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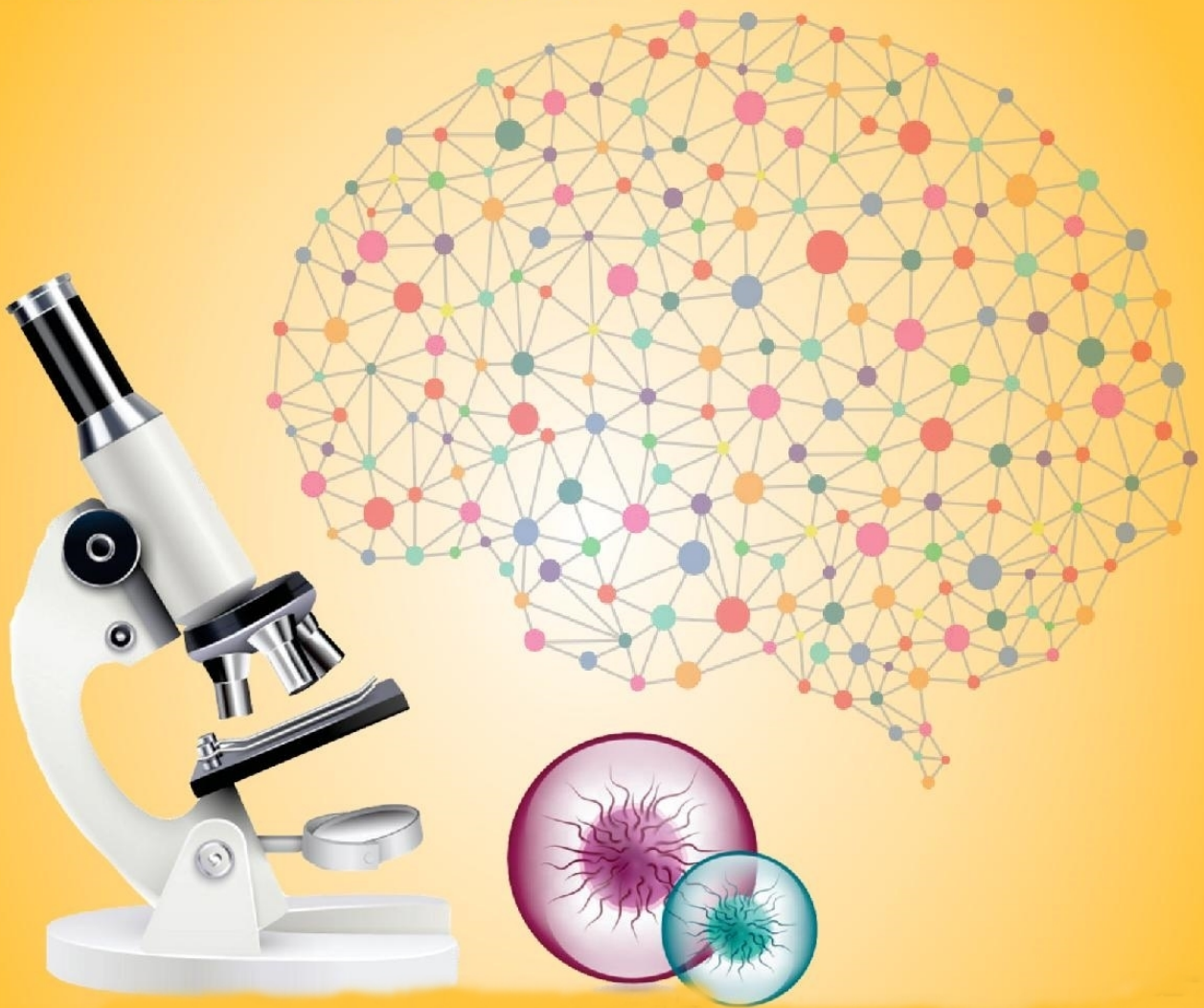
PCMB

- Important Formulae & Functions
- For 9th & 10th Classes



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DEFINATION OF MATTER

1. **Matter** is everything in this universe that occupies space and has mass.
    - In ancient time, according to the researches carried on our religious books and scriptures, the Indian philosophers stated that matter is made from five constituents or tatvas: Fir, Water, Air, Earth, Sky, Wind
    - All matter comprises of very small particles.
    - All matter can be broken up in a similar manner to get very small particles.

2. **Particle** of matter have three characteristics:
    - Particles of matter have spaces between them. E.g. Mixing of salt in water.
    - Particles of matter are moving all the time. Hence, they possess kinetic energy. The process of mixing two different types of particles together is called diffusion. Diffusion becomes faster on heating. E.g. Various Gases in air.
    - Particles of matter attract each other. The amount of this force between the particles varies in different forms of matter: Gas < Liquid < Solids

3. **States of Matter :** Based on particle characteristics, matter is divided into 5 kinds: Solid, Liquid, Gas, Plasma and Bose-Einstein Condensate (BEC). The last two states of matter have been discovered recently.
    - **3.1. Plasma**: is a state of matter in which the particles are super excited and super energetic. They are in the form of ionized gases. Example – Fluorescent tubes and neon light bulbs consist of plasma. As electricity is passed in the tube or the bulb, neon gases and helium get ionized and this creates the plasma inside them that glows. In fact, the Sun and the stars glow because they plasma is present in them.
    - **3.2. Bose-Einstein Condensate (BEC):** It is the fifth state of matter discovered by Albert Einstein on the basis of the studies conducted by an Indian scientist Satyendra Nath Bose. BEC is formed by condensing gases of extremely low densities to much lower temperatures.

Solid	Liquid	Gas
Definite shape	Indefinite shape	Indefinite shape
Definite volume	Definite volume	Indefinite volume
Maximum force of attraction between particles	Less forces of attraction between particles compare to solid	Negligible force of attraction between particles
Cannot be compressed	Cannot be compressed	Can be compressed
Kinetic energy of particles is minimum	Kinetic energy of particles is more than solid	Kinetic energy of particles is maximum
Particles cannot move rather they vibrate only at their fixed position	Particles can slide over one another	Particles can move freely
Highest density	Density is lower than solid	Lowest density
Cannot flow	Flow	Flow

4. **Change in State :** Water can exist in all three states, ice, water and steam. A matter can change states depending on multiple factors.

FACTORS	SOLID	LIQUID	GAS
Increase in Temperature	**Melting** : Kinetic energy between the particles increases which decreases	**Boiling** : kinetic energy between the particles increases which further	**Sublimation :** phase transition in which solid transforms into gas without

	the force of attraction between them. Turns to Liquid at 0 °C	decreases the force of attraction between them. Turns To Gas at 100 °C	passing through the liquid phase. Example : Camphor
Decrease in Temperature	**Deposition :** phase transition in which gas transforms into solid without passing through the liquid phase. Example **:** Water Vapor into Ice Crystal	**Freezing** : kinetic energy between the particles decrease which further increase the force of attraction between them. Turns to Solid	**Condensation** : kinetic energy between the particles decrease which further increase the force of attraction between them. Turns to Liquid
Pressure	Dry Ice – Carbon dioxide in solid form is known as Dry Ice. It can directly turn into gas by decreasing the pressure to 1 atmosphere.		On compressing the gas changes into a liquid.

5. **Evaporation:** The phenomenon of change of a liquid into vapors at any given temperature below its boiling point (vapor pressure < atmospheric pressure). This is different than boiling point where vapor pressure = atmospheric pressure. The process of evaporation uses the energy of the liquid particles. Therefore, the particles absorb energy from the surroundings in order to compensate the energy that is being lost in the process of evaporation. This results in cooling of the surrounding area.
Examples :
   - We are able to sip hot tea faster in a saucer than in a cup
   - People wear cotton clothes in summer
   - Water droplets appear on the surroundings of a glass with ice-cold water

Condition	Rate of Evaporation	Reason
Increase in Surface Area	Increases	Particles have more space and thus can evaporate easily
Increase in temperature	Increases	Kinetic energy among the particles increases
Increase in humidity	Decreases	Water content in air increases and so evaporation decreases
Increase in wind speed	Increases	Water vapours are blown away by winds allowing more evaporation

6. **Latent Heat :** The heat energy which is used to break the force of attraction between the particles of matter is known as latent heat. Since the heat is hidden therefore it is called as Latent Heat.
   - **6.1.** Latent heat of fusion: The heat energy required to convert 1 kilogram of a solid into liquid at atmospheric pressure at its melting point.
   - **6.2.** Latent heat of vaporization: The heat energy required to convert 1 kilogram of liquid into gas, at atmospheric pressure, at its boiling point.

7. **Brownian motion** : The random or zig-zag movement of microscopic particles in a fluid, as a result of continuous bombardment from molecules of the surrounding medium.

8. **Measurements** :
   - Common unit: Degree Celsius (°C)
   - SI unit: Kelvin (K)
   - Relation between common unit and SI unit of temperature : 0 °C = 273K

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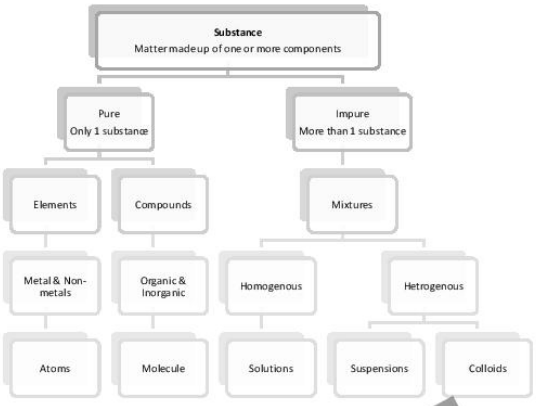
PARTICLE NATURE & BASIC UNITS



1. **Element** is the simplest form of matter. Elements cannot be broken down into further elements by chemical reactions. Elements are further characterized as Metals, Non-Metals and Metalloid.
   - 1.1. **Metals** is an element that is malleable and ductile, has high tensile strength and conducts electricity. It is sonorous, shiny and solid at room temperature (expect Mercury) E.g. Iron, Copper, Aluminum, Magnesium
   - 1.2. **Non-metals** as the name suggests are opposite to metals. They are comparatively less in number, but they are very important for living organism. Only about fourteen to fifteen elements are non-metals. E.g. Carbon, Sulphur, Phosphorous, Hydrogen and Oxygen.
   - 1.3. **Metalloids** There are a few elements which possess the characteristics of both the metals and nonmetals. These are actually border-line elements and are known as metalloids. E.g. Boron (B), Silicon (Si), Germanium (Ge).

2. **Compounds** is a substance that consists of two or more substances. These substances are combined chemically with each other in fixed proportions. The properties of a compound are different than that of its constituents. E.g. Ammonium Sulphate, Sulphur Chloride, Water
   - 2.1. **Organic** compound are obtained from living beings i.e., plants and animals. It has been found that all the organic compounds contain carbon as their essential constituent. E.g. Oil, Proteins, Methane, Alcohol
   - 2.2. **Inorganic** compound obtained from non-living sources such as rocks and minerals. E.g. Baking Soda, Salt, Marble

3. **Mixture** is the combination of two or more substance (element of compounds) which are not chemically combined with each other and may also be present is any proportion. Two Kinds : Homogenous and Heterogenous.

Homogenous Mixtures	**Heterogeneous Mixtures**
They have a uniform composition throughout	They have a non-uniform composition
We cannot separate the components of the mixture through physical processes	We can separate the components through physical processes
Components cannot be seen through naked eyes	Components can easily be seen through naked eyes
The mixture is in single phase throughout	The substances can be of two different phases and we may see separate layers of the substances
Example: A mixture of water and milk	**Example**: A mixture of oil in water

4. **Alloy** is a mixture of different metals or non-metals and metals that cannot be separated from each other using physical methods. For Example: Brass – Copper with up to 50% zinc and Bronze – Copper with up to 12% tin

5. **Solution** = Solvent + Solute. It is a homogenous mixture, with particle as small as 1 nanometre in diameter. The path of light is not visible through the solution. Particles of a solution cannot be separated by methods of filtration.
   - **5.1. Solvent**: The substance in which another substance is mixed. E.g. Water is solvent.
   - **5.2. Solute**: The substance that is added to the solvent to form a solution. E.g. Sugar is Solute.
   - **5.3. Different Types of Solutions**
     - **Dilute** – A solution in which the concentration of the solute is much less than that of the solvent. **For Example**, If we mix 1gm of salt in 500 ml of water, the salt solution thus obtained will be diluted. If we keep on adding the solute in a solution there comes a point when no more solute dissolves in the solution. This is called the **Saturation Point of a Solution**.
     - **Unsaturated Solution** – A solution, in which we can add more amount of solute as it has not achieved its saturation level yet, is called an Unsaturated Solution. A dilute solution can be called as an **Unsaturated Solution**.
     - **Concentrated Solution** – A solution with a large amount of solvent is called a **Concentrated Solution**.
     - **Saturated Solution** – A solution in which no more solute can be added since it has already dissolved the maximum amount of solute it can is called a **Saturated Solution**.

6. **Concentration** refers to the amount of a substance per defined space or can be defined as the ratio of solute in a solution to either solvent or total solution. To calculate the concentration consider the formulae below:
   - **Percent by Mass** = (Mass of solute / Mass of solution) X 100
   - **Percent by Volume** = (Volume of solute / Volume of solution) X 100
   - **Molarity (M)** = Number of moles of solute / Volume of Solution in litres

   Where, Moles of solute = Given mass / molar mass
   - **Molality (m)** = Moles of solute / weight of solvent in kg
   - **Normality (N)** = Number of mole equivalents/ volume of solution in litres
     = Mass of solute / (equivalent mass * volume of solution in Litres)
   - **ppm (Parts Per Million)** = (Mass of Solute / Mass of Solvent) * 10^6
   - **Mole Fraction**$_{SOLUTE}$ = Moles of Solute / Total Moles of Solution
   - **Mole Fraction**$_{SOLVENT}$ = Moles of Solvent / Total Moles of Solution
   - **Mole Fraction**$_{SOLUTE}$ + Mole Fraction$_{SOLVENT}$ = 1

7. **Suspension** is formed when two or more substances are mix in a non-uniform manner. Heterogeneous mixtures are suspensions. The solute does not mix with the solvent and can be viewed through naked eyes. We can see the path of light through the particles of a suspension and can be separated using filtration.

