged particles.

In MRI

In NMR

Magnetic field:-

- The area around a magnet in which the effect of the magnet can be felt is called the magnetic field.
- The direction of the magnetic field is determined by the magnetic needle.

Unit of magnetic field = Gauss (in C.G.S.) and Tesla (in S.I)

Note:- 1 gauss = 10^{-4} Tesla

Intensity of a magnetic field / magnetic intensity:

- When a unit's length of conductor wire with a unit of electric current is placed perpendicular on a magnetic field then the force acting on the conductor wire will be the intensity of the magnetic field.

Magnetic intensity is a vector quantity.

Unit:- newton / ampere-meter OR weber / Meter² OR Tesla.

Magnetic lines of force:-

- Magnetic line of force are the lines that depict the direction of magnetic force that exists in the surrounding of the magnet.

Properties of magnetic lines of force:

- The magnetic field lines always emerge from the north pole and end at the south pole.
- Inside the magnet, the direction of the magnetic field lines is from the south pole to the north pole.
- Magnetic lines of force never intersect each other.
- Magnetic field lines form a closed loop.
- The magnetic lines at the poles are very close to each other which shows that the magnetic field at the poles is strong.
- If the magnetic field is uniform, then the lines of force are parallel to each other and at equal distances.

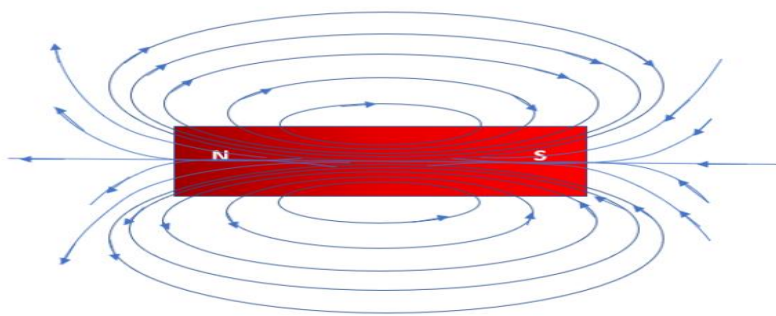


Figure: Magnetic lines of forces

Magnetic Permeability:-

When a magnetic material (such as a soft iron rod) is placed in a magnetic field then the density of the magnetic force of lines inside the rod increases as compared to outside.

Similarly when a non-magnetic material (such as aluminium) is placed in a magnetic field then the density of the lines of force inside it decreases as compared to outside.

Therefore, the conducting property of matter, due to which the density of magnetic lines of force inside it increases or decreases, is called magnetic permeability.

It is represented by μ (mu).

$$\mu = B/H$$

B - Number of lines of force / square meter of magnetic material .

H- Number of lines of force / square meter of air.

Unit of magnetic permeability: Henry/ meter.

Magnetic Susceptibility:-

The property of a substance that describes how easily the substance acquires magnetic property.

If the value of the force magnetizing the material is H and it produces magnetic intensity I in the material , then the magnetic susceptibility.

$$X = \frac{I}{H} = K(\text{constant}) \quad X = \chi \text{ (Kai)}$$

K is called the magnetic susceptibility of the material.

Earth's magnetism:

When a magnet is freely suspended from its centre of gravity, it is always stationary in the north - south direction.

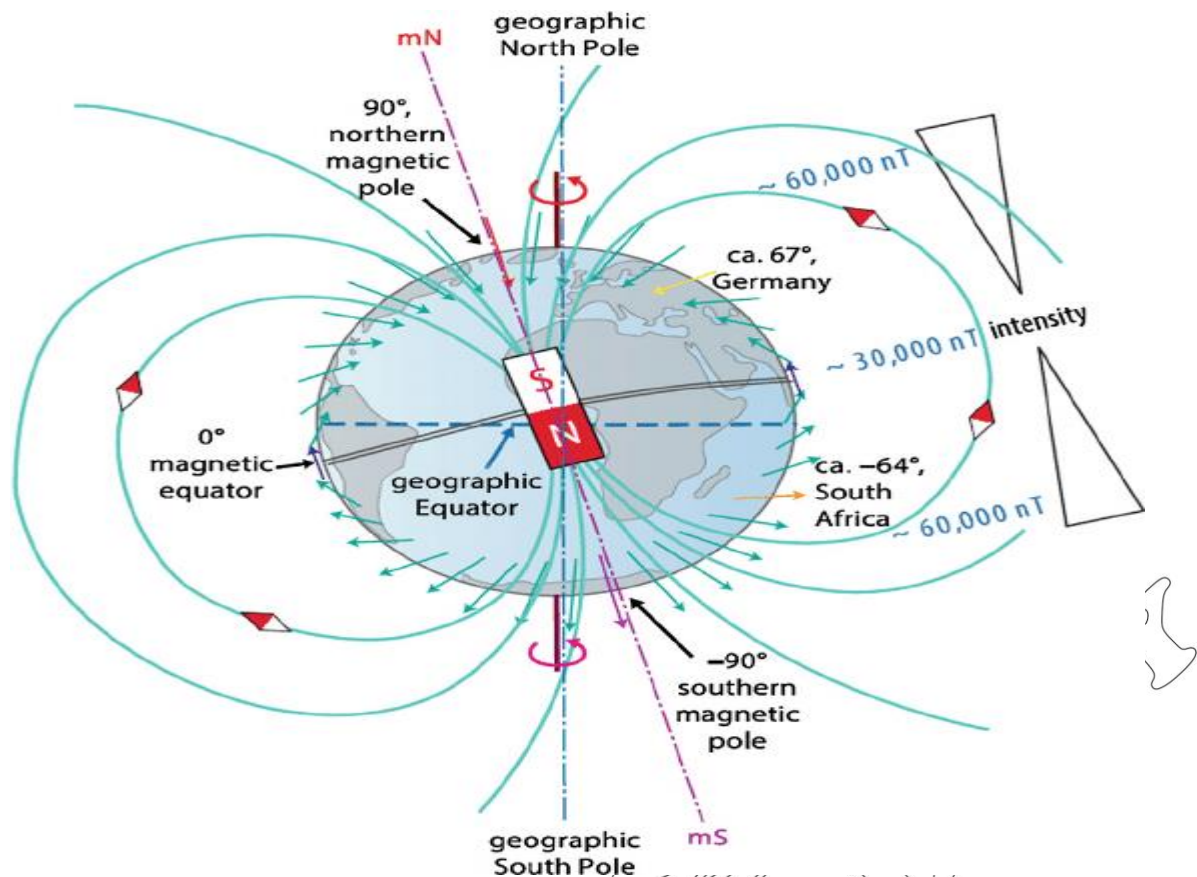
By which it proves that some other magnetic force is definitely acting on it.

Actually the other magnetic force is not of any other magnet but of the earth itself.

It explains that the earth also acts like a giant magnet and it also have the property of magnetism which is called earth - magnetism.

We can imagine a giant magnet inside the earth whose South pole is towards the earth's geographic north pole and the north pole is towards the earth's Geographic south pole.

The lines of force of the earth's magnetic field are equidistant and parallel to each other and are directed towards north.



Earth magnetic axis is obtained by joining the north and south pole of the imaginary giant magnet of the earth which makes an angle of about 15° ($15^\circ / 17^\circ$) with the earth's geographic axis.

Therefore, the geographic and magnetic poles of the earth are different from each other.

Earth's magnetic field at a place is expressed by three components

(1) Angle of Declination:- The angle between the magnetic meridian and the geographical meridian at a place is called the angle of declination.