8. **Colloids** solution is a uniform solution of two or more substances. The particles are relatively very small that the solution appears as a homogeneous mixture but it is not. The particles scatter a beam of light passed through a colloid and produce Tyndall effect. Colloids are stable in nature and do not settle down if left uninterrupted. They cannot be separated through filtration. We use a method called **Centrifugation** to separate the particles of a colloid.
   - **8.1. Dispersed Phase** – The dispersed particles or the solute-like components in a colloid.
   - **8.2. Dispersing Medium** – The substance in which these solute-like particles are added
   - **8.3.** Based on the state of the dispersing medium colloids are classified as:

Example	Dispersing Medium	Dispersed Substance	Colloid Type
Fog, Aerosol sprays	Gas	Liquid	Aerosol
Smoke, Airborne bacteria	Gas	Liquid	Aerosol
Whipped cream, Soap suds	Liquid	Gas	Foam
Milk, Mayonnaise	Liquid	Liquid	Emulsion
Paints, Clays, Gelatin	Liquid	Solid	Sol
Marshmallow, Styrofoam	Solid	Gas	Solid foam
Butter, cheese	Solid	Liquid	Solid emulsion
Ruby glass	Solid	Solid	Solid sol

9. **Separate Methods:** We can separate the heterogeneous mixtures into their constituents by means of physical methods like: Filtration, Hand-picking and Sieving, other methods techniques are :
    - **Evaporation** : For separating a mixture of a non-volatile and a volatile substance
    - **Crystallization :** obtain a pure solid in the form of crystals from its solution
    - **Centrifugation** : Separating dense particles from lighter particles
    - **Sublimation** : To separate two immiscible liquids
    - **Chromatography** : To separate solutes that can dissolve in the same solvent
    - **Distillation** : To separate miscible liquids (the boiling points of the liquids must be sufficiently different)
        - **Simple Distillation** – when the miscible liquids have a satisfactory difference in their boiling points
        - **Fractional Distillation** – when the difference between the boiling points of the liquids is less than 25 K

ATOMS AND MOLECULES

1. **Molecules** : Atoms cannot survive independently. So, atoms join together and form molecules or ions. Therefore, a molecule is the smallest particle of a substance that can exist independently and shows all the properties of that substance.
    - **1.1. Atomicity** – the number of atoms in a molecule of an element is called its atomicity. For example, helium is monoatomic and oxygen is diatomic.
        - **a.** Molecules of Elements are formed by combination of similar types of atoms. E.g. Oxygen O_2
        - **b.** Molecules of Compound are formed by combination of different types of atoms. E.g. Water H_2O

2. **Ions** : It is an electrically charged atom or group of atoms. It is formed by the loss or gain of one or more electrons by an atom. Cation (+) is positive charge and Anion (-) is negative charge.

3. **Law of conservation of mass:** According to this law, during any physical or chemical change, the total mass of the products remains equal to the total mass of the reactants.

4. **Law of constant proportion**: Another French chemist, Joseph Proust, stated this law as 'A chemical compound always contains same elements combined together in the same proportion by mass'.

5. **Law of multiple proportion:** John Dalton (1803) stated this law as 'when two elements combine with each other to form two or more than two compounds, the mass of the element which combine with the fixed mass of the other bears a simple whole number ratio'.

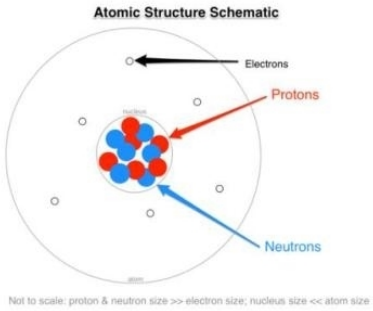
6. **Molecular Mass** – summation of all the atomic masses in a molecule (amu). E.g. the molecular mass of HNO_3 can be calculated as: Atomic mass of H =1u + Atomic mass of N =14u + Atomic mass of O = 16u = Molecular mass of HNO_3 = 1 + 14 + (16*3) = 63u

7. **Mole** The mole is represented by Avogadro's number, which is 6.022×10^{23} atoms or molecules per mol. The mole allows scientists to calculate the number of elementary entities (usually atoms or molecules) in a certain mass of a given substance. The mass of one mole of a substance is equal to that substance's molecular weight in grams.
    - **7.1.** Gram atomic mass of a substance – the atomic mass of a substance when expressed in grams.
    - **7.2.** Gram molecular mass of a substance – the molecular mass of a substance when expressed in grams.

8. **Formulas**: 1 mole = Mass of Substance / Gram Atomic Mass OR Number of particle / Avogadro Number
    Gram Molecular Volume = Gram Molecular weight / Volume of Gas at STP
    RMM = Mass of one molecule of substance / $(1/12)^{th}$ Mass of atom of C^{12}

STRUCTURE OF ATOMS

Atom is the smallest particle of an element. It has two parts: nucleus and outer nuclear part. Nucleus of the atom consists of protons and neutrons. The out part consists of Electrons.



1. **Neutrons** discovered by James Chadwick. It possess no charge and are present in the center of an atom that is the nucleus. The neutron is slightly later than protons in shape. Besides, simple hydrogen is the only element that does not have a neutron. A neutron does not have any electrical charge and they are really dense. Its mass is equal to one atomic mass unit. Neutrons are stable and decay very slowly, however the free neutron decay very quickly as it is unstable.

2. **Protons** discovered by Ernest Rutherford, in his famous gold foil experiment. They are the positively charged particles that are present in the nucleus of the cell. The proton is larger in shape than an electron. The charge of a proton is equal to the charge of an electron to maintain the balance in the atom. In addition, the number of protons in the nucleus of an element makes up the atomic number. Proton is stable in its free state and does not breakdown simultaneously.

3. **Electrons** discovered by J.J. Thomson, in his cathode ray tube experiment. They are negatively charged particles and the smallest particle of the atom. It revolves around the nucleus of the atom and resides in the orbitals or shells that surround the nucleus of the atom. They exist in both free and bound form with an atom. They exist in spherical shells of various radii, representing energy level. Electron plays a major role in magnetism, chemistry, electricity, thermal conductivity, and many others.

Particle	Symbol	Mass (amu)	Relative Mass (proton = 1)	Relative Charge	Location
Proton	p^+	1	1	+1	inside the nucleus
Electron	e^-	5.45×10^{-4}	0.00055	−1	outside nucleus
Neutron	n^0	1	1	0	inside the nucleus

4. **Models of Atoms**
   - 4.1. **Dalton's model of the atom**: John Dalton proposed that all matter is composed of very small things which he called atoms. When Dalton proposed his model electrons and the nucleus were unknown. Dalton suggested that atoms can neither be created nor destroyed and are indivisible. But the discovery of electrons and protons in atoms lead to failure of this aspect of Dalton's theory.
   - 4.2. **Thomson's model of the atom**: According to J.J. Thomson, the structure of an atom can be compared to Christmas pudding where electrons are present inside a positive sphere. Thomson was awarded the Nobel Prize for his work in this field. However, even with the Plum Pudding Model, there was still no understanding of how these electrons in the atom were arranged.
   - 4.3. **Rutherford's model of the atom:** Rutherford model described the atom as a tiny, dense, positively charged core called a nucleus surrounded by lighter, negatively charged electrons. This model is sometimes known as the planetary model of the atom. Some problems with this model is it could not explain the very interesting observation that atoms only emit light at certain wavelengths or frequencies.
   - 4.4. **Bohr's model of the atom**: Niels Bohr solved Rutherford's Model problem by proposing that the electrons could only orbit the nucleus in certain special orbits at different energy levels around the nucleus.

5. **Atomic number** (Z) = No. of Protons = No. of Electrons

6. **Mass Number** = No. of Protons + No. of Neutrons

7. **Atomic Mass** of a single atom is simply its total mass and is typically expressed in atomic mass units or amu.

8. **Difference between Isotopes and Isobars**

Isotope	Isobar
Isotopes are atomic structures of same elements having a different mass number/atomic mass	Isobars are different chemical elements having same atomic mass.
Atomic numbers of all isotopic forms of a single element are equal.	Atomic numbers of isobars vary from each other
They are the same chemical element, but their forms are different	They are different elements altogether.
All isotopic forms of single elements have different physical properties.	Physical properties can be similar to each other

9. **Naming Compound**

PREFIX OR SUFFIX	MEANING	EXAMPLE
Mono-	There is 1 atom of that type in that molecule	Carbon monoxide (CO)
Di-	There are 2 atoms of that type in the molecule	Carbon dioxide (CO_2)
Bi-	Hydrogen is present in the molecule	Sodium bicarbonate ($NaHCO_3$)
-ide	There are only 2 types of atoms present in the molecule	Lead oxide (PbO)
-ate	There are 3 or more types of atoms in the molecule, and 1 type is oxygen	Calcium carbonate ($CaCO_3$)

10. **Valency :** is the charge of an ion or radical which has either lost or gained electrons
    a. The arrangement of electrons in the various shells/orbits/energy levels of an atom of the element is known as electronic configuration.
    b. Atoms of a given atomic number can have different number of neutrons are called isotopes.
    c. The atoms of different elements, which have the same mass number but different atomic numbers are called isobars. These have different number of protons but equal sum of number of protons and neutrons.
    d. The atoms of different elements, which have the same number of neutrons but different atomic numbers, are called isotones.

1	2	3	-1	-2	-3
H^{1+}	Mg^{2+}	Al^{3+}	F^{1-}	O^{2-} oxide	$PO4^{3-}$ phosphate
Na^{1+}	Ca^{2+}	Fe^{3+} ferric	Cl^{1-}	S^{2-} sulphide	
Li^{1+}	Cu^{2+}		Br^{1-}	CO_3^{2-} carbonate	
K^{1+}	Zn^{2+}		OH^{1-} hydroxide	SO_4^{2-} sulphate	
Ag^{1+}	Pb^{2+}		NO_3^{1-} nitrate		
NH_4^{1+}	Fe^{2+}		HCO_3^{1-}		

ammonium	ferrous		bicarbonate		

CHEMICAL REACTIONS AND EQUATIONS

1. **Chemical reactions**: The transformation of chemical substance into a new chemical substance by making and breaking of bonds between different atoms is known as Chemical Reaction.
   - **1.1. Signs of a chemical reaction**: These factors denote that a chemical reaction has taken place- change of state of substance, change of color of substance, evolution of heat, absorption of heat, evolution of gas and evolution of light.

2. **Chemical Equation**: The representation of chemical reaction by means of symbols of substances in the form of formulae is called chemical equation. E.g. $H_2 + O_2 \rightarrow H_2O$ (Hydrogen and Oxygen are reactants whereas Water is Product)
   - **2.1.** Forward Arrow (→) when reaction proceeds in forward direction
   - **2.2.** Double Arrow (⇄) when reaction is reversible
   - **2.3.** Equilibrium Arrow (⇌) when a reversible reaction is at equilibrium.

3. **Balanced Chemical Equation**: A balanced chemical equation has number atoms of each element equal on both left and right sides of the reaction. According to Law of Conservation of Mass, mass can neither be created nor destroyed in a chemical reaction. To obey this law, the total mass of elements present in reactants must be equal to the total mass of elements present in products.

4. **Types of Chemical Reactions**:

Name & Definition	Example
In a **combination** reaction, two or more reactants combine to give single product.	$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$
In a **decomposition** reaction, a single reactant breaks down into two or more simpler products.	
When decomposition reaction is carried out by heating, it is called **thermal decomposition** reaction.	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
When decomposition reaction is carried out in the presence of sunlight, the process is called **photochemical decomposition.**	$2AgBr(s) \rightarrow 2Ag(s) + Br_2(g)$
Electrolysis: When decomposition reaction is carried out with the help of electric current, the process is called electrolysis.	$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$
In a **displacement** reaction, a more reactive element displaces a less reactive element from a less compound.	$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$
Those reactions in which the different atoms or groups of atoms are displaced by other atoms or groups of atom, i.e., two compounds exchange their ions and one of the products formed is insoluble, are said to be **double displacement** reactions**.**	$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
The reactions in which acid or acidic oxide reacts with the base or basic oxides to form salt and water are called **neutralization** reactions.	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O(l)$
Precipitation the insoluble compound called precipitate forms in this reaction.	$AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$

Exothermic reactions which produce energy are called exothermic reaction. Most of the decomposition reactions are exothermic.	$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ $(\Delta H<0)$
Endothermic reactions which absorb energy are called endothermic reaction. Most of the combination reactions are endothermic.	$C(s) + H_2O(l) \rightarrow CO(g) + H_2(g)$ $(\Delta H>0)$
Oxidation is gain of oxygen or removal of hydrogen or metallic element from a compound is known as oxidation.	$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$
Reduction is addition of hydrogen or removal of oxygen from a compound is called reduction.	
Redox is a chemical reaction where oxidation and reduction both take place simultaneously are also known as redox reaction.	$NaOH(aq) + HCl(aq) \rightarrow NaCl(s) + H_2O(l)$

5. **Rusting**: When iron reacts with oxygen and moisture forms a red substance called rust.
   - **Reaction**: $4Fe + 3O_2 + 2H_2O \rightarrow 2FeO_3.H_2O$ (rust)

6. **Rancidity**: Oils and fats when get oxidized on exposure to air show a change in taste and smell. Due to this reason packets of chips are flushed with gas such as nitrogen that acts as antioxidant and prevents spoilage of the fried chips.

ACIDS, BASES AND SALTS

1. **Acids:** Those substances which turn blue litmus solution red are called acids. Acids are sour in taste. They give H+ ions in aqueous solution. Some acid are organic while others inorganically created. A concentrated acid is one which contains the minimum amount of water in it. A dilute acid is obtained by mixing the concentrated acid with water. Example: HCl, H_2SO_4, HNO_3, CH_3COOH
   - **1.1. Types:**
     - Weak Acid: weak acids → releases less number of H^+ ions → acetic acid
     - Strong Acid: strong acids → release more H^+ ions → HCl
   - **1.2. Reactions:**
     - **Neutralization**: Acid + Base → Salt + Water - $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
     - **With Water**: Acids produce H^+ ions when dissolved in water. H^+ ions cannot exist alone. They combine with water molecule (H_2O) to form H_3O^+(hydronium ions). It conducts electricity. Decrease in H_3O^+ ions concentration per unit volume results in formation of dilute acids. It is a highly exothermic reaction. Acids when dissolved in water release large amount of heat. If water is added to concentrated acid, then the heat generated may cause the mixture to splash out and cause bums. Hence to avoid burns acid must be added drop wise into water with constant stirring.
     - **With Metals**: Acid + Metal → Salt + Hydrogen Gas - $2HCl + Zn \rightarrow ZnCl_2 + H_2$
     - **With Metal Oxides**: Acid + Metal Oxide → Salt + Water - $2HCl + CuO \rightarrow CuCl_2 + H_2O$
     - **With Metal Carbonate**: Acid + Metal carbonate → Salt + CO_2 + H_2O - $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

2. **Bases:** They are bitter in taste and soapy to touch. Sea water and detergents are some examples of substances that are basic. Many bases are oxide or hydroxide compounds of metals. Strong bases can also burn ones skin. Example: Caustic soda, NaOH; Caustic potash, KOH; Milk of magnesia, $Mg(OH)_2$; Liquor ammonia, NH_3; Washing powder, Tooth paste.
   - **2.1. Types:**
     - Weak Base: weak base → gives less OH^- ions → CH_3COOH
     - Strong Base: strong base → give more OH^- ions → NaOH
   - **2.2. Reactions**:
     - **With Water**: Bases produce OH^- ions when dissolved in water. Bases soluble in water are called alkalis. It conducts electricity. Decrease in OH^- ions single concentration per unit volume results in formation of dilute bases. It is a exothermic reaction. To make basic solution, base must be added drop wise into water with constant stirring, so that the heat generated spreads over in water.
     - **With Metals:** Base + Metal → Salt + H_2 Gas - $2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$
     - **With Non - Metal Oxides:** Base + Non-metallic oxide → Salt + H_2O

3. **Salts:** Salts are obtained by treating an acid with a base. Salts consist of both positive ions or 'cations', and negative ions or 'anions'. The cations are called basic radicals and are mostly obtained from metallic ions (ammonium ion being one exception), while the anions are called acidic radicals and are obtained from acids. Salts can be classified into the following types:
   - **3.1. Normal Salts**: A salt that is formed by the complete replacement of the replaceable hydrogen ions of an acid by a metal ion or ammonium ion is called a normal salt. Examples: NaCl, Na2SO4, Na3PO4, NH4Cl, K2CO3 etc.
   - **3.2. Neutral Salts**: A neutral salt arises due to the neutralization reaction. Here, salts of strong acid and strong base combine to form such salts that show a neutral pH of 7.

Acid	Uses
Organic acids	
Citric acid	1. As a preservative for food 2. As a flavoring agent
Ascorbic acid (also called vitamin C)	In the treatment of bone marrow and scurvy diseases
Acetic acid	Added to pickles to make them sour
Tartaric acid	A component of baking power (baking powder is a mixture of sodium hydrogen carbonate and tartaric acid)
Inorganic acids	
Hydrochloric acid	1. Its presence in the gastric juice helps digestion of food we eat. 2. As a bathroom cleaner 3. Manufacturing of PVC
Nitric acid	1. Nitric acid present in rainwater forms nitrates in the soil which are then used by plants to obtain nitrogen. 2. In manufacturing fertilizers like ammonium nitrate. 3. Making explosives like TNT and dynamite
Sulphuric acid	1. In storage batteries 2. In manufacturing fertilizers, paints, fibers, HCL and alum
Phosphoric acid	In fertilizer and detergent industries
Boric acid	1. In the manufacture of glass, glazes and enamels, leather, paper, adhesives and explosives 2. In detergents 3. As grain preservative
Bases	**Uses**
Sodium hydroxide	1. In the manufacture of soaps, textile, paper, medicines 2. In the refining of petroleum
Ammonium hydroxide	1. As a reagent in the laboratory 2. In making fertilizers, rayon, plastics and dyes
Calcium hydroxide	1. In making cement and mortar 2. In making bleaching powder 3. In whitewashing 4. In removing acidity of soils
Salts	**Uses**
Sodium chloride	1. An essential requirement of our food 2. In the preservation of food 3. In curing fish and meat 4. In making a freezing mixture which is used by ice-cream vendors 5. In the manufacture of soaps
Sodium carbonate	1. As washing soda for cleaning clothes 2. Used in the manufacture of glass, paper, textiles, caustic soda, etc. 3. In the refining of petroleum 4. In fire extinguishers
Sodium bicarbonate	1. Used as baking soda 2. In fire extinguishers 3. As an antacid in medicine

Potassium nitrate	1. To make gunpowder, fireworks and glass 2. As a fertilizer in agriculture
Copper sulphate	1. Called 'blue vitriol', used as a fungicide to kill certain germs 2. In electroplating 3. In dyeing
Potash alum	1. Used to purify water; makes suspended particles in water settle down 2. As an antiseptic and in Dying

4. **Baking Soda:** The chemical name of baking soda is sodium hydrogen carbonate ($NaHCO_3$). Chlorine produced on passing electricity through brine solution undergoes reaction with ammonia produces baking soda.
   $NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$
   - On Heating: $NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$
   - Uses: As a component of baking powder. In fire extinguishers. In medicines as a mild antiseptic for skin diseases and to neutralize the acidity of stomach. As a reagent in laboratory.

5. **Plaster of Paris:** Chemical name is Calcium sulphate sodium carbonate hydrated. Formula: $CaSO_4.1/2\ H_2O$
   - On Reaction with Water : $CaSO_4.1/2\ H_2O + 11/2.H_2O \rightarrow CaSO_4.2H_2O$

6. **Bleaching Powder**: Chlorine produced on passing electricity through brine solution undergoes reaction with dry slaked to produce Bleaching powder. Formula : $CaOCl_2$
   - Reaction: $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$
   - Uses: For bleaching cotton and linen in the textile industry, To bleach wood pulp in paper manufacturing industry. To bleach washed clothes in laundry. To disinfect drinking water and make it germfree.

7. **Washing Soda:** Chemical name is Sodium carbonate hydrated. The heating of baking soda produces sodium carbonate. This sodium carbonate undergoes recrystallization to give off washing soda. Formula: $Na_2CO_3.10H_2O$
   - On recrystallization: $Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3.10H_2O$
   - Uses: In glass, soap and paper manufacturing industries. It is also used in the manufacture of sodium compounds like borax. It is also used as a cleaning agent and in removing permanent hardness of water.

8. **pH Indicator**: The acidity or basicity (alkalinity) of a solution is usually expressed in terms of a function of the H+ ion concentration. This function is called the pH of a solution.
   8.1. Types of indicators:
   - Olfactory indicators: Those substances whose odor changes in acidic or basic media e.g., clove, vanilla, onion.
   - Natural indicators: Turmeric, Litmus (obtained from lichen).
   - Synthetic indicators: Methyl orange, phenolphthalein

   8.2. pH scale Value: The scale lies between 0 to 14
   - The pH of a neutral solution is 7.
   - The pH of an acidic solution is less than 7.
   - The pH of an alkaline solution is more than 7.
   - The pH of an aqueous solution is the negative logarithm of its H+ ion concentration. That is, $pH = -\log [H^+]$. $pOH = -\log [OH^-]$.

   8.3. Rules for pH scale (at 298 K)
   - Acidic solutions have pH less than 7.
   - The lower the pH, the more acidic is the solution.
   - Neutral solutions or pure water has pH equal to 7.
   - Basic solutions have pH greater than 7.
   - The higher the pH, the more basic is the solution.

METALS AND NON-METALS

1. **Chemical Properties of Metals**

   1.1. Metals react with air or oxygen to form metal oxide. E.g. Copper reacts with oxygen to form copper oxide.

   Metal + O_2 → Metal oxide

1.2. Oxides of metals can react with both acids and bases to produce salt and water. Such oxides are known as **Amphoteric Oxides**. **$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + H_2O$**

1.3. Metals also reacts with water to form metal oxide. Metal oxide in turn can react with water to form metal hydroxide. **$2Na + 2H_2O \rightarrow 2NaOH + 1H_2$**

1.4. Metals also reacts with dilute acids to form salt and hydrogen. **Metal + Acid → Metal Salt + Hydrogen**

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

2. Chemical Properties of Non-metals

2.1. Non-metals reacts with oxygen to form non-metal oxide. **Non-metal + Oxygen → Non-metal oxide**

$C + O_2 \rightarrow CO_2$

2.2. Non-metals do not react with water and acids to evolve hydrogen gas.

2.3. Non-metals can react with salt solution; more reactive element will displace the less reactive non-metal.

$2\ NaBr\ (aq) + Cl_2(aq) \rightarrow 2NaCl\ (aq) + Br_2\ (aq)$

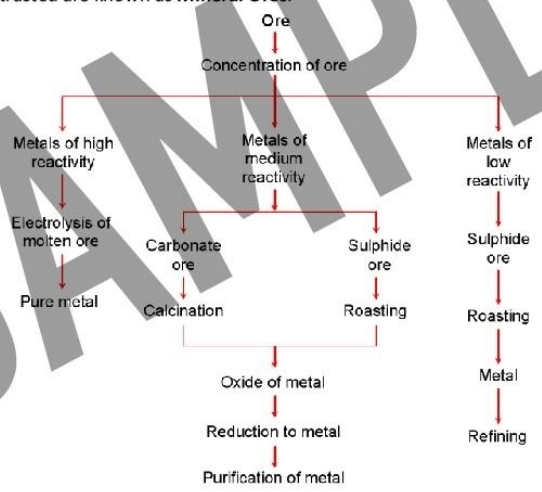
2.4. Non-metals can also react with hydrogen to form hydrides. **$H_2(g) + S(l) \rightarrow H_2S(g)$**

3. Reactivity Series: The series in which metals are arranged in the decreasing order of reactivity.

3.1. K (most reactive) > Na > Ca > Mg > Al > C > Zn > Fe > Sn > Pb > H > Cu > Ag > Au > Pt (least reactive)

4. Ionic Compounds: compounds formed due to the transfer of electrons from a metal to a non-metal. They are generally solid, with a high melting and boiling point. They are soluble in water but insoluble in inorganic solvents like ether. They conduct electricity in molten and solution state.

5. Occurrence of Metals Elements or compounds which occurs naturally in earth crust are known as **Minerals**. Minerals from which pure metals can be extracted are known as **Mineral Ores**.



6. Extraction: Extraction of pure metals from its ores start with enrichment of the ore, extraction of metals, refining of metal.

6.1. The metals at the top of the activity series (K, Na, Ca, Mg and Al) are so reactive that they are never found in nature as free elements.

6.2. The metals in the middle of the activity series (Zn, Fe, Pb, etc.) are moderately reactive. They are found in the earth's crust mainly as oxides, sulphides or carbonates.

6.3. Below copper lies gold and silver that are found in Free State. These metals have low reactivity.

7. Gangue - Ores contain different impurities in it such as sand, soil etc. Gangue + Flux = Slag

8. Refining of Metals: Refining of impure metal is done using electrolytic refining. Impure copper is used as anode and strip of pure copper is used as **Cathode**. Acidified copper sulphate is used as electrolyte. When electric current is passed through this, impure metal from the anode gets deposited in the electrolyte solution, whereas pure metal from the electrolyte is deposited at cathode.

9. **Extracting Metals which are low in activity series**: Metals which are low in activity series are unreactive. The oxides of such metals can be reduced to metals by heating alone. **For** Example, Cinnabar (HgS)

10. **Extracting Metals in the middle of the Activity Series**: These metals are moderately reactive. They exists as sulphides or carbonates in nature. Before reduction, metal sulphides and carbonates must be converted into metal oxides. Sulphide ores are converted into oxides by heating strongly in presence of excess air, this is known as **Roasting**. Carbonate ores are converted into oxides by heating in limited air. This is known as **Calcination**.

$$2HgS(s) + 3O_2(g) \xrightarrow{Heat} 2HgO(s) + 2SO_2(g)$$

$$2HgO(s) \xrightarrow{Heat} 2Hg(l) + O_2(g)$$

Roasting

$$2ZnS(s) + 3O_2(g) \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$$

Calcination

$$ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$$

Reduction-metal oxides can be reduced to metals using reducing agent such as such as **Carbon**.

11. **Extracting metals towards the top of the activity series**: The metals are highly reactive. They cannot be obtained by heating. **For Example**, Sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides.

At cathode $Na^+ + e^- \rightarrow Na$
At anode $2Cl^- \rightarrow Cl_2 + 2e^-$

12. **Corrosion**: Metals when exposed to moist air for a long period of time, they become corroded. E.g. Silver reacts with moist air and becomes black in colour due to silver sulphide coating. **Iron + oxygen → Iron (III) oxide** = $Fe + O_2 \rightarrow Fe_2O_3$

12.1. Prevention of Corrosion

   a. Rusting of iron can be prevented by oiling, galvanizing, painting, greasing etc.
   b. To protect steel and iron from rusting, a thin layer of zinc are coated on them, this is known as **Galvanization**.
   c. Sacrificial Protection 'Rusting' can be prevented by connecting iron to a more reactive metal
   d. **Electroplating**: Coating the surface with metals like tin, chromium, nickel etc.
   e. **Alloying**: Iron or steel along with other metals can also be protected by 'alloying' or mixing with other metals (e.g., chromium) to make non-rusting alloys.

CARBON AND ITS COMPOUND

1. **Hydrocarbons**: Compounds containing carbon and hydrogen. **Organic Compounds** – Hydrocarbons and compounds derived from hydrocarbons.

2. **Properties of Carbon**: Always forms covalent bonds, Tetravalent, Tetrahedral, 3 allotropes (Diamond, Graphite, Fullerene)

3. **Covalent Bonds:** It is defined 'as the force of attraction arising due to mutual sharing of electrons between the two atoms.' The combining atoms may share one, two or three pairs of electrons. The covalent bond is formed between two similar or dissimilar

atoms by a mutual sharing of electrons, which are counted towards the stability of both the participating atoms. The covalent compounds do not exist as ions but they exist as molecules, their melting and boiling points are. They are insoluble or less soluble in water and in other polar solvents and are poor conductors of electricity.