(2) Angle of Dip: the angle made by the earth's magnetic field with its horizontal plane at a place is called the angle of dip for that place. The angle of dip at the geographic poles of the earth is 90° and at the equator it is 0° .

(3) Horizontal component of earth's magnetic field: The horizontal component (H) of the entire magnetic field of the earth varies place to place but its average value is considered to be 0.4 gauss OR 0.4×10^{-4} Tesla.

Law of force between pole of magnets:-

The force (F) between two poles of a magnet is directly proportional to the multiple of the strengths of the two poles and inversely proportional to the square of the distance between the two poles.

$$F \propto \frac{m_1 m_2}{r^2}$$

Where, M1. M2 is the strength of the two poles and r is the distance between them.

Electro-Magnetism

Electromagnetism is a process where a magnetic field is created by introducing the current in the conductor.

When a conductor is electrically charged it generates magnetic lines of force of conductor.

Electro- Magnet

Electromagnet is a solenoid coil in which magnetism is generated due to electric current.

It works on the law of the effect of magnetic current.

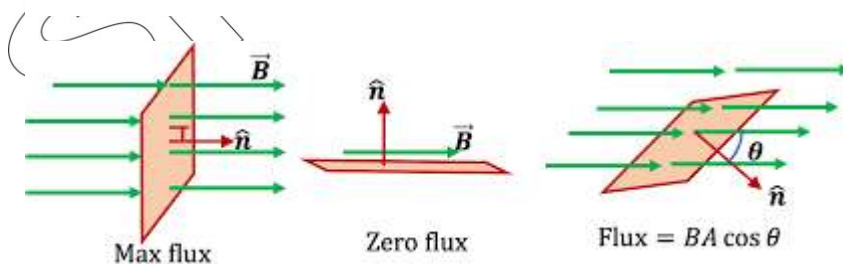
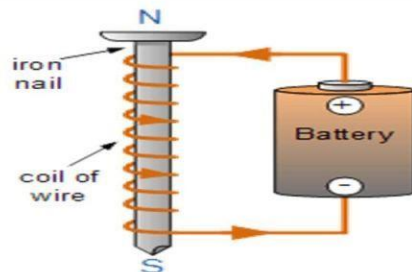
Solenoid:- If the insulated wire is wrapped around a cylindrical hollow tube, it is called a solenoid, the cylindrical tube is called its core.

It is used in dynamo, transformer, electric bell, telephone, etc.,

The intensity of the magnetic field produced by an electro magnet depends on

- (i) Number of turns in the solenoid coil:- If the number of turns is more then the intensity of the magnetic field will also be high.
- (ii) Nature of core material :- If the core is of soft iron, then the intensity of the magnetic field is high.
- (iii) Magnitude of the current:- The greater the magnitude of the current, the more intense the field.

Electromagnetism



Magnetic Flux

The total number of magnetic lines passing perpendicular to a surface in a magnetic field is called the magnetic flux of that surface .

Unit of magnetic flux (in SI): Weber (wb)

$$\Phi = B.A$$

Magnetic field (B) is also called magnetic flux density.

If a surface is parallel to the magnetic field , then no flux line will pass through it and the magnetic flux passing through that plane will be zero

Electromagnetic Induction:-

Faraday discovered in A.D.1831 that, when the number of magnetic lines of force passing through a circuit or a closed coil changes , an electro-motive force is produced in the coil .

As a result the current flow in the coil.

This current keeps flowing as long as the number of magnetic lines of force keep changing.

The electromotive force produced in the coil is called induced electromotive force and the current flowing through it is called the induced current.

This phenomenon is called the electromagnetic induction.

The magnetic flux passing through a coil can be changed in many ways such as:-

- (i) By moving a magnet with respect to a coil.
- (ii) By rotating the coil in a magnetic field.
- (iii) By changing the value of current flowing in the coil.

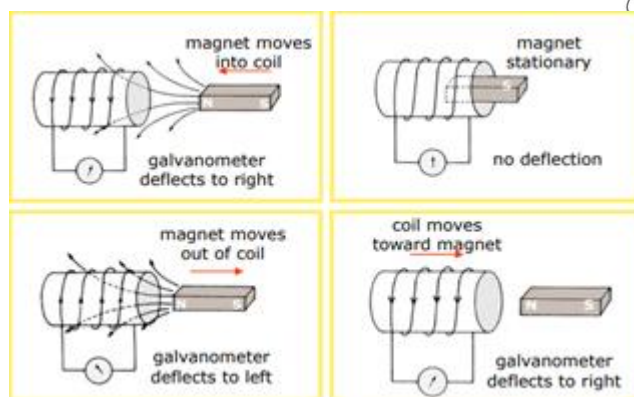
When the magnet is kept stationary near the coil, no deflection is observed in the galvanometer.

When the north pole (N) of the magnet is brought closer to the coil, it causes deflection in the galvanometer; this deflection lasts as long as the magnet remains in motion in relation to the coil. This shows the current flows in the coil.

Now, if the north pole (N) of the magnet is taken away from the coil, then the deflection in the galvanometer occurs in the opposite direction.

It clarifies that the current direction in the coil is opposite then before.

Similarly, if the south pole (S) of the magnet is moved near or away from the coil, the deflection in the galvanometer occurs in the opposite directions then before.



Result:

The induced current in the coil flows only as long as the motion of the magnet is relative to the coil.

The current stops flowing as soon as the magnet is stopped.

The faster the magnet is moved, the greater is the induced current.

Deflection in the galvanometer is also obtained when the magnet is kept stationary and the coil is moved with respect to the magnet.

The strength of the induced electromotive force increases as the number of turns in the coil increases.

Faraday's law of electromagnetic induction : there are two laws-

1. First law – when the number of magnetic lines of force passing through a closed coil or magnetic flux changes then the induced electromotive force is produced in that coil. It causes flow of induced current and this current keeps flowing till the number of magnetic lines keeps changing.

2. Second law- the amount of induced electromotive force produced in a closed coil is directly proportional to the rate of change in the magnetic flux.

$$E \propto \frac{d\phi}{dt}$$

Lenz's Law :

According to this law , the induced current or electromotive force in a coil is produced in such a direction that it can oppose the cause which produced itself. $E \propto \frac{-d\phi}{dt}$

When we move the north pole of the magnet near the coil , the induced current in the coil flows in such a direction that the plain of the coil in front of the magnet acts as the north pole.

Therefore, it tries to move away the magnet which is coming closer as it opposes its motion.

By Lenz's Law : $E = -d\Phi/dt$ Where -ve sign means opposing the producing causes .

LENZ'S LAW

An induced Current always flows in a direction such that it opposes the change which produced it.

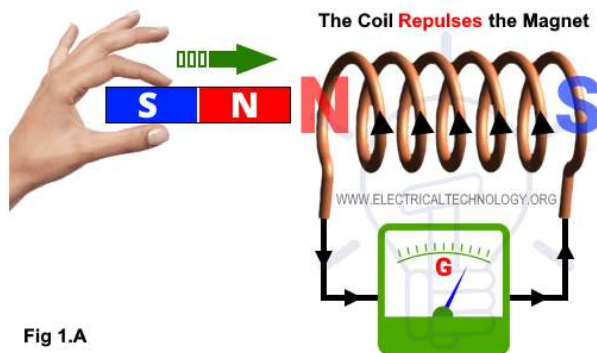


Fig 1.A

When the "N" Pole of the magnet is moved towards the coil, end of the coil becomes "N" Pole.