4. **Name of Compound**

Name of Compound	IUPAC Name	General Formula
Alkene	+ene	C_nH_{2n}
Alkynes	+yne	C_nH_{2n-2}
Haloalkanes	+alkane	C_nH_{2n-1}
Alcohols	+ol	$C_nH_{2n+2}OH$
Aldehydes	+al	$C_nH_{2n}O$
Ketones	+one	$C_nH_{2n}O$
Carboxylic Acid	+oic acid	$C_nH_{2n+2}COOH$

5. Chemical properties of Carbon Compounds
   - 5.1. **Combustion:** All the allotropic forms of carbon burn in the presence of oxygen releasing carbon dioxide along with heat and light. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   - 5.2. **Substitution:** When one atom in hydrocarbon is replaced by chlorine, bromine, etc.
   - 5.3. **Addition:** Hydrogenation of vegetable oil is an example of addition reaction. Addition of hydrogen in presence of catalyst such as nickel or palladium. This converts oil into ghee.
   - 5.4. **Oxidation**: Carbon compounds gets readily oxidized on combustion.

6. Important Compounds
   - 6.1. **Ethanol**: It is a volatile liquid with low melting point. It reacts with sodium to form sodium ethoxide. Dehydration of ethanol in presence of hot sulphuric acid forms alkene.
   - 6.2. **Ethanoic Acid**: It is a colourless liquid. When pure ethanoic acid freeze like ice, it is known as Glacial Acetic Acid. It is formed at a temperature of about 16.6 degree centigrade Ethanoic Acid/Acetic acid when reacts with ethanol it forms an ester. Ester can be identified by its sweet smell.
   - 6.3. **Soaps & Detergent**: Sodium or potassium salt of carboxylic acid is known as Soap. Detergents are sulphonate or ammonium salt of long chain of carboxylic acid. Soaps can work effectively on soft water but detergent can work on both soft as well as hard water. Reaction of ester with strong base is used to form soap. This is known as Saponification. Acetic acid also reacts with strong base to form sodium acetate and water.

     - **Cleansing Action:** Ability to minimize the surface tension of water, to emulsify oil or grease and to hold them in a suspension of water. When soap dissolves in water, it forms soap anions and soap cations. The hydrophobic part of soaps and detergents are soluble in grease and hydrophilic part is soluble in water.
     - **Soap and Micelle Formation** When dirt and grease are mixed with soap water, soap molecules arrange them in tiny clusters known as Micelle. The hydrophilic part sticks to the water and form outer surface of the micelle and hydrophobic part binds to oil and grease.

PERIODIC CLASSIFICATION OF ELEMENTS

1. **Periodic table** – The table giving the arrangement of the known elements according to their properties so that similar elements fall within the same vertical column and dissimilar elements are separated.

2. **Dobereiner's Triads** In the year 1829, Johann Wolfgang Dobereiner, a German scientist, was the first to classify elements into groups based on John Dalton's assertions. He grouped the elements with similar chemical properties into clusters of three called 'Triads'. The distinctive feature of a triad was the atomic mass of the middle element. When elements were arranged in order of their increasing atomic mass, the atomic mass of the middle element was approximately the arithmetic mean of the other two elements of the triad.
   - 2.1. **Limitations:**
     - a. Dobereiner could identify only three triads.

b. He was not able to prepare triads of all the known elements.

Triad 1	Triad 2	Triad 3
Lithium (Li)	Calcium (Ca)	Chlorine (Cl)
Sodium (Na)	Strontium (Sr)	Bromine (Br)
Potassium (K)	Barium (Ba)	Iodine (I)

3. **Newlands' Octave:** John Newlands arranged the elements in order of their increasing atomic mass. It states that whenever the elements are arranged in increasing order of their atomic mass, the properties of the eighth element are a kind of repetition of the first, just like the notes of music.
   - **3.1. Achievements:**
     - **a.** Periodicity of elements was recognized for the first time.
   - **3.2. Limitations:**
     - **a.** The law was applicable to elements up to calcium (Ca) only.
     - **b.** It contained only 56 elements. It was assumed that only 56 elements existed in nature and no more elements are going to be discovered in the future.
     - **c.** In order to fit these elements into the table, Newlands adjusted two elements in the same slot and also put some unlike elements under the same note. For example, cobalt and nickel are in the same slot and these are placed in the same column as fluorine, chlorine and bromine which have very different properties than these elements. Iron, which resembles cobalt and nickel in properties, has been placed differently away from these elements.

4. **Mendeleev's periodic table:** Mendeleev arranged all the 63 known elements in increasing order of their atomic masses. The table consists of vertical columns called 'groups' and horizontal rows called 'periods'. The elements with similar physical and chemical properties came under same groups.
   - **4.1. Limitations of Mendeleev's periodic table:**
     - **a.** He could not assign a correct position to hydrogen in the periodic table.
     - **b.** Positions of isotopes of all the elements were not certain according to Mendeleev's periodic table.
     - **c.** Atomic masses did not increase in a regular manner in going from one element to the next. So it was possible to predict how many elements could be discovered between the two elements.

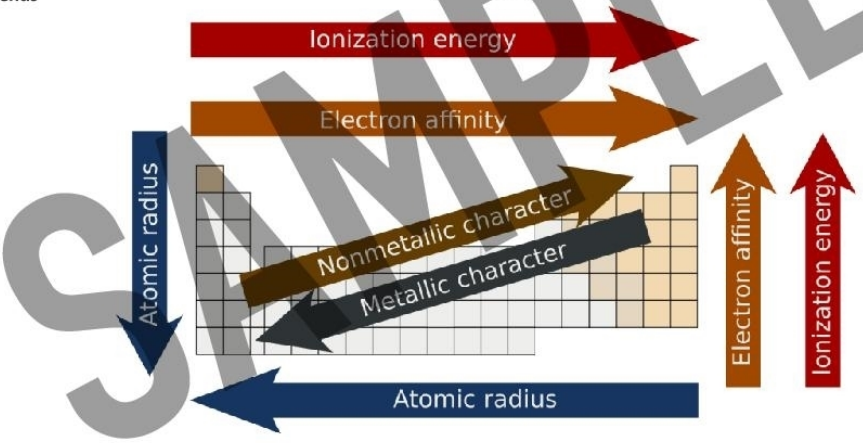
5. **The Modern Periodic table:** The Modern Periodic table consists of 18 groups and 7 periods. Elements present in any one group have the same number of valence electrons. Also, the number of shells increases as we go down the group. Elements present in any one period, contain the same number of shells. Also, with increase in atomic number by one unit on moving from left to right, the valence shell electron increases by one unit. Each period marks a new electronic shell getting filled.
   - **5.1. Modern Periodic Law:** ''Properties of elements are periodic functions of their atomic numbers, i.e., the number of protons or electrons present in the neutral atom of an element.''
   - **5.2. Achievements:**
     - **a.** Systematic Study of Elements Mendeleev's Periodic table simplified the study of elements.
     - **b.** Prediction of New Elements, he left three blanks for elements that were not discovered at that time.
     - **c.** Correcting the atomic masses of some of the elements, based on their positions in the periodic table.
   - **5.3. Limitations**:
     - **a.** The position of hydrogen was not correctly defined. It was placed in Group I although its properties resembled both the Group I elements (the alkali metals) and the group VII elements (the halogens).
     - **b.** Mendeleev placed elements according to their similarities in properties and not in increasing order of their atomic masses, while some dissimilar elements were grouped together.
     - **c.** Anomalous Pair like, Ar (40) and K (39); Co (58.9) and Ni (58.6); Te (127.6) and I (126.9) arrangement was not justified.
     - **d.** Isotopes have not been given separate places in the periodic table.
     - **e.** Lanthanides and Actinides: 14 elements that follow lanthanum called lanthanides and fourteen elements following actinium called actinides were not given proper places in Mendeleev's periodic table.

6. **Long form of Periodic Table:** Arranged in increasing order of their atomic numbers. The prediction of properties elements and their compounds can be made with precision. All drawbacks of Mendeleev's Periodic Table vanish when the elements are arranged on the basis of increasing atomic numbers.
   - **6.1. Main Features:**
     - **a.** It shows arrangement of elements based on modern periodic law.
     - **b.** There are 18 vertical columns known as groups.
     - **c.** There are 7 horizontal rows known as periods.
     - **d.** Elements having similar outer electronic configurations, i.e., having same valence electrons have been placed in same groups
   - **6.2. Types of Elements:** On the basis of electronic configuration, the elements of the periodic table are classified into:
     - **a. Noble gases** (18 or VIIIA group): Noble gases are also known as inert gases and do not take part in chemical reactions. They have their outermost shell complete and thus remain stable. Since, the outermost shell is complete, the valency is zero, hence VIIIA group is also referred to as zero group.

b. **Normal elements**: In the case of these elements, all shells except the outermost shell are completely filled. Elements belonging to 1 (IA), 2 (IIA), 3 (IIIA), 4 (IVA), 5 (VA), 6 (VIA) and 7 (VIIA) are normal elements.
c. **Transition elements** (3 to 12 groups): They resemble each other in several physical and chemical properties. They are all metals. They are called transition elements because they are placed between the most reactive metals on the left and non-metals on the right. Their compounds are colored. They exhibit variable valency.
d. **Inner-transition elements**: The 6th period consists of elements that have atomic numbers 58 to 71 are Lanthanides. The 7th period consists of elements that have atomic numbers 90 to 105 are called Actinides. Lanthanides and actinides are not accommodated in the main body of the periodic table but are placed in separate rows in form of two series at the bottom of the modern periodic table. The 7th period is an incomplete period as it has only 23 elements.
e. **Alkali metals** (I A group): This family is of very reactive metals called alkali metals. They are lithium, sodium, potassium, rubidium, cesium and francium. All of them have one electron in the valence shell. They are called alkali metals because their hydroxides are strong alkalis. These metals are soft, light and easily fusible. In fact, sodium and potassium are lighter than water.
f. **Halogens** (7 (VIIA) group): All these elements form salts called halides, e.g. NaCl, NaI, KCl, KI etc. Halogen is an ancient Greek word meaning 'salt producer'. Halogens have seven electrons in their valence shell and so are monovalent.

6.3. Demerits: Although the long form of the period table has been able to help in systematic studying the elements to a great extent, it has some minor defects
a. Hydrogen resembles both the alkali metals and halogens.
b. But it has been placed with the alkalis and with the halogens.
c. The lanthanides and actinides have not been placed in the main body of the table.

6.4. Trends



a. **Ionization Energy:** The minimum energy needed to remove the outermost electron from the neutral atom in the gaseous state.
b. **Electron Affinity:** Electron affinity is the amount of energy released when an electron is added to an isolated gaseous atom.
c. **Atomic Radius:** The distance between the center of the nucleus and the outermost shell of an isolated atom.
d. **Atomic Volume**: It is defined as the volume occupied by one mole atoms of the element at its melting point, in solid state. Increases on moving down the group and decreases along the period.
e. **Electronegativity:** It is the tendency of an atom to attract electrons towards itself in a molecule of a compound. The value of electronegativity of an element describes the ability of its atom to compete for electrons with the other atom to which it is bonded. Electronegativity is however not the property of an isolated atom. Electronegativity increases from left to right in each period ending at group 17.

LIFE PROCESSES

Biology is the study of living things. We decide whether something is living or non-living depends on 8 life processes.

1. **Movement**: Plants are rooted and move slowly as they grow. Their roots move down into the soil and their stems move up towards the light. Animals on the other hand move quickly and can move their entire bodies.

2. **Sensitivity**: All living organisms are sensitive; this means that they have an awareness of changes in their environment. Animals respond quickly to stimuli such as heat, light, sound, touch and chemicals which have taste and smell. On the other hand, plants appear less sensitive and their response is slower.

3. **Growth**: All living organisms grow. Plants continue growing throughout their lives. Animals stop growing once they reach adulthood. Even when growth stops, materials within an animal's body are still being replaced from its food.

4. **Reproduction**: All living things must produce offspring like themselves in order for their species to survive. Reproduction can be of two types, Sexual which involves two parents and the union of two gametes and Asexual where one parent can reproduce itself.

5. **Respiration**: It is the process of extracting energy out of the food we eat. All living things respire because they need energy to grow, to replace worn out parts and to move. Respiration takes place in the mitochondria of the cell. During respiration, the digested food materials are broken down to release energy in the form of ATP. Depending on the requirement of oxygen, respiration may be of two types:
   a. Anaerobic respiration: It occurs in the absence of (air) oxygen.
      In all cases the first step is the break-down of glucose, a six-carbon molecule, into a three-carbon molecule called pyruvate. This process taken place in the cytoplasm. Further, the pyruvate may be converted into ethanol and carbon dioxide. This process takes place in yeast during fermentation. Since this process takes place in the absence of air (oxygen), it is called anaerobic respiration.
   b. Aerobic respiration: It occurs in the presence of air (oxygen).
      Break-down of pyruvate using oxygen takes place in the mitochondria. A large amount of energy is released in aerobic respiration as compared to anaerobic respiration. Sometimes when there is a lack of oxygen in our muscle cells, the pyruvate is converted into lactic acid. This build-up of lactic acid in our muscles during sudden activity causes cramps.

   Terrestrial organisms use atmospheric oxygen for respiration, whereas aquatic organisms use oxygen dissolved in water. In humans, inhalation of air occurs through the following pathway:
   Nostrils > Nasal passage > Pharynx > Larynx > Trachea > Bronchus > Bronchiole > Alveolus

6. **Excretion:** It is the process of getting rid of metabolic waste. During excretion, the harmful metabolic nitrogenous wastes generated are removed from the body. Note: Getting rid of feces or undigested food is not excretion but egestion.
   a. **Excretion in plants:** Plants do not have an excretory system and carry out excretion in various ways such as transpiration, releasing wastes into the surrounding soil, losing their leaves and storing waste materials in cell vacuoles. Other waste products are stored as resins and gums in old xylem.
   b. **Excretion in Human Beings:** In humans, a pair of kidneys, a pair of ureters, the urinary bladder and the urethra constitute the excretory system. Kidneys are located in the abdomen, one on either side of the backbone. Urine produced in the kidneys passes through the ureters into the urinary bladder where it is stored until it is released through the urethra.