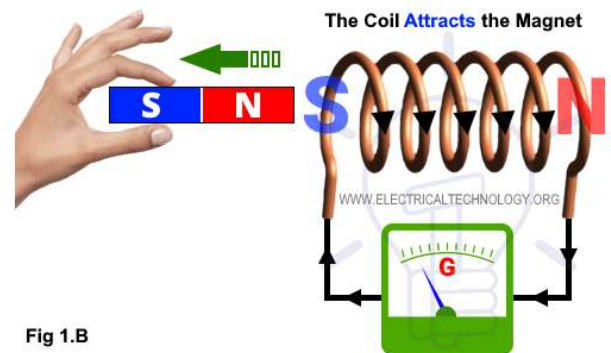


Fig 1.B

When the "N" Poles of the magnet is moved away from the coil, end of the coil becomes "S" Pole.

Self-Induction :-

The phenomenon of electromagnetic induction in which the changing in current flowing in a coil produces an induced current in the same coil itself, is called self-Induction.

A current (I) is flowing in a coil of N turns. The number of magnetic lines of forces passing perpendicular through the coil due to this current I or magnetic flux (ϕ), is directly proportional to the current.

i.e.

$$N\phi \propto I$$

$$N\phi = LI$$

Where ; L is a constant which is called the coefficient of self inductance of the coil.

Unit of self-Inductance= Henry (H)

Mutual Inductance

If we keep two coils close to each other and pass electric current in one of them through a battery or change the amount of current flowing or stop the current in it, then an electromotive force is generated due to electromagnetic induction in the other coil. This is called as mutual induction.

Coefficient of mutual inductance :-

Let the current (I) is flowing in the first coil, the number of lines of force passing perpendicular through the secondary coil due to this current will be directly proportional to the current.

$$\Phi \propto I$$

$$\Phi = MI$$

Where M is a constant and is called the "coefficient of Mutual Inductance" between the two coils.

Its unit is also Henry (H).

Eddy Current:-

When there is a change in the value of magnetic flux of a coil, an induced emf is produced in the coil which causes induced current.

Scientist Foucault's has shown that when there is a change in the value of magnetic flux of a metallic conductor, then the induced current starts forming in form of closed loop. This closed loop induced current looks like eddies or whirlpools.

These currents are called eddy current or Foucault currents.

The value of eddy current depends on the resistance of the conductor.

If the resistance of the conductor is high then the eddy currents become weak and if the resistance of the conductor is less then the eddy currents become stronger.

Disadvantages of eddy currents:-

If the core of dynamo (DC Generator) and Electric motor made of soft iron , eddy current is generated in them and electric energy is lost in thermal energy.

To solve this problem , instead of making the core of these instruments only from soft iron it is made by joining thin plates of soft iron.

This method increases the resistance of core and as the resistance increases the eddy currents decreases.

Application Of Eddy Currents :-

1. Electromagnetic damping.
2. Induction motor.
3. Speedometer.
4. Energy meter.
5. Electric break :- When the train is required to be stopped a strong magnetic field is applied to the drum attached to the wheels. Due to which eddy currents is generated in the drum which opposes the motion of the drum , thus stopping the wheels along with the drum.

Some Definitions Related To the Magnetic Circuit:-

1. Magneto Motive Force (MMF)

Just as in electricity , the work done in moving a unit charge from one point to another is equal to the potential difference between two points , in the same way the work done to bring a unit

magnetic pole from one point to another in a magnetic circuit is equal to magneto-motive force (MMF) between two points.

MMF is the source of establishing the magnetic flux in a magnetic circuit.

In magnetic circuit the MMF is equal to the product of Number Of Turns(N) and current(I)

Unit= Ampere - turn (AT)

$MMF = NI$

Reluctance :-

Reluctance is that property of a magnetic medium which opposes the establishment of magnetic flux in the magnetic medium i.e. reluctance is the property of obtaining magnetic force to establish magnetic flux in the medium.

It is analogous to resistance in electric circuits.

It is denoted by S.

$S = MMF / \text{magnetic flux.}$

Permeance

The inverse of reluctance in a magnetic circuit is called Permeance.

It is analogous to conductivity in an electric circuit.

It is denoted by P.

$\text{Permeance} = 1 / \text{Reluctance.}$

Unit = henry or weber / Ampere-turn.

Comparison Between Magnetic Circuit And Electric Circuit

Magnetic Circuit	Electric Circuit
Magnetic motive force (MMF) causes magnetic flux	Electro motive force (EMF) causes the flow of current.
Flux=MMF/Reluctance	Current=emf/resistance
Unit of MMF=Ampere-turn (AT)	Unit of emf=Volt (V)
Permeance=1/S	Conductance =G=1/R
Resistance (S)	Resistance (R)
Magnetic permeability on a constant temperature depends on the total magnetic flux	Conductivity of the circuit does not depend on the intensity of the current
Some magnetic material materials posses some amount of magnetic field even after removal of MMF	The value of current in a electric circuit become zero if the EMF is completely removed from the circuit.

SOUND WAVES

- They are one kind of mechanical wave which need medium for propagation.
- They are longitudinal waves and propagated in all medium solid, liquid and gas.
- They are generated due to vibration in a thing.

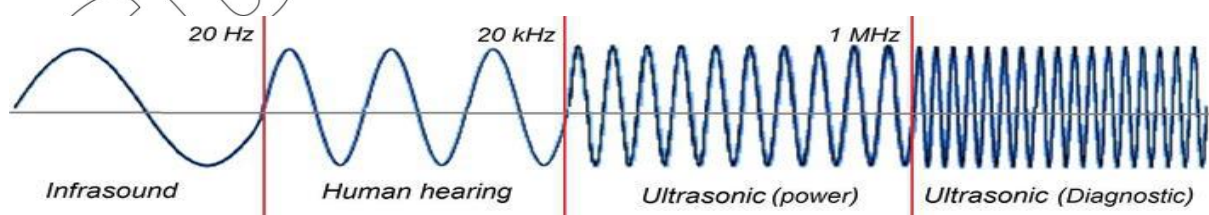
Sound waves are divided in three types according to frequency.

1. Infrasonic:

- Frequency - less than 20 Hz.
- They are not audible by human but can hear by Rhinos, elephant, Whales, Octopus, Pigeons etc.
- Generated with earthquake.

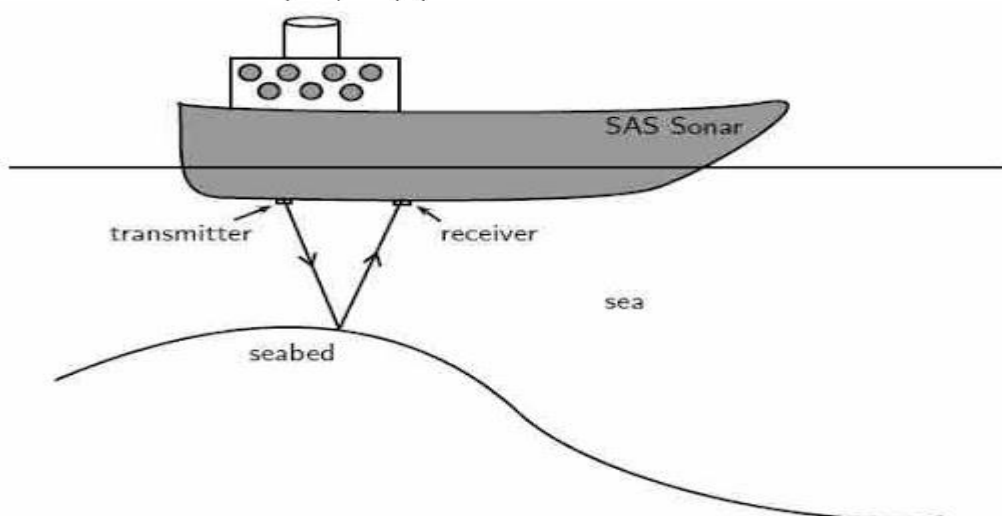
2. Sonic:

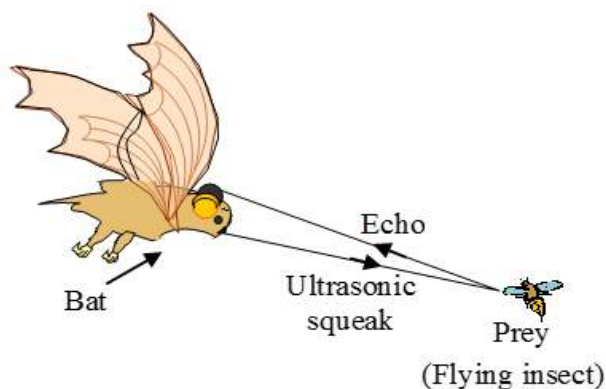
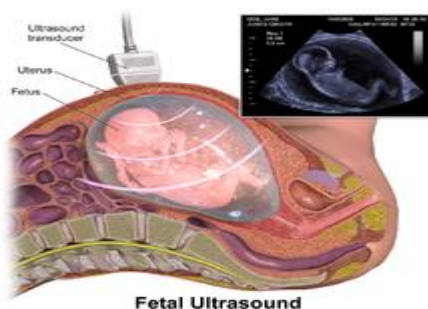
- Frequency - between 20 Hz to 20,000 Hz.
- They are audible



3. Ultra Sonic:

- Frequency – more than 20,000 Hz.
- Not audible to humans.
- But audible to Bat, Insects, dolphins, frog dogs, etc.
- Galton has first generated these waves.
- They are generated by flowing electricity through different crystals like Quartz, lead-Zirconate.
- This effect is called Piezoelectricity.
- These sound waves are used in different fields.
- In Medical field –Sonography.
- Sonar System in ships – to measure depth of ocean and identify icebergs.
- To reduce fog in atmosphere so aircraft can be landed safely.
- To destroy bacteria.





SPEED OF SOUND-

- Sound has maximum speed in solid and lowest in gas.
- Speed of sound depends upon elasticity and density.
- Speed of Sound increases with increase in elasticity and decreases with increase in density.

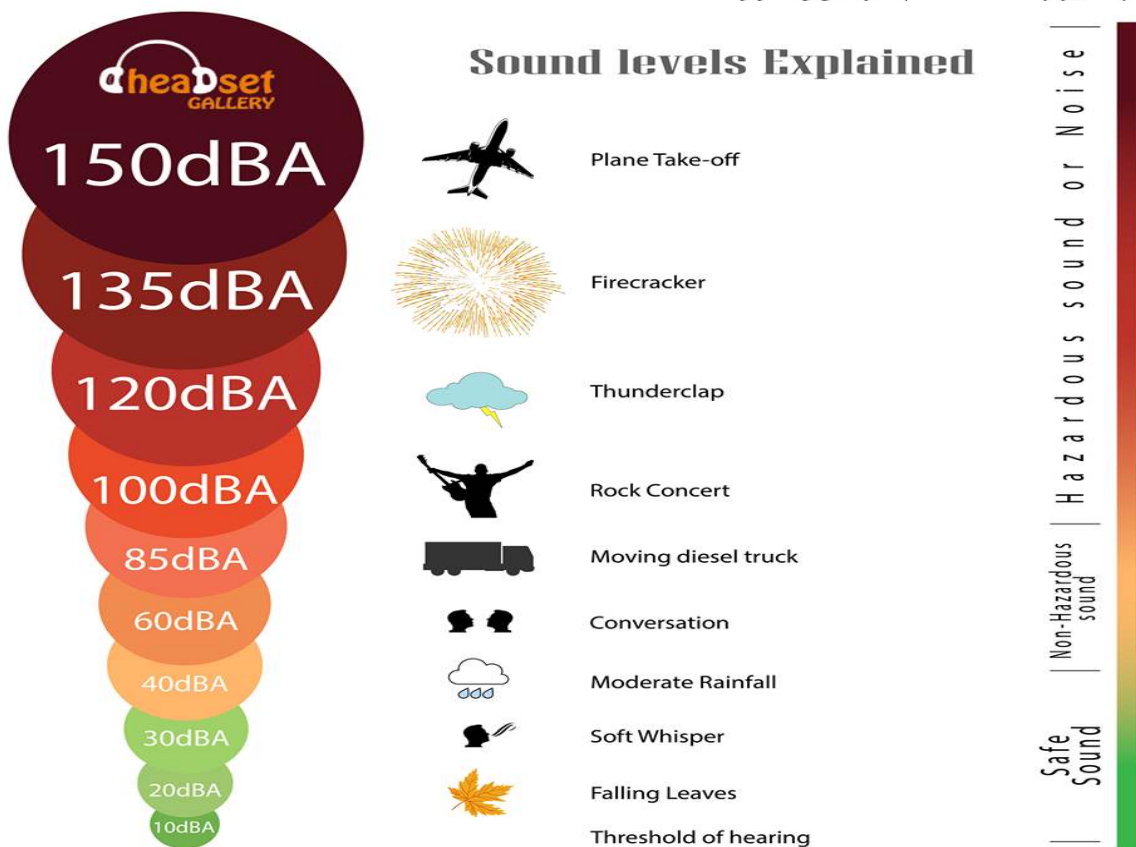
➤ $V = \sqrt{\frac{E}{d}}$

Material	Speed of Sound (m/s)
Air	343
Wood	3960
Water	1493

Intensity of Sound -

- That characteristic of sound according to which sound is identified slow or fast.

- Intensity depends on Amplitude of Sound.
- Intensity is measured in decibel.
- Sound reading meter is used for this purpose.
- Whisper – 15-20 db
- Conversation – 50-60 db
- Sound Pollution – More than 80 db.
- Maximum intensity of sound is of sirens used for navigation in ships (180 db – 200 db)



2. Pitch of Sound –

- That characteristics of sound which tells about loudness of the sound.

- Pitch depends on frequency as frequency increases sound becomes shrill like in women.

3. Quality of Sound –

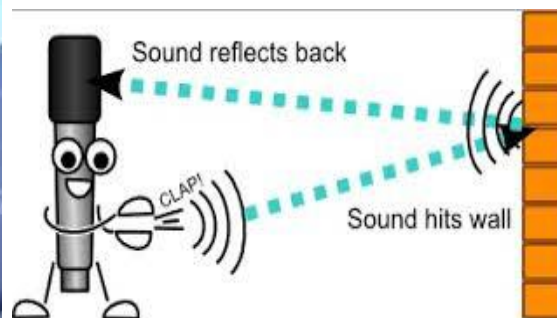
- Sounds of similar amplitude and frequency are distinguished on the basis of quality.

Reflection of Sound Waves:-

- When sound returns back after colliding the surface of another medium then this phenomena is called Reflection.
- For reflection of Sound big reflective surface is needed as it has higher wave length.

Echo of sound-

- Reflection of Sound cause echo.
- When speed of sound in air is 332 m/s and our ear are not able to distinguish among sounds coming during 0.1 sec , therefore for echo to be produced there should be at least 17 m distance between source and reflecting surface.



Refraction of Sound waves:-

- Sound wave gets deflected from its path when it moves from one medium to another medium. This phenomenon is called refraction.

- When it moves from dense medium to rare medium then it deflects away from normal and when it moves from rarer to denser than sound wave move towards the normal.
- Because of refraction sound is heard to large distance in night in comparison to day.