7. **Nutrition**: Energy required to carry out different life processes is obtained through the process of nutrition. Depending on the mode of obtaining nutrition, organisms are classified as autotrophs or heterotrophs.
   a. **Autotrophic Nutrition:** A type of nutrition in which organisms synthesize the organic materials they require from inorganic sources. Chief sources of carbon and nitrogen are carbon dioxide and nitrates, respectively. All green plants are autotrophic and use light as a source of energy for the synthesis of food through photosynthesis.
      $$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$
   b. **Heterotrophic Nutrition:** All heterotrophs depend on autotrophs for their nutrition. The three main types of heterotrophic nutrition are:
      - Holozoic nutrition: Complex food is taken into a specialist digestive system and broken down into small pieces to be absorbed. E.g.: Amoeba, Humans
      - Saprophytic nutrition: Organisms feed on dead organic remains of other organisms. E.g.: Fungi like bread molds yeast and mushrooms.

- Parasitic nutrition: Organisms obtain food from other living organisms (the host), with the host receiving no benefit from the parasite. E.g.: cascuta, ticks, lice, leeches and tape worms.

- **Nutrition in Organisms** In single celled organisms, the food may be taken in by the entire surface. E.g.: Amoeba
- **Nutrition in Human Beings**: In humans, digestion of food takes place in the alimentary canal, made up of various organs and glands, through the following pathway:

  Mouth > Esophagus > Stomach > Duodenum > Small Intestine > Large Intestine > Rectum

8. **Transportation**: It is the movement of material from one part to another, usually from their availability to the region of their usage, storage or elimination. Animals have circulatory system while Plants have vascular system for this function.
   a. **Transportation in plants:** Plant transport systems will move energy stores from leaves and raw materials from roots. These two pathways are constructed as independently organized conducting tubes. One, the xylem moves water and minerals obtained from the soil. The other, phloem transports products of photosynthesis from the leaves where they are synthesized to other parts of the plant.
      - The loss of water in the form of vapors from the aerial parts of the plant is known as transpiration. Transpiration creates a suction pressure, as a result of which water is forced into the xylem cells of the roots. It also regulates temperature.
      - The translocation in phloem is achieved by utilizing energy. Material like sucrose is transferred into phloem tissue using energy from ATP. This increases the osmotic pressure of the tissue causing water to move into it. This allows the phloem to move material according to the plant's needs.
   b. **Transportation in Human Beings:** The circulatory system is composed of the heart, blood and blood vessels which transport various materials throughout the body. The human heart has four chambers—two atria (right and left) and two ventricles (right and left). The right half of the heart receives deoxygenated blood, whereas the left half receives oxygenated blood. Humans show double circulation i.e. blood goes through the heart twice and complete separation of oxygenated and deoxygenated blood.

CONTROL AND COORDINATION

1. **Nervous System**: controls and coordinates different activities of the body, it comprises of the brain, the spinal cord, and a huge network of nerves that are spread throughout the body. The nervous system is responsible for sending, receiving and processing messages in the form of chemical signals called as impulses.

2. **Nervous tissue** is made up of an organized network of nerve cells or neurons. A neuron is the basic unit of the nervous system. Each neuron consists of three parts, namely, the cell body or cyton, branched projections called the dendrites, and axon. Synapse is a gap between two neurons. Types of nerve cells or neurons:
   a. Sensory nerves send messages from the sense organs to the brain or spinal cord.
   b. Motor nerves carry messages back from the brain or spinal cord to all the muscles and glands in the body.
   c. Interneuron or relay neuron connects neuron within specific regions of the central nervous system. These are neither motor nor sensory.

3. **Reflex action:** It is an involuntary and instantaneous movement in response to a stimulus. The process of detecting signal or the input and responding to it by an output action might be completed quickly. Such a connection is called a reflex arc. **Reflex arcs** are formed in the spinal cord itself; although the information input goes on to reach the brain.

4. **Human Brain :** The brain has three such major parts or regions namely the fore brain, mid brain and hind brain. Human brain is protected by the thick bones of the skull and a fluid called cerebrospinal fluid which provides further shock absorption.
   a. The forebrain is the main thinking part of the brain. It consists of the cerebrum and diencephalon. The cerebrum is the seat of memory and intelligence, and of sensory centers like hearing, smell and sight. The diencephalon is the seat for pressure and pain.
   b. The midbrain connects the forebrain to the hindbrain and controls the reflexes for sight and hearing.
   c. The hindbrain consists of the cerebellum, pons and medulla. The cerebellum coordinates muscular activities and maintains balance and posture. The medulla controls involuntary activities like blood pressure, salivation, vomiting and heart beat. The spinal cord extends from the medulla of the brain through the whole length of the vertebral column and is protected by the vertebral column or backbone.

5. **Types of nervous system** The nervous system is divided into two systems – the central nervous system and the peripheral nervous system.
   a. **Central nervous system:** It includes the brain and the spinal cord. It receives information from the body and sends out instructions to particular organs.

b. **Peripheral nervous system:** It consists of the cranial and spinal nerves arises from the brain and spinal cord respectively. It is of two types : Sympathetic and Para-Sympathetic.

6. **Coordination in plants:** Plants also respond to stimuli with the help of chemical compounds secreted by the cells. Plants show two different types of movement- one dependent on growth and the other independent of growth.
   a. **Directional movements:** These are also called as tropic movements. These movements can be either towards the stimulus or away from it. Phototropism (towards light) Geotropism (towards ground), Hydrotropism (stimuli of water) and Chemotropism (towards chemical stimulus)
   b. **Hormones** are the chemical compounds released by stimulated cells.
      i. Auxins are the hormones synthesized at the tip of the stem. These help the plant in growth by cell elongation. Auxin induces shoot apical dominance.
      ii. Gibberellins are hormones that help in the growth of the stem, seed germination, bolting, and flowering.
      iii. Cytokinin are hormones present in the areas of rapid cell division, such as fruits and seeds. They also promote the opening of the stomata.
      iv. Abscisic acid is a hormone that inhibits the growth in various parts. It is also responsible for the closure of stomata. Its effects include wilting of leaves.

7. **Coordination in Humans:** Endocrine system is the system formed by ductless glands which secrete chemical substances called as hormones. Endocrine glands release hormones directly into the blood. Hormones are minute, chemical messengers thrown into blood to act on target organs. Endocrine glands in our body are
   a. **The adrenal glands:** Secretes the hormones like cortisol (stress), aldosterone and adrenaline (excitement or danger)
   b. **The thyroid gland:** Secrets triiodothyronine and thyroxine (regulates the metabolism of carbohydrates, proteins and fats in the body) Iodine is essential for the synthesis of thyroxin. Deficiency of iodine in food causes goiter. One of the symptoms in this disease is a swollen neck.
   c. **The pituitary gland:** Secretes Growth hormone, TSH, FSH, LH, ACTH, MSH, Vasopressin and Oxytocin. Growth hormone regulates growth and development of the body.
   d. **Gonads**: Two types of gonads : **Female gonads** produce two hormones, namely, estrogen (changes during puberty) and progesterone (menstrual cycle **Male gonads** produce the hormone testosterone (changes during puberty)
   e. **The pancreas:** Secretes hormones such as insulin, glucagon, somatostatin and pancreatic polypeptide (regulates the sugar level in our blood) Less Insulin causes a disease called diabetes mellitus.
   f. **The pineal gland:** Secrets melatonin (reproductive development, modulation of wake and sleep patterns)
   g. **The hypothalamus:** Secrets Somatostatin, Dopamine.
   h. **Parathyroid glands:** Secrete parathormone (regulate calcium and phosphate ions in the bones and blood)
   i. **The thymus gland:** Secrets the hormone thymosin (regulates maturation of T-lymphocytes)

The timing and amount of hormones released are regulated by **feedback mechanisms**. For example, if the sugar levels in blood rise, they are detected by the cells of pancreas which respond by producing more insulin. As the blood sugar level falls, insulin secretion is reduced.

REPRODUCTION

Reproduction is the phenomenon which involves the production of an offspring by particular individual or individuals to propagate their species.

1. **Reproduction in Unicellular Organisms** : Most often unicellular organisms reproduce asexually.
   a. **Fission:** Splitting of the cells along any plane during division. E.g. Amoeba, Plasmodium.
   b. **Fragmentation:** Breaking into smaller pieces on maturation each fragment grows into a new individual. E.g. Spirogyra.
   c. **Regeneration:** Growing a part or self from and existing part. E.g: Planaria, Hydra
   d. **Budding:** Bud grows and detaches from the parent to develop into a separate organism. E.g. Hydra.
   e. **Vegetative propagation** Production of new plants from the vegetative parts of an existing plant. Different methods of vegetative propagation in plants include stem cutting, layering and grafting.
   f. **Spore formation:** Spores germinate into new individuals on moist surfaces. e.g. Rhizopus.

2. **Reproduction in Multicellular Organisms:** Sexual reproduction involves two organisms, the male and the female in the process of producing the offspring. Sexual reproduction provides greater variations in the DNA thereby making the offspring adapted for better survival.
   a. **Sexual Reproduction in flowering plants**: Plants reproduce sexually by producing male gametes in the form of pollen and the female gametes in the form of eggs. Stamen is the male reproductive part and it produces pollen grains. Carpel is present in the center of a flower and is the female reproductive part. It consists of the ovary, style and

stigma. This fusion of the germ cells or **fertilization** forms the zygote which is capable of growing into a new plant. This process occurs via pollination, there are two types of pollination are self-pollination and cross-pollination.

b. **Sexual Reproduction in humans:** Humans use a sexual mode of reproduction. Sperms are male germ cells and eggs are female germ cells. Reproductive phase involves the changes in appearance and size of the bodily organs.

3. **Male Reproductive System :** This system includes a pair of testis, vas deferens and a muscular organ, the penis. Testes produce the male gametes known as sperms. Testosterone is the male sex hormone secreted by the testes. The vas deferens is a tube that carries sperm from the testes. The urethra forms a common passage for both the sperm and urine as it is just one tube that connects both the glands – urinary bladder and vas deferens. Prostate gland and seminal vesicles secrete semen to make the movement of sperms easier and also provides nutrition. The sperms are tiny bodies that consist of genetic material and along tail that helps them to move towards the female germ cell.

4. **Female Reproductive System :** This system includes a pair of ovaries, a pair of oviducts, uterus and vagina opening out through urethra. Eggs, the female gametes develop inside the ovaries. One mature egg is released by either of the ovaries per month. The egg is carried from the ovary to the uterus through a thin oviduct or fallopian tube. The uterus opens into vagina through cervix. The uterus helps in the development of the fetus. The sperm enter through the vaginal passage during sexual intercourse. The sperms begin moving up the vagina and uterus, finally reaching the fallopian tubes. The fertilized egg, the zygote gets implanted in the lining of the uterus and starts dividing to form an embryo.

5. **Menstruation :** The uterus prepares itself every month to receive a fertilized egg. Thus, its lining becomes thick and spongy. If the egg is not fertilized it lives for about one day, and then the lining slowly breaks and comes out through the vagina as blood and mucous. This cycle take place every month and lasts for about 2-8 days.

6. **Reproductive Health.** Reproductive health is concerned with healthy and safe sexual practices. Unhealthy practices can lead to the transmission of disease from one partner to another and even to the offspring. Such diseases are called sexually transmitted disease (STDs). E.g. Bacterial infections such as Gonorrhea and Syphilis, Viral infections such as Warts and HIV.

7. **Contraceptive devices** are the devices which block the entry of sperm into oviducts thereby preventing the egg from being fertilized. These devices help to prevent transmission of many infections. E.g. Condom, Copper-T or intra uterine contraceptive device (IUCD), Contraceptive drugs. Surgical methods like vasectomy in males to block the vas deference so that sperm transfer will be prevented and tubectomy in females to block the fallopian tube which makes the egg unreachable to uterus are proven to be contraceptive methods. Surgical methods are safe in the long run. Surgery can also be used for aborting unwanted pregnancies. However, this is often misused for illegally aborting female fetuses. To prevent female feticide (killing of a fetus), prenatal sex determination has been prohibited by law.

HEREDITY AND EVOLUTION

1. **Heredity**: The process of passing traits from parent to offspring is called heredity. Trait is any characteristic that is transferred from parent to offspring. e.g. height and color.

2. **Inheritance:** This process by which genetic traits are passed from one generation to next. These traits are controlled by genes and the complete set of genes within an organism's genome is called its genotype.

3. **Principle of Inheritance (Mendelism)**: Mendel also known as the "Father of Genetics" proposed this. He chose pea plants (*Pisum Sativum*) for his experimentation and found variations among them. Pea Plants have several characteristics, they allow self-fertilization making it best to study.

4. **Gene** is a structural and functional unit of heredity and variations. Gene is a DNA segment on the chromosome. Genes control the expression of characteristics. Mendel called the genes to be factors. Traits can be either dominant or recessive.

5. **Monohybrid inheritance**: is inheritance of a single characteristic controlled by different alleles of the same gene.

6. **Dihybrid inheritance:** is the simultaneous inheritance of two characters. • Dihybrid inheritance is the experimentation of two characteristics with their four contrasting traits.

7. **Sex determination:** It is a mechanism which determines the individual to be a male or a female based on the sex chromosomes present in it. In human beings, sex is determined by genetic inheritance. Women have XX chromosomes while men have XY. All

the children will inherit an X chromosome from their mother regardless of whether they are boys or girls. Thus, the sex of the children will be determined by what they inherit from their father.

8. **Evolution:** It is the sequence of gradual changes over millions of years in which new species are produced. Charles Robert Darwin was an English naturalist who observed various species of life on the earth and put forward the idea of "evolution of species by natural selection."
    a. **Acquired trait** are those variations which an individual develops during its lifetime due to effects of environmental factors and disuse of organ or conscious efforts. They are not transmitted to the off spring and only affect structure and functioning of body cells, tissues and organs.
    b. **Inherited trait** is trait or character that is genetically inherited or passed down from generation to generations. If a particular trait spreads in the population, it means that is favored by natural selection.

9. **Speciation:** Species can be defined as a group of individuals of the same kind that can interbreed and produce fertile progeny. It is an event that splits a population into two independent species which cannot reproduce among them.
    a. **Process of speciation-Genetic Drift**: It occurs due to changes in the frequencies of particular genes by chance alone. e.g. If a hurricane strikes the mainland, and bananas with beetle eggs on them are washed away to an island. This is called a genetic drift.
    b. **Process of speciation - Natural Selection**: These are the variations caused in individuals due to natural selection which lead to the formation of a new species. e.g. If the ecological conditions are slightly different on the island as compared to the mainland, it leads to a change in the morphology and food preferences in the organisms over the course of generations.
    c. **Gene flow:** It is the transfer of genes from one population to another due to migration. Breeding between the brown and green beetles introduces new gene combinations into the population.

10. **Tracing Evolutionary relationships:** Homologous characteristics are organs that have the same basic structure and origin, but different functions. For example, mammals, birds, reptiles and amphibians have four limbs with the same basic limb layout because they have inherited the limbs from a common ancestor. These limbs have been modified to perform different functions. Analogous characteristics are organs that have different structures and are of different origin, but perform same functions. For example, the design of the wings of bats and the wings of birds look similar because they have a common purpose – to fly.

11. **Fossils:** Usually, when organisms die, their bodies will decompose and be lost. But sometime some body parts may not decompose completely, and they will eventually harden and retain the impression of the body parts. All such preserved traces of living organisms are called fossils. **Fossilization** is the process in which an organism is converted into a fossil. **Paleontology** is the study of fossils. There are two ways to determine the age of fossils. One way is to dig the earth and start finding fossils (Present most in Sedimentary Rocks). The second way of dating fossils is by detecting the ratios of different isotopes of the same element in the fossil material.

Biological convergence is a phenomenon by which two unrelated organisms become quite alike after a period of time through few generations, if it is assumed that they have a common ancestor.

CELL-BASIC UNIT OF LIFE

All living organisms are made up of cells. Cell is the basic structural and functional unit of complex organisms.
Every cell has three features- plasma membrane, nucleus and cytoplasm. Each cell has got certain specific components within it known as **cell organelles.** Each kind of cell organelle performs a special function. A cell is able to live and perform all its functions because of these organelles. These organelles together constitute the basic unit called the **cell**.

1. **History of Cell:**
    - Robert Hooke in 1665, discovered the cell with the help of a primitive microscope.
    - Robert Brown in 1831 discovered the nucleus in the cell.
    - Purkinje in 1839 coined the term 'protoplasm' for the fluid part of the cell.
    - Schleiden in 1838 & Schwann in 1839 proposed the cell theory, that all plants and animals are composed of cells.
    - Rudolf Virchow in 1855 further expanded the cell theory by suggesting that all cells arise from pre-existing cells.

2. **Types of Cells:**
    a. **Prokaryotic Cell :** Unicellular, with Capsule and without Nucleus. E.g. Bacteria.
    b. **Eukaryotic Cell :** Multicellular, with Nucleus. E.g. Plant or Animal Cell

3. **Types of Organism:**
    a. **Unicellular organisms** are the organisms in which a single cell performs all the functions like nutrition, respiration, excretion and reproduction. E.g. Amoeba, Chlamydomonas.
    b. **Multicellular organisms** are the organisms which possess many cells to perform different functions. E.g. Fungi, plants have many cells that group together to form tissues. Every multi cellular organism has come from a single cell.

4. **Difference Between Plant and Animal Cell**

BASIS	PLANT CELL	ANIMAL CELL
Cell Size	Usually larger, which is fixed.	Smaller in size and irregular.
Cell Shape	Rectangular	Round
Cell Wall	Present	Absent
Nucleus	Present, on one side of the cell.	Present, in center of the cell.
Centrosomes	Absent	Present
Plastids	Present with chloroplast in them.	Absent
Vacuoles	One	Multiple
Lysosomes	Rarely noticed in plant cells.	Present
Chloroplast	Present	Absent
Reserve food	Present as starch.	Present as glycogen.

5. **Functions of the few important cell organelles PLANT:**
    a. **Plasma Membrane** – It controls the movement of the molecules in and out of the cell and function in adhesion and signaling also.
    b. **Cell Wall** – The cell wall is usually rigid, non-living and permeable component surrounding the plasma membrane. They are two types: The primary cell wall and the secondary cell wall. The primary cell wall is made up of cellulose and is formed at the time of cell division. The secondary cell wall is made up of lignin and cellulose and helps giving shape and size to the cell.
    c. **Chloroplasts** – This is the unique features found in plant cells, which help in the preparation of the food at the site of photosynthesis. Plastids are the term used collectively to represent chloroplasts (green plastids containing chlorophylls), chromoplast (yellow to reddish color plastids) and leucoplast (colorless plastids).
    d. **Vacuoles** – Vacuoles occupy 90% of the total cell volume. These are the membrane-bound, liquid filled vesicles. Vacuoles contain the high range of dissolved salts, sugars, pigments and other toxic waste. They also provide physical support and contribute in giving color to the leaves and the flowers.
    e. **Plastids**: Plastids are present only in plant cells. These are of two types- chromoplasts (coloured plastids) and leucoplasts (white or colourless plastids). Plastid contains pigment called chlorophyll are known as chloroplasts. These are important for photosynthesis in plants. Chromoplasts are the organelles which provide bright colours to the plant structures like buds, flowers etc. Plastids also have their own DNA and ribosomes.

6. **Functions of some important organelles ANIMAL:**
    a. **Mitochondria** – It is called as 'the powerhouse of the cell' as ATP (adenosine triphosphate) is generated by oxidation of glucose and fatty acids. The outer membrane is smooth while the inner membrane is thrown into folds called as cristae. The cristae increase the area of cellular respiration. Mitochondria releases energy in the form of ATP molecules. ATP is known as the "energy currency of the cell". Mitochondria have its own DNA.
    b. **Lysosomes** – Lysosomes are membranous sacs filled with enzymes. They help to keep the cell clean by digesting any foreign material as well as worn out cell organelles. Lysosomes contain hydrolytic enzymes which are capable of digesting cellular macromolecules. When the cell gets damaged, the lysosome may burst, and its enzymes may digest the cell itself. Hence, lysosomes are called as 'suicidal bags'.
    c. **Nuclear envelope** – This is the double layer membrane, protecting the contents of the nucleus.
    d. **Nucleus** – The nucleus has a double layered covering called nuclear membrane which allow the transfer of material from inside to outside. The nucleus contains chromosomes which are composed of Deoxyribonucleic acid (DNA) and proteins. Nucleus controls all the activities of the cell. As the nucleus carries genetic information in the form of DNA, it plays a major role in cell division and cell development. The functional segments of DNA are called genes.
    e. **Endoplasmic reticulum (ER):** The ER is a large network of membrane bound tubes and sheets. It serves as channels for the transport of materials especially proteins between various organs of the cytoplasm or between the cytoplasm and nucleus. There are two types of RER- Rough endoplasmic reticulum and SER - Smooth endoplasmic reticulum. Membrane biogenesis: Some of the proteins and lipids synthesized by EF help in building the cell membrane. This process is known as membrane biogenesis.
    f. **Golgi Complex** – The Golgi consists of a stack of membrane-bound cisternae, its functions include the storage, modification and packaging of products in vesicles. It is also involved in the formation of lysosomes.
    g. **Secretory vesicles** – It stores secreted proteins and fuse with the plasma membrane to release their content.

h. **Peroxisomes** – Also known as microbodies and are the single membrane cellular bodies. They are oval or spherical and contain the enzyme catalase. Peroxisomes detoxify the molecules and break down the fatty acids to produce acetyl groups for biosynthesis.
i. **Cytoskeletal fibers** – It forms the network and bundles that support cellular membrane and help organize organelles and supports the cell movement. The cellular matrix is collectively referred to as cytosol. The cytosol is a compartment containing several metabolites, enzymes, and salts in an aqueous gel like the medium.
j. **Microvilli** – It increases the surface area for absorption of the nutrients from surrounding medium.

TISSUE

A group of cells that are specialized to perform a particular function forms a tissue. Tissues are mainly classified into two types: 1. Plant Tissues 2. Animal Tissues

1. **Plant Tissues**
   - Most of the tissues they have are supportive, which provides them with structural strength.
   - Most of these tissues are dead, as they can provide better mechanical strength than the live ones, and need less maintenance.
   - Some of the plant tissues keep on dividing throughout the plant life. These tissues are localised in certain regions.
   - Types of Plant Tissues: Based on the dividing capacity of the tissues, various plant tissues can be classified as growing or meristematic tissue and permanent tissue which have further sub-divisions as explained below:

1.1. **Meristematic Tissue**: Meristematic tissues are responsible for growth in plants. Cells in these tissues can divide and form new cells. Meristematic tissues are of three types:
   a. Apical Meristem: It is present at the growing tip of the stem and roots and increases the length.
   b. Lateral Meristem (cambium): It is present beneath the bark. It is responsible for growth in girth of trunk.
   c. Intercalary Meristem: It is present at internodes or base of the leaves and increases the length between the nodes. Cells of meristematic tissues change their shape & size to get specialized in performing other functions in plants body. This process is called Differentiation.

1.2. **Permanent Tissue :** Once the cells of meristematic tissue divide to a certain extent, they become specialised for a particular function. Permanent tissues are of two types:
   a. **Simple tissues:** This type of tissue is composed of same type of cells. These are again of four types:
      i. *Parenchyma simple tissues*: Cells of parenchyma tissues are live. They are oval, elongated and loosely packed with large inter-cellular space, forming basic packing of tissue and are found throughout the plant body.
      ii. *Collenchyma simple Tissues:* Cells of collenchyma are live. They are oval and elongated and tightly packed with no inter-cellular spaces. They are found below epidermis in leaves and stem.
      iii. *Sclerenchyma Simple Tissues:* Cells of sclerenchyma are dead. They are narrow and elongated. The cell wall in sclerenchyma is composed of lignin which makes it hard. Sclerenchyma are found around vascular bundles, veins of leaves in hard covering of seeds and nuts. Functions : They help to makes parts of plant hard and stiff. Also provides mechanical strength.
      iv. *Protective tissues:* They protect the plant body by forming an outer layer. There are two types of protective tissues:
         - *Epidermis Simple Tissues*: Epidermis tissue covers the entire body of plant. They protect plant from injury, germs and water loss. Cells of epidermal tissue form a continuous layer without intercellular spaces. Stomata are small openings on epidermal layer of leaf and soft part of stem to facilitate the gaseous exchange and transpiration in plants.
         - *Cork Simple Tissues:* These types of tissue consist dead cells with no intercellular spaces. They form the outer layer of old tree trunks.

   b. **Complex tissues:** Group of different type of cells performing common task together are named as complex tissues. Complex tissues are of two types: (a) Xylem (b) Phloem
      i. *Xylem*: This is the tissue that transports water and nutrients from root to upper parts of plant. It is composed of four types of cells i.e., tracheid, vessel, xylem parenchyma and xylem sclerenchyma (fiber).
         - Tracheid are long elongated cells with tapered ending. Tracheid cells are dead. Tracheid transports water through pits.
         - Vessel is a pipe like structure. Vessels are dead and have lignified thick cell wall. Upper and lower portion of cell wall is absent.
         - Parenchyma are living cells. They store food and nutrients.

- Sclerenchyma (fibers) are dead cells. They provide mechanical support to plant.

ii. *Phloem*: Phloem is the tissue that transports food from site of photosynthesis to different parts of plants. It is composed of four types of cell i.e. sieve cells, companion cells, phloem parenchyma, phloem fiber or blast fiber. All types of cells are live except phloem fibers.

- Sieve cells are elongated and have thin cell wall. They have cytoplasm but no nucleus and other organelles. These cells are responsible for transportation of food and nutrients.
- Companion cells have cytoplasm, nucleus and other organelles. They perform the tasks required for sieve cells for living.
- Phloem parenchyma store food.
- Phloem fibers have thick cell wall and they provide mechanical support to plant.

2. Animal Tissues

- Most of the tissues they contain are living.
- The structural organization of organs and organ systems is far more specialized and localized in animals than in plants.
- Types of Animal Tissues: Animal tissues are classified into four types based on the functions they perform: (i) Epithelial (ii) Connective (iii) Muscular (iv) Nervous

2.1 Epithelial tissues: They form the covering of the external surfaces, internal cavities and organs of the animal body. Epithelial tissue cells are tightly packed and form a continuous sheet. The skin, the lining of the mouth, the lining of blood vessels, lung alveoli and kidney tubules are all made of epithelial tissue.
Types of epithelial tissues:

a. Simple squamous epithelium: In cells lining blood vessels or lung alveoli, where transportation of substances occurs through a selectively permeable surface, there is a simple flat and extremely thin kind of epithelium which is named as simple squamous epithelium. It is found in the lining of the mouth, esophagus, lung, alveoli, etc.

b. Stratified Squamous Epithelium: The skin, which protects the body, is also made of squamous epithelium. Skin epithelial cells are arranged in many layers to prevent wear and tear. Since they are arranged in a pattern of layers, the epithelium is called stratified squamous epithelium.

c. Cuboidal epithelium: This is cuboidal in shape and forms the lining of kidney tubules and ducts of salivary glands. In some cases a portion of the epithelial tissue folds inward to form a multicellular gland. This is called glandular epithelium. It performs a function of secretion and absorption.

d. Columnar Epithelium: Where absorption and secretion occur, as in the inner lining of the intestine, tall epithelial cells are present and are named as columnar epithelium.

e. In the respiratory tract, on the outer surfaces of epithelial cells there are hair like projections called cilia. These cilia can move, and their movement pushes the mucus forward to clear it. This type of epithelium is named as ciliated columnar epithelium.

2.2 Connective tissues: The cells of connective tissue are loosely spaced and embedded in an intercellular matrix. For example Blood (plasma), bones, Cartilage. ligaments and tendons etc.
Types of connective tissue:

a. Areolar tissue: They are found in the skin and muscles, around the blood vessels, nerves, etc. It fills the space inside the organs, supports internal organs and helps in repair of tissues.

b. Adipose tissue: It is found between the internal organs and below the skin. It stores fats and act as an insulator.