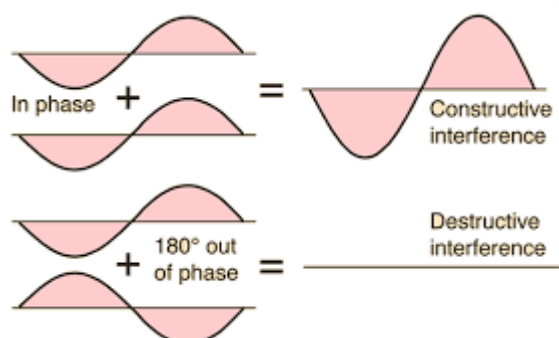
Interference of Sound:-

- When two sound waves of equal amplitude and frequency are met at a point then sound energy gets redistributed, at that point. This is called interference of Sound.

Two conditions in interference-

Constructive Interference -

- When two sound waves of equal amplitude and frequency are met in same phase at a point then its amplitude get increased and its intensity is maximum.



2. Destructive Interference -

- When two sound waves of equal amplitude and frequency are met in opposite phase. Amplitude get reduced and intensity is minimum.
- Example-
- In Pandal at some places intensity is more and some places it is less.
- In ocean at some places intensity of sound is minimum, that's why silence zone are constructed.
- In Radio at some places intensity is more and some places it is less.

RESONANCE:-

- When a body is freely vibrating and an external force is imposed with equal frequency then amplitude of oscillation get increased. This phenomena is called Resonance.

Example:

- Radio works on the principle of resonance.
- Army personnel's are not advised to have similar steps while walking on a bridge.
- When Tansen used to sing song cracking glasses (In History it is said) can be explained through resonance.

Diffraction of Sound:-

- Quality of Sound because of which sound gets diverted in different direction after colliding at edges of an obstacle.

Example:

- Person sitting in room can listens sound of moving train.

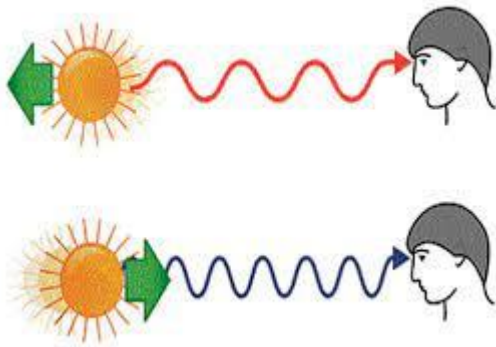
DOPPLER'S EFFECT:-

- When there is a relative motion between source of sound and listener then frequency of sound appears to be changing. This effect is called Doppler Effect.
- If distance is reducing then frequency gets increased and when distance is increased then frequency get reduced.

Example:

- When train approaches platform, frequency of sound appears to be increasing for a person standing on platform, and appears lowering if train is moving away from the platform.
- Radar decides velocity of aircraft on the basis of Doppler Effect.

- Doppler Effect is also seen in light waves.
- In laboratory, if light received from a star is displacing towards violet color then that star is moving towards earth but its getting displaced towards red color then that star is moving away from the star.



WAVES:-

- Wave is a disturbance which moves without changing original medium.
- Energy is transmitted from one place to another through wave.
- Generally waves are divided in **two** categories.

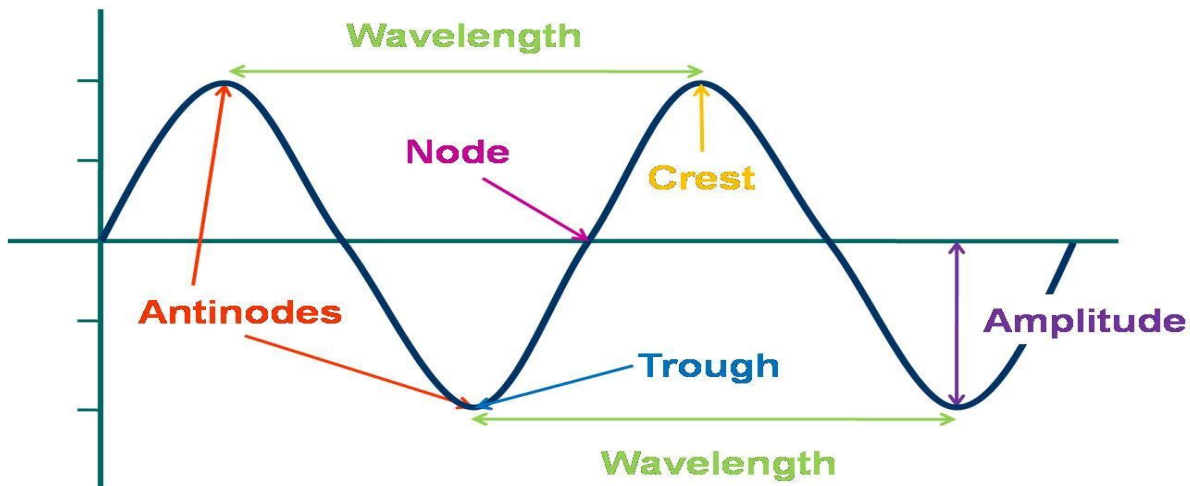
1. Mechanical waves:-

- Waves which needs medium for transmission.
- They are of two types:

i. Transverse Waves –

- Propagation of wave is perpendicular to direction of the particle vibration.
- They can be generated in solids and liquid surface.
- They propagate in the form of crest and trough.

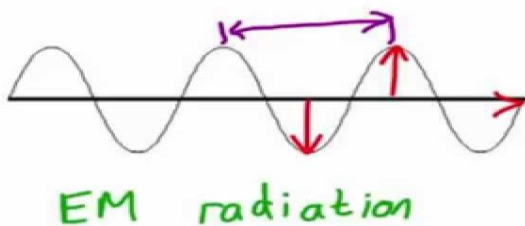
- Example- Waves generated on water surface.



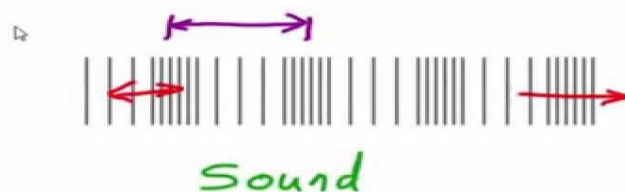
ii. Longitudinal Waves -

- Waves propagate along the direction of particle vibration.
- They can be generated in all medium (solid, liquid, gas)
- Wave propagates through compression and rarefaction.
- Example - Sound wave in air, earthquake wave.

Transverse



Longitudinal



Some Vocabulary:-

I. Amplitude:-

- The maximum displacement from mean position of the vibration of the particles of the medium is called the amplitude of the wave.
- It is represented by A.

II. Frequency:-

- The number of oscillation executed by the particles of the medium in one second is called frequency (n) and
- In SI unit it is expressed in hertz (Hz).

III. Time period:-

- The time taken by the vibration of the particles of the medium in completing one cycle of vibration to pass a given point.
- It is represented by T.

IV. Wave length -

- In Transverse wave the distance between two consecutive crests or troughs is called its wavelength and in longitudinal wave it is the distance between two consecutive compression or rarefactions.
- It is represented by λ

V. Wave speed -

- The distance travelled by wave in unit time is called Wave speed (V).

Wave speed = frequency $\times$ wavelength.

$$V = n \times \lambda$$

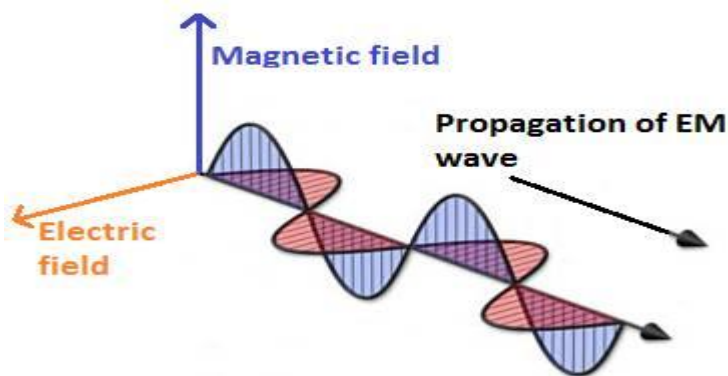
$$n = v / \lambda$$

- frequency = 1/ Time period

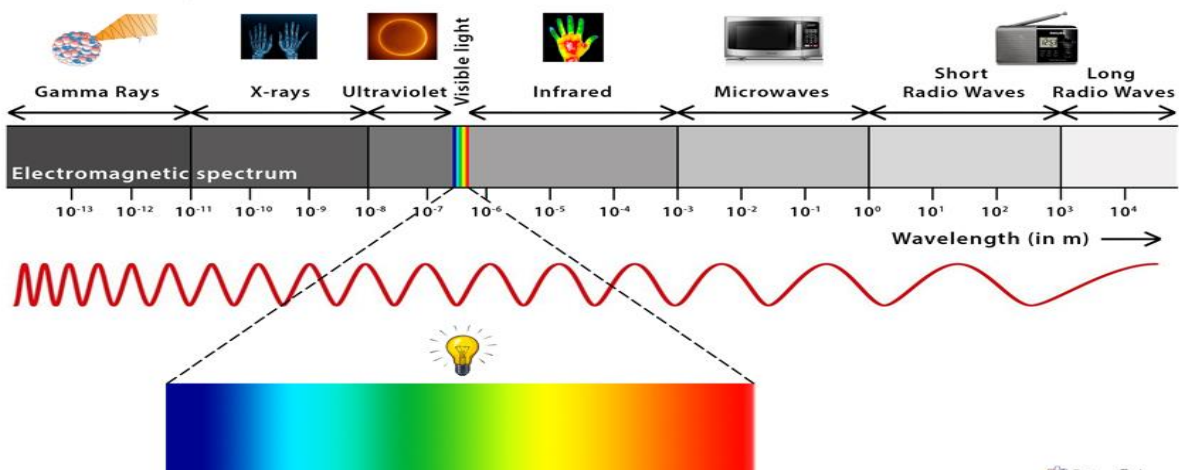
$$n = 1 / T$$

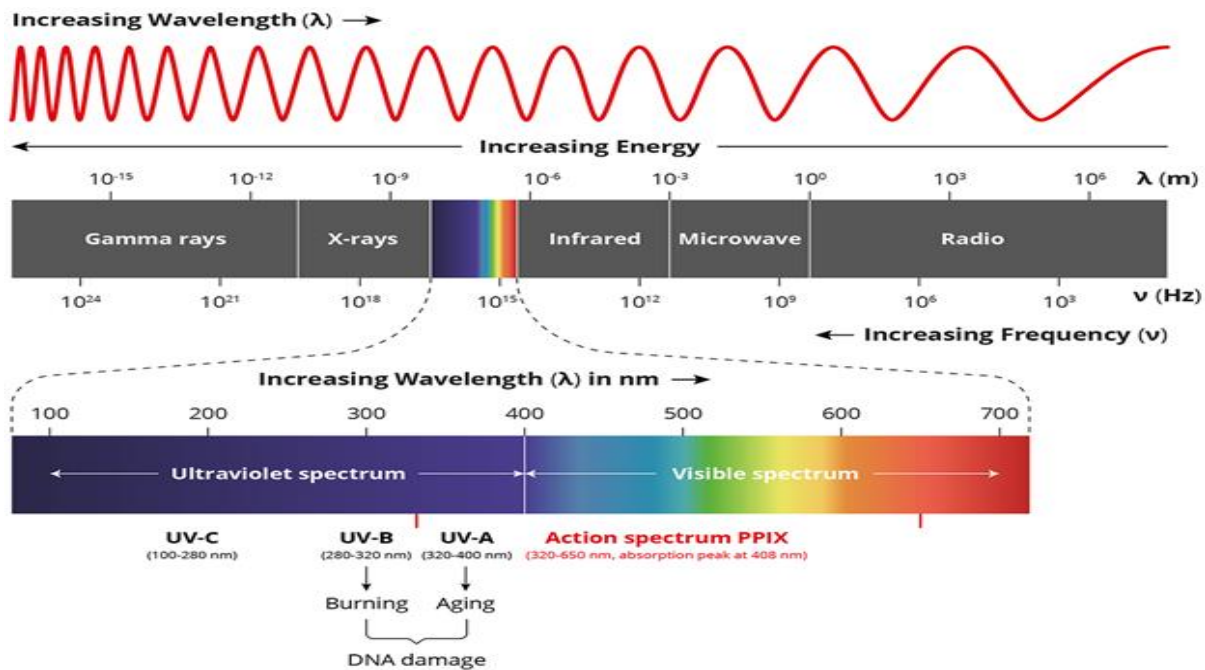
2. Non-Mechanical Waves:-

- Waves which do not need any medium to propagate are called non-mechanical or electromagnetic waves.
- These waves can travel in vacuum.
- They are transverse waves.
- Direction of wave propagation is perpendicular to electric and magnetic field.
- Their velocity is equal to velocity of light.



Types of Electromagnetic Waves

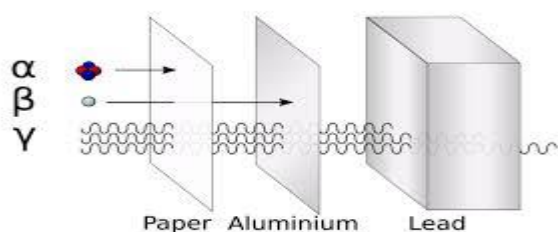




Following are **electromagnetic waves**:-

a) Gamma Waves -

- Inventor = Paul Villard
- They are used for treatment of cancer, to identify specific elements.
- They are used to produce nuclear reaction.
- Their penetration capacity, Energy and Frequency is high due to less wave length.



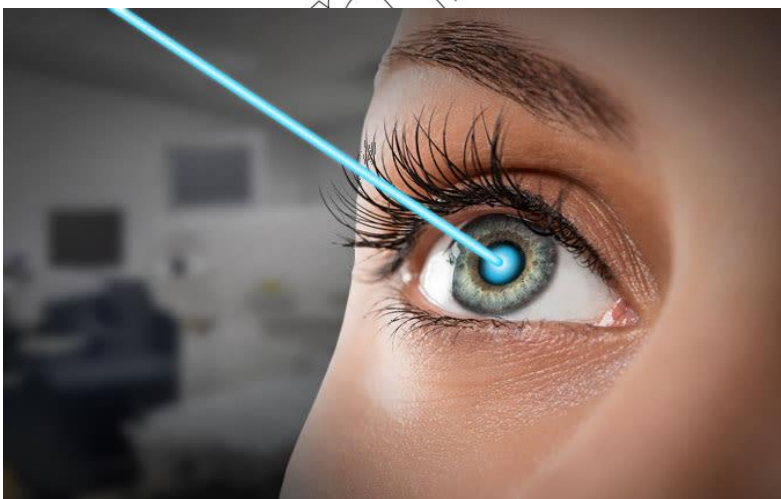
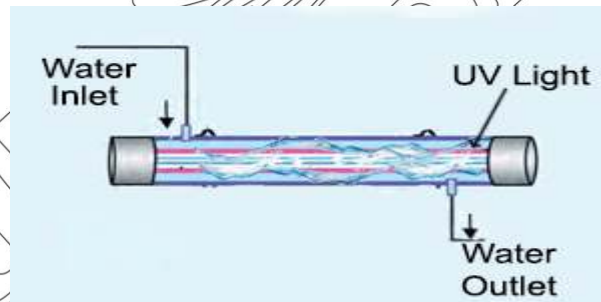
b) X- Rays -

- Inventor - Wilhelm Roentgen.
- Source- By bombarding high energy electrons on metal.