2.3 Muscular tissues: Muscular tissue consists of elongated cells, also called muscle fibers. This tissue is responsible for movement in our body. Muscles contain special proteins called contractile proteins, which contract and relax to cause movement.
Types of Muscular Tissues:

a. *Striated muscles or skeletal muscles or voluntary muscles*: These muscles are also called skeletal muscles as they are mostly attached to bones and help in body movement. Cells are cylindrical, unbranched and multinucleate.

b. *Smooth muscles or involuntary muscles:* They are found in the iris of the eye, in ureters and in the bronchi of the lungs. Cells are long, spindle-shaped and possess a single nucleus.

c. *Cardiac muscles or involuntary muscles:* They help in rhythmic contraction and relaxation of the heart. Cells are cylindrical, branched and uninucleate

2.4 Nervous Tissues: Cells of the nervous tissue are highly specialized for being stimulated and then transmitting the stimulus very rapidly from one place to another within the body. The brain, spinal cord and nerves are all composed of the nervous tissue.
Neuron: Cells of the nervous tissue are called neurons. A neuron consists of a cell body, an axon and a dendrite.

BIOLOGICAL DIVERSITY

- **Basis of classification**: The grouping of related organisms helps us in studying their evolutionary relationships. Classification is the division of organisms on the basis of characteristics into groups and sub-groups.

- **The hierarchy of classification groups:** Charles Darwin put forward the idea of evolution in 1859, in his book, The Origin of Species. Robert Whittaker, in 1969 proposed 'Five kingdoms classification' of living organisms. The hierarchy can be represented as Kingdom sub grouping into Phylum for animals or Division for plants, Class, Order, Family, Genus and Species. Hence, the basic unit of classification is **species**. Species includes all the organisms that are similar to breed and produce fertile offspring.

1. **Five Kingdom Classification:**
   - **1.1. Monera** It includes prokaryotic cells lacking organized nucleus and membrane bound cell organelles. Some are autotrophic and others are heterotrophic forms. Examples are Bacteria, cyanobacteria, blue-green algae.
   - **1.2. Protista** It includes algae, diatoms and protozoans. These are unicellular and the simplest form of eukaryotes exhibiting both autotrophic and heterotrophic mode of nutrition. Locomotion and movement are possible by whip-like flagella and hair-like cilia or finger-like pseudopodia. Examples are unicellular algae, diatoms and protozoans.
   - **1.3. Fungi** These are multicellular, eukaryotic saprophytes. The cell wall of fungi is made up of chitin. They feed on dead and decaying matter. They include Mushrooms, Rhizopus and Mucor. Some fungi are symbiotic forming an association with algal cells. These symbionts are termed to be lichens.
   - **1.4. Plantae** It includes all the plants that are non-motile, multicellular and eukaryotic organisms with their cell walls made up of cellulose. These are complex organisms which can perform photosynthesis. Plants comprise cells with thick cell walls.
   - **1.5. Animalia** It includes all the animals that are motile, multicellular, eukaryotic organisms with their cells possessing no cell walls. It exhibits species diversity. Members of this kingdom are complex organisms with tissue differentiation.

2. **Plantae**
   - **2.1. Cryptogamae** - This sub-kingdom includes plants with hidden reproductive organs and plants do not bear flowers or seeds. Cryptogams are further divided into three groups: Thallophyta, Bryophyta and Pteridophyta.
     - **a. Thallophyta** are the simplest of plants that do not have a well-differentiated body design. The plants in this group are commonly called algae. These are predominantly aquatic. E.g. Spirogyra, Ulothrix, Cladospora and Chara
     - **b. Bryophyta** are often called amphibians of the plant kingdom as they require both aquatic and terrestrial conditions for the completion of their life cycle. E.g. Moss or Funaria.
     - **c. Pteridophyte** include fern plants which possess the plant body differentiated into stem, leaves and roots. They also possess naked embryos in the form of spores underneath the leaf.
   - **2.2. Phanerogamae** - This sub-kingdom includes plants that develop seeds and have well-formed stem, leaves and roots. They are further classified into Gymnosperms and Angiosperms.
     - **a. Gymnosperms** were the first plants to have a seed habit. These are the plants which possess naked seeds and are usually perennial, evergreen and woody. e.g. Pinus, Cycas and Deodar.
     - **b. Angiosperms** are also called as flowering plants. These plants possess seeds enclosed inside the fruit. Angiosperms are divided into two groups, namely, monocots and dicots based on the number of cotyledons that they have. Ex: Paphiopedilum- Monocot, Ipomea- Dicot.

3. **Animalia**

   These are organisms which are eukaryotic, multicellular and heterotrophic. Their cells do not have cell wall. Most animals are mobile. Animals are classified on the basis of different features like cellular or tissue level of body organization, body symmetry, type of body cavity called as coelom, presence or absence of segmentation and presence or absence of a backbone.
   - **3.1. Invertebrate**: It includes group of animals that do not possess a vertebral column.
     - **a. Porifera** are multicellular organisms exhibiting minimal level of tissue organization. They are commonly called sponges. Example : Sycon, Spongilla and Euplectella.
     - **b. Coelenterates** are radially symmetrical organisms which live in water, there is a cavity in the body. Example : Corals, Hydra, sea anemone.
     - **c. Platyhelminthes** are either free living or parasitic. They are bilaterally symmetrical and triploblastic animals. These are called flatworms. e.g. Planaria (free living) liverfluke (parasite).
     - **d. Nematoda** are bilaterally symmetrical, triploblastic parasitic worms. Body is cylindrical. Pseudo coelom is present. They cause diseases such as elephantiasis. Example : Ascaris.
     - **e. Annelids** are bilaterally symmetrical, triploblastic segmented animals. They have a true body cavity. Example : Earthworm, Nereis, leech etc.
     - **f. Arthropoda** animals are bilaterally symmetrical, segmented, triploblastic animals with true coelom. They include Insects. They have jointed legs. Example : prawns, butterflies.
     - **g. Mollusca** are bilaterally symmetrical, triploblastic animals with reduced coelom. Locomotion is by a muscular foot. They have little segmentation. Example : Pila, octopus
     - **h. Echinodermata** are triploblastic with true coelomic cavity. They are spiny skinned organisms. Skeletons are of hard calcium carbonates. They exhibit radial symmetry. Example : Starfish and sea urchins
     - **i. Protochordata** - These are bilaterally symmetrical, triploblastic and have a coelom and are primitive chordates. They possess a notochord during their early stage of development. Example : Balanoglossus, and Amphioxus.
   - **3.2. Vertebrata**: These are the most advanced group of animals with true vertebral column and strong endoskeleton.

a. **Pisces** are aquatic cold-blooded organisms and covered by scales. The body is streamlined, and a muscular tail is used for movement. Fish breathe through their gills. Skeleton may be cartilaginous or bony in nature. They have two-chambered heart and reproduce by laying eggs. Example: Torpedo, Mandarin fish.
b. **Amphibians** are cold-blooded animals, they can live both on land and in water. Respiration is by gulls and lungs. They possess a three-chambered heart and reproduce by laying eggs. Example : Frogs, toads and salamanders.
c. **Reptilia** are cold-blooded animals have scales and breathe through lungs. Heart is three-chambered except for crocodiles and reproduce by laying eggs. Example : Snakes, turtles, lizards and crocodiles.
d. **Aves** are warm-blooded animals. Their fore limbs are modified for flight. Bones are hollow. Body is covered by feathers. Respiration is through lungs. They have four-chambered heart and they lay eggs. Example : Crow, Ostrich.
e. **Mammals** are warm-blooded animals with four chambered hearts. Their skin is covered by hair, sweat glands and oil glands that regulate body temperature. Mammals give birth to young ones. They have mammary glands for the production of milk to nourish their young ones. Mammals like platypus lay eggs. Kangaroos give birth to under-developed young ones that are carried in their mother's abdominal pouch. Example : Human, rat and cat etc.

HEALTH AND DISEASES

- Health is a state of complete physical, mental and social well-being of an individual. The health of all organisms will depend on their surroundings or their environment. The environment includes the physical environment.
- Being healthy refers to being free from any diseases. But, being diseases free does not refer to be healthy, i.e. a person who is disease free does not have any diseases but, they might not be stable from inside as that of a healthy person.

1. **Disease** Change in either the functioning or the appearance of one or more systems of the body results to a disease. These changes give rise to symptoms and signs of disease. These symptoms indicate there may be a disease, but they don't indicate what the disease is. Types of Diseases:
    a. **Acute Diseases:** Acute diseases last for a short time without posing adverse effects on the health. e.g. common cold.
    b. **Chronic Diseases :** Chronic diseases last for prolonged period with drastic effects on health. e.g. Diabetes. Chronic diseases have very drastic long-term effects on people's health as compared to acute diseases.
2. **Cause of Diseases** :
    a. **Non-infectious diseases** are caused by genetic abnormalities. They are called non-communicable diseases as they do not spread from one person to another. e.g. cancer.
    b. **Infectious diseases** are spread through microbial organisms from an infected person to a healthy person. So they are also called communicable diseases. These are the diseases caused by micro -organisms like bacteria, virus, fungi and protozoa. Means of Spread :
        - **Air** (transmitted through air) E.g. common cold, pneumonia and tb.
        - **Waterborne** (transmitted through water) E.g. Typhoid
        - **Physical contact** (transmitted through direct contact or blood contact) E.g. AIDS
        - **Vectors** (transfer through micro-organisms) E.g. Rabies, Malaria
3. **Principles of treatment and Prevention:** There are two ways one general and one specific to prevent diseases. The general ways of preventing infections mostly relate to preventing infections.
    a. Antibiotics are the drugs used to treat the diseases caused by bacteria, fungi and protozoans. E.g. penicillin.
    b. Airborne micro-organisms can be prevented by providing living conditions which are not over crowded. Water-borne microorganisms can be prevented by providing safe drinking water. Vector-borne diseases can be prevented by providing clean environment.
    c. Public hygiene is one basic step in the prevention of infectious diseases. Immunization through vaccines is specific way of preventing diseases. Eg: vaccines against tetanus, diphtheria, whooping cough, measles and polio etc.
4. **Pulse Polio Program**: Pulse Polio is an immunization campaign established by the Government of India in 1995-96 to eliminate poliomyelitis (polio) in India by vaccinating all children under the age of five years against the polio virus. Oral Polio Vaccine Oral Polio Vaccine (OPV) is a live-attenuated vaccine, produced by the passage of the virus through non-human cells at a sub-physiological temperature, which produces spontaneous mutations in the viral genome.

Sources of Energy

1. Characteristics of a good fuel: (i) High calorific value (ii) Less smoke (iii) Less residue after burning (iv) Easy availability (v) Inexpensive (vi) Easy to store and transport

2. **Fossil fuels:** Were formed millions of years ago, when plants and animal remain got buried under the earth and were subjected to high temperature and pressure conditions. E.g.: Coal, Petroleum, etc. These fossil fuels are non-renewable sources of energy and cause environmental problems due to pollution.

3. **Convention Sources of Power:**
    a. **Thermal power plants**: (i) Use coal, petroleum and natural gas to produce thermal electricity. (ii) Electricity transmission is very efficient. (iii) The steam produced by burning the fossil fuels runs the turbine to produce electricity
    b. **Hydro power plants:** (i) It is the most conventional renewable energy source obtained from water falling from a great height. (ii) It is clean & nonpolluting source of energy. (iii) Dams are constructed to collect water flowing in high altitude rivers. The stored water has a lot of potential energy. (iv) When water is allowed to fall from a height, potential energy to kinetic energy, which rotates the turbines to produce electricity. Disadvantages of Hydro power plant: (i) Highly expensive to construct. (ii) Dams cannot be constructed on all river sites. (iii) Large areas of human habitation and agricultural fields get submerged. (iv) People face social and environmental problems.

4. **Non-Conventional Sources of Power:**
    a. **Bio Mass:** It is the source of the conventionally used fuels that are used in our country. E.g.: Cow dung cakes, fire-wood, coal, charcoal. Bio gas: It is a mixture of gases produced during decomposition of bio mass in the absence of Oxygen. (Anaerobic Respiration). Methane is the major component of bio gas. Bio gas plants: Animal dung, sewage, crop residues, vegetable wastes, poultry droppings, etc. are used to produce Bio gas in Bio gas plants.
    b. **Wind Energy:** It can be converted into mechanical and electrical energy. Kinetic energy of the wind is used in running of wind mills, which are used to lift water, grind grains, etc.
        i. Advantages: (i) Eco friendly (ii) Renewable.
        ii. Disadvantages: (i) Wind speed not uniform always. (ii) Needs a large area to erect series of wind mills. (iii) Big amount of investment is needed. (iv) Output is less as compared to investment.
    c. **Solar Energy:** Solar radiations can be converted electricity through solar cells (photovoltaic cells). Photovoltaic cells convert solar radiations directly into electricity through silicon solar cells. Solar cells arrange on a large flat sheets form a solar panel. Solar cookers are painted black from outside and a large glass plate to trap solar radiations by green-house effect.
        i. Advantage of Solar cookers: (i) Eco friendly (ii) Renewable (iii) Used in rural areas. (iv) Retains all the nutrients in food due to slow cooking.
        ii. Disadvantages of solar cooker: (i) Silicon cells are expensive. (ii) Solar radiations are not uniform over earth's surface. (iii) Cannot be used at night or on cloudy days.
    d. **Geo Thermal Energy:** Energy harnessed from the heat of the sun is called Geo thermal energy. Magma is formed when this heat melts the rocks. The molten rocks and hot gases are called magma. The magma gets collected at some depths below the earth's surfaces. These places are called "Hot spots". When underground water comes in contact these hot spots, it changes into steam, which can be used to generate electricity.
        i. Advantages of Geo thermal energy: (i) Renewable (ii) Inexpensive
        ii. Disadvantages of Geo thermal energy: (i) Only few sites available for harnessing energy. (ii) Expensive
    e. **Nuclear Energy**: Energy released when some changes take place in the nucleus of the atom of a substance, is called Nuclear energy. It is used for heat generation, fuel for marine vessels.
        i. Advantages or Nuclear Energy: (i) Alternative source of energy due to depletion of fossil fuels. (ii) From a small amount of fuel, a large amount of energy is released.
        ii. Disadvantages of Nuclear Energy: (i) Risk of nuclear waste leakage (ii) High cost of setting up of nuclear plant (iii) Pollution of environment.
    f. **Energy from the sea**: Tidal Energy: Locations in India – Gulf of Kutch, Gujrat & W. Bengal. Dams are constructed across a narrow part of sea and turbine converts tidal energy into electrical energy.