- Used in medical field for diagnosis.
- Cancer treatment (certain forms).

c) U. V. Rays –

- Inventor – Johann Ritter
- Source- very hot bodies, the sun.
- **Used** in destroying bacteria in surgical instrument, water purifiers, photoelectric effect, in burglar alarm, used in fluorescent tubes, Eye surgery-LASIK,



d) Visible light (spectrum) -

- Inventor = Newton
- Wave length = $3.9 \times 10^{-7}\text{m}$ to $7.8 \times 10^{-7}\text{m}$ / 400 nm to 700 nm.
- Source- Objects emitting or reflecting visible rays.
- Use: objects become visible due to it, use in laser,

e) Infra red -

- Inventor - Hurssel

Used in

- (i) Photography,
- (ii) data transmission
- (iii) Remote sensing,
- (iv) in Physiotherapy to treat muscular strain,
- (v) use in solar water heater,
- (vi) solar cooker,
- (vii) use weather forecasting,
- (viii) Maintain earth's warm,
- (ix) infrared detectors,



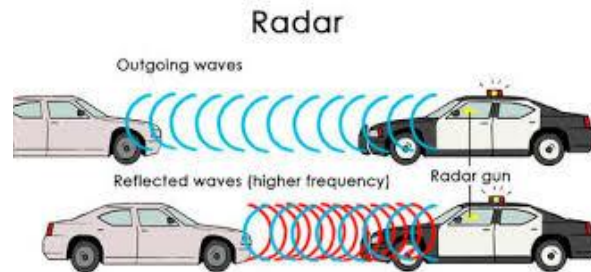


f) Microwave –

- Inventor = Hertz
- Wave length = 10^{-3} m to 1 m / 1mm to 1m
- Frequency = 10^{11} Hz to 10^8 Hz
- Source- special vacuum tube (oscillating circuits).

Used –

- (i) TV,
- (ii) Mobile,
- (iii) Wimax,
- (iv) Cooking purpose in microwave oven
- (v) Used in RADAR system for aircraft navigation,
- (vi) To measure the speed of vehicle or speed of cricket ball.



Band	Frequency range	Wavelength range
Extremely low frequency (ELF)	< 3 kHz	>100 km
Very low frequency (VLF)	3 - 30 Hz	10 - 100 krn
Low frequency(LF)	30 - 300 kHz	1 - 10 km
Medium frequency (MF)	300 kHz - 3 MHz	100m - 1km
High frequency (HF)	3 - 30 MHz	10 - 100m
Very high frequency (VHF)	30 - 300 MHz	1 - 10m
Ultra high frequency (UHF)	300 MHz - 3 GHz	10cm - 1m
Super high frequency (SHF)	3 - 30 GHz	1 - 10cm
Extremely high frequency (EHF)	30 - 300 GHz	1mm - 1cm

g) Radio Waves –

- Inventor – Marconi
- Wave length = 1 to 10^4 m .

- Frequency = less than 10^9 Hz
- Source- Accelerated motion of charges in conducting wires.
- Use -
- Mobile , Radio, T.V.

Springboard
ACADEMY

NUCLEAR MAGNETIC RESONANCE (NMR)

- Nuclear magnetic resonance (NMR) is a technique wherein the nuclei of an atom placed in an external magnetic field gets excited by some imposed radio waves and shows electro-magnetic effect.
- The nuclei then emit back the radio frequency photons imposed upon it in a distinct frequency. These emitted waves give us the details about structure of the nuclei.
- NMR technique was invented by Feliv Bloch and Edward Purcell in 1946.
- The medical use of NMR technique i.e. MRI was started by Raymond Damadian.
- The NMR technique describes the structure of an unknown organic mixture on the basis of Hydrogen atoms and protons available in it.
- NMR technique is used to study various NMR active nuclei, i.e. ^1H , ^{13}C , ^{15}N , ^{19}F , ^{31}P etc.
- **NMR Active Elements:** Either atomic number or atomic mass or both of these elements are odd number thereby their Nuclear Spin Quantum number $\neq 0$ (is not 0) and they possess the quality of nuclear spin. Eg $^1\text{H}_1$, $^{14}\text{N}_7$, $^{13}\text{C}_6$ etc.
- **NMR Inactive Elements:** Both the atomic number and atomic mass of these elements are even numbers. Their Nuclear Spin Quantum number = 0 (is always 0) and they don't have the quality of nuclear spin. Eg $^{16}\text{O}_8$, $^{12}\text{C}_6$ etc.
- Nuclear Magnetic Resonance (NMR) can occur only in the NMR active elements.
- **Nuclear Spin:** Negatively charged electron in an atom revolves around the nuclei and also it rotates on its axis.

- Same time the nucleus of the atom which is positively charged due to the protons in it, also rotates randomly on its axis.
- This motion is called Nuclear Spin and due to this spin the nuclei produces a magnetic effect.
- As all the protons present in a nucleus rotates randomly thereby they lack uniformity in their rotation.
- **α Spin Stage:** When an external magnetic field is imposed upon a nucleus, maximum protons adjust themselves in the direction of the imposed magnetic field and start rotating uniformly in one direction. This is called α spin stage. It is a stable stage and requires very less amount of energy.
- Though in α spin stage also some protons place themselves in the opposite direction of the imposed magnetic field but they need very high energy to remain in that opposite direction.
- **β Spin Stage:** When in α spin stage, radio frequency waves (RF) are imposed upon the nucleus, the protons gets excited and they turn 180° to come to opposite direction to the imposed magnetic field. This is called β spin stage. It is a unstable stage and requires very high amount of energy to be in this stage.
- Protons require additional amount of energy (ΔE) for coming to β spin stage from their natural α spin stage. They get this energy from the imposed RF waves.
- When the imposed RF waves reach the level of ΔE , then the RF waves are absorbed by the protons and they get excited by this high energy and they come to the β spin stage. This is the stage of resonance (NMR).
- As the β spin stage is an unstable stage, the protons try to return to their natural α spin stage. For that they have to release the absorbed extra energy (ΔE). They release back the absorbed RF

waves in distinct frequencies. These emitted RF waves give us the NMR spectrum of that atom. The NMR spectrum is studied in order to ascertain the structure of that material.

Usage:

- NMR technique is widely used in medical field in the form of MRI scan.
- It is used for analysis of chemicals in the industrial field.
- It is helpful in structural analysis of molecules of solid and liquid materials.
- It is used in getting the water – fat ratio in foods/medicines etc.
- It is used to monitor the flow of corrosive liquids in the pipes.

NMR & MRI:

- Both these techniques are based on study of the RF waves emitted by protons.
- NMR technique uses the frequency of the emitted RF waves to collect information whereas the MRI technique uses their rate.
- NMR spectroscopy is used for ascertaining the chemical structure of a material whereas MRI is used for getting detailed images of internal organs/tissues of the body.

MAGNETIC RESONANCE IMAGING (MRI)

- It is an advanced technique of radiology in the medical field which is used to form picture of anatomy and physiological processes of the body.

- As the MRI scan is a medical use of NMR technique, it is performed with the help of a magnetic field and RF waves. Since unlike the traditional scanning techniques MRI doesn't use X-rays or any ionizing radiations, therefore, MRI is considered a safer scanning method.
- MRI scan gives far better images of soft tissues/ organs than any other scan.
- Since the MRI scan works on the principle of NMR, it needs a NMR active element.
- Hydrogen is the best NMR active element which is naturally abundantly present in our body in the form of water (70% of the body), fat etc. MRI scan uses these hydrogen atoms to create NMR effect.
- Therefore, the MRI scan gives good images of soft tissues which are rich in water/fat content and at the same time it is of no use for scanning teeth, bones etc. which lacks hydrogen atoms due to no water/fat content.
- Apart from scanning the internal organs MRI is also useful for checking blood flow in the body and in medical research.
- MRI technique is also used for getting images of non-living things and for chemical analysis in industries.

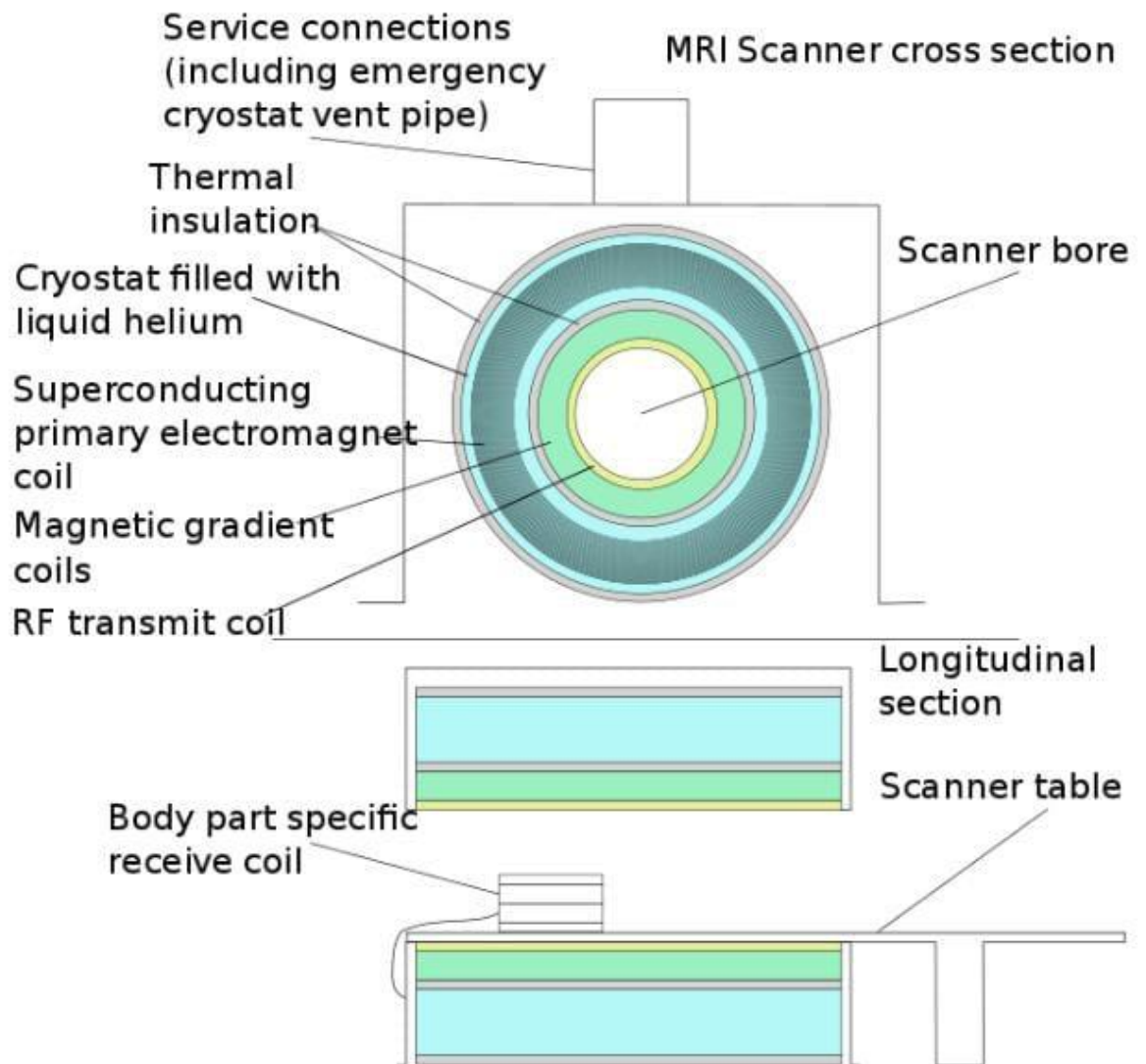
Method:

The MRI machine has a hollow portion in the middle of it where the patient to be scanned is laid down.

Construction and physics



Main article: [Physics of magnetic resonance imaging](#)



Schematic of construction of a cylindrical superconducting MR scanner

- Superconducting primary electromagnet is used for creating external magnetic field which is placed in a coiled tube in the machine.

- In the MRI machines used for medical purposes this superconductor magnet creates magnetic field of 1.5 tesla.
- This magnet needs to be kept at very low temperature in order to keep its superconductivity intact. Therefore, this magnet is surrounded by the liquid helium on both sides. Both the layers of liquid helium have magnet on their one side and on other side they are covered by thermal insulation layers.
- Inside the layers of magnet and liquid helium, the MRI machine has a magnetic gradient coil which is used for focusing the imposed external magnetic field on the particular place which is to be scanned.
- Inside the gradient coil it has RF transmit coil for imposing radio frequency waves which excites the protons in the atoms of a NMR active element and brings them to β spin stage from their natural α spin stage.
- Protons emit the radio waves back in order to return to their α spin stage from the β spin stage. These emitted RF waves vary in their energy, rates, wavelength etc. according to the structure of the concerned tissue/organ.
- The images of internal structure of the organ are drawn with the help of these emitted RF waves. Since different tissues have different contents of water/fat, the MRI gives clear images of them. Whenever any change occurs in a tissue Eg. formation of lesion or cancer cells etc., the RF waves emitted from that deformed part start varying from the RF waves emitted from the healthy portion of the same tissue.
- As a result, the deformity of the tissue is clearly visible in the image drawn by the MRI scan.
- A contrast agent Gadolinium is used in MRI scan for getting clearer and high resolution images.

- MRI scan draws images between the range of white and black colour according to the amount of fluid present in the scanned tissue.
- Tissues rich in water and fat content gives better signal (RF waves emission) and make lighter images. The portions of edema, tumor, lesion etc. make darker images. Images of teeth, bones etc. are drawn in near to black colour.

Advantages:

- It gives sectional images of the internal organs.
- Physiological activities/ blood flow etc. can also be monitored by it.
- Formation of any lesion/tumor can be monitored in its advance stage only.
- Examination of grey and white matter in the body.
- This technique is safer due to non-use of harmful radiations.
- Growth of plants can be studied by examining their internal structure.

Disadvantages:

- It is a very expensive technique.
- Water poor organs like teeth, bones etc. cannot be examined through this scan.
- As the technique uses strong magnetic field, people with any kind of metallic implants i.e. pacemakers, rods/bolts in bones etc. cannot be scanned.
- Some side effects of gadolinium in the body are also seen sometimes.