Our Environment

1. The environment of an organism means the physical and biological conditions in which it lives.
    a. Physical conditions include soil, light, temperature, etc.
    b. Biological conditions include the other plants, animals and microorganisms around it.

2. **Substances** or wastes are of two types:
    a. Biodegradable Substances: that are broken down by biological processes.
    b. Non-biodegradable Substances: that are not broken down by biological processes. These substances may be inert and simply persist in the environment for a long time or may harm the various members of the eco-system.

3. **Ecosystem:** The ecosystem is a community of organisms and their physical environment interacting with each other as an ecological unit, involving the flow of energy.
    a. An ecosystem consists of biotic components including living organisms and abiotic components, the physical factors like temperature, rainfall, wind, soil and minerals.
    b. An ecosystem can be natural or artificial. Ponds, forests and lakes are natural ecosystems while garden and crop fields are human made or artificial ecosystems.

4. Organisms in the ecosystem can be categorized into producers, consumers and decomposers according to the manner in which they obtain their substance from the environment.
    a. **Producers** are the organisms that produce their own food without the help of any other organism. These are also known as autotrophs. They make their food from inorganic substances through a process called photosynthesis. Autotrophs are green plants, phytoplankton and blue green algae.
    b. **Consumers** are the organisms which cannot produce food but depend directly or indirectly on producers for the same. These are also known as heterotrophs. Consumers can be classified into herbivores, carnivores, omnivores and parasites. Eg: Humans, Snake, Eagle
    c. **Decomposers** are the organisms which feed on dead and decaying matter. They break down the complex organic substances into simple inorganic substances that go into the soil and are sued up once more by the plants. Eg: Bacteria and fungi

5. **Food chains and Webs:** The series of organisms taking part at various biotic levels form a food chain. Food chains describe the feeding relationship between the organisms of an ecosystem. The flow of energy from one species to another at various biotic levels forms a food chain, it is unidirectional.
    - A food chain always starts with producers. The successive levels in the food chains of a community are called as trophic levels. From autotrophs the energy goes to the heterotrophs and decomposers. Example :
      Plant >> Deer >> Lion OR Plants >> Grasshopper >> Frog >> Snake >> Hawk
    - There are generally a greater number of individuals at the lower trophic levels of an ecosystem; the greatest number is of the producers.
    - Food web is a web of cross-linked food chains.
    - **Biological magnification** is a phenomenon by which toxic substances accumulate from one trophic level to another. As human beings occupy the top level in any food chain, the maximum concentration of these toxic chemicals gets accumulated in our body which becomes toxic to us.
    - **10% Law:** There is only 10% flow of energy from one trophic level to the next higher level.

6. **Ozone layer**: Ozone (O3) is a molecule formed by three oxygen atoms. There is a layer of ozone in the stratosphere. It is a deadly poison. It is known to cause skin cancer in human beings. However, at the higher levels of the atmosphere, it acts as a natural sun-block and shields us from UV radiations of the sun which are dangerous to living organisms. Ozone depletion is the sharp reduction of ozone in the stratosphere due to chlorofluorocarbons (CFC's) used as refrigerants and in fire extinguishers.

Management of Natural Resources

1. **The 3R's:** Reduce, Recycle and Reuse.

2. **Need of sustainable management:** Our natural resources are limited. With the rapid increase in human population, due to improvement in health care, the demand for all resources is also increasing. Sustainable management is necessary to provide the economic well-being to the present and the future generations and to maintain a healthy environment and life support system.

3. **Components of fossil fuels:** (i) Carbon, (ii) Hydrogen, (iii) Nitrogen, (iv) Sulphur. These are non-renewable and causes pollution. They contribute to global warming.

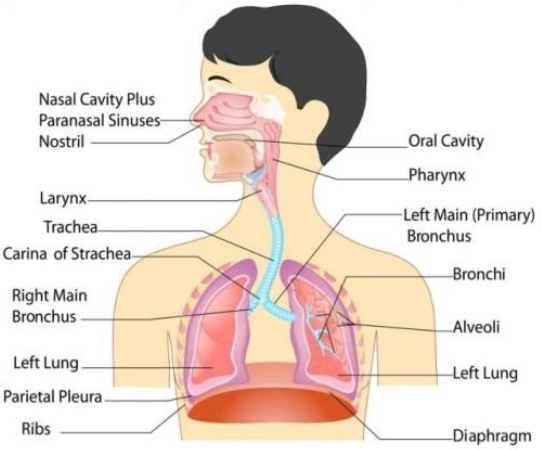
4. **Forest Stakeholders:**
   a. The people living in or around the forests who are directly dependent on forest product.
   b. The Forest Department of the government which owns the land and controls the resources from forests.
   c. The industrialists who use the forest produce but are not dependent on the forest of a particular area.
   d. The wildlife and nature enthusiasts, who want to conserve nature in its present form.

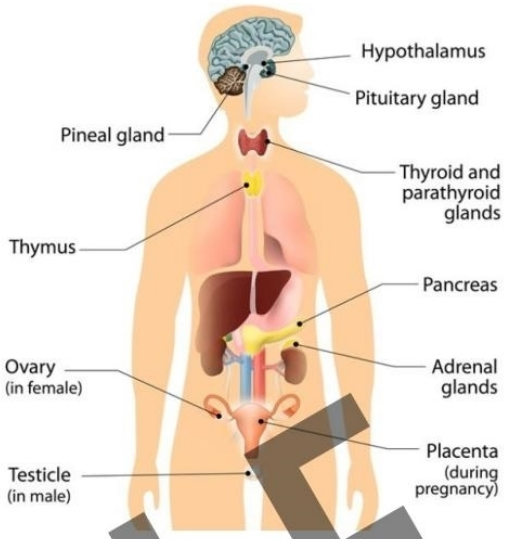
5. **Coal and Petroleum:** Coal is a blackish solid fossil fuel that occurs in seams inside earth, used primarily for fuel. Petroleum is a dark coloured liquid fuel that is taken out from various depths of earth both on land and sea shore. It is called mineral oil or rock oil. Petroleum extracted from earth is called crude oil. With the help of fractional distillation, it is used for Fuel Petrol, LPG, Paraffin wax is used in candles, Vaseline and water proofing and Asphalt is source of several chemicals and dye. It is also used in carpeting of road.

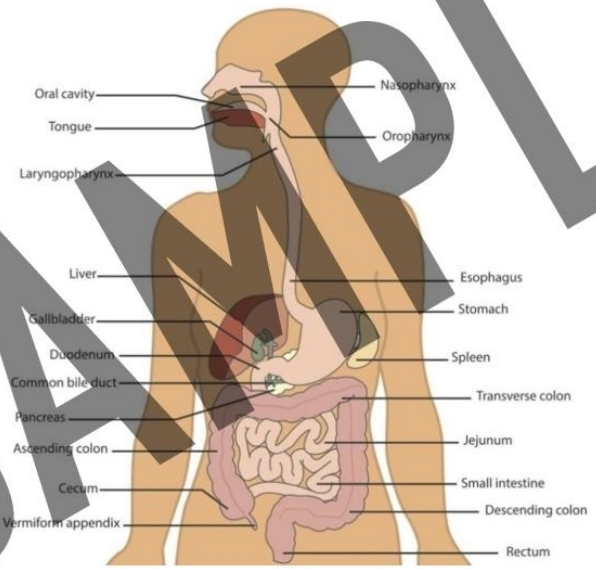
6. **Pollution:** Fossil fuels are formed of carbon, hydrogen, nitrogen and Sulphur. On burning they produce carbon dioxide, water, oxides of Sulphur and nitrogen. In the presence of insufficient oxygen, carbon monoxide is produced instead of carbon dioxide.
   a. **Carbon Monoxide:** It readily combines with hemoglobin forming carboxyhemoglobin. The latter is unable to combine with oxygen. Therefore, carrying capacity of blood is reduced. In closed rooms, it may cause death due to asphyxiation. This is common in winter when coal fired heating device is used.
   b. **Carbon dioxide:** Being a greenhouse gas, it adds to global warming.
   c. **Nitrogen Oxides:** They cause necrosis and killing of plant parts. Internal injuries, eye irritation and loss of smell are produced in human and animals. Corrosion occurs in metals. They are also component of acid rain.
   d. **Sulphur Oxides:** They kill lichens, damage metals, marble and other articles, cause eye irritation, damage to respiratory tract and cause acid rain.
   e. **Fly ash:** Burning of coal also produces particulate matter called fly ash it contains toxic ingredients.

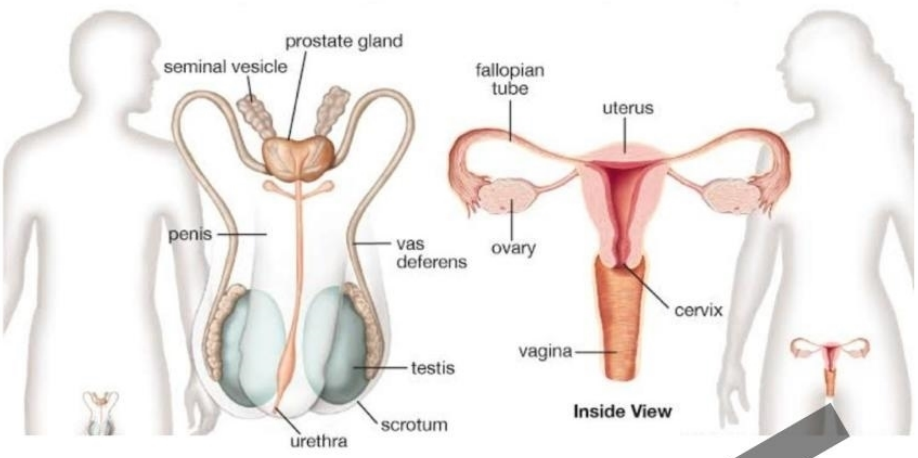
7. **Management of Fossil Fuels:** The management of fossil fuels is based on better use through use of more and more efficient machines. The internal combustion engines used by vehicles employed in transportation are concentrating on ensuring complete combustion. It will reduce air pollution and increase efficiency. 5-10% ethanol (ethyl alcohol) is being added to petrol to reduce consumption of the latter. Hybrid engines using hydrogen and gasoline are also being developed.

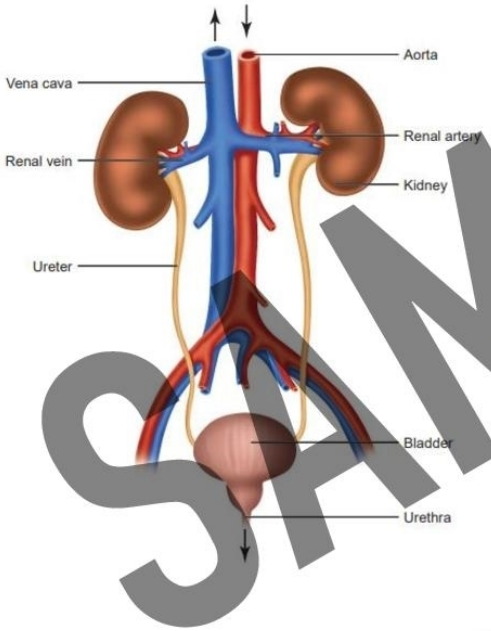
IMPORTANT DIAGRAMS

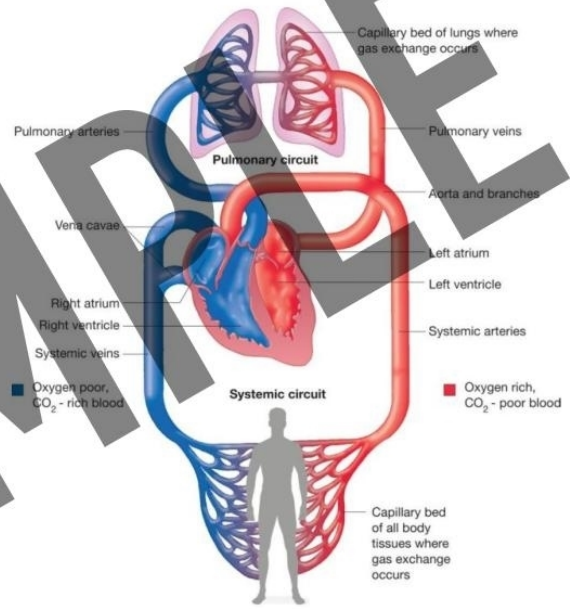

Nasal Cavity Plus
Paranasal Sinuses
Nostril
Oral Cavity
Pharynx
Larynx
Trachea
Left Main (Primary)
Bronchus
Carina of Strachea
Bronchi
Right Main
Bronchus
Alveoli
Left Lung
Left Lung
Parietal Pleura
Ribs
Diaphragm

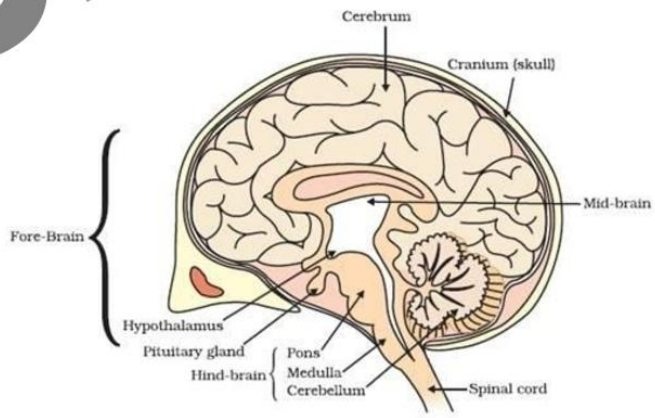

Hypothalamus
Pituitary gland
Pineal gland
Thyroid and
parathyroid
glands
Thymus
Pancreas
Ovary
(in female)
Adrenal
glands
Placenta
(during
pregnancy)
Testicle
(in male)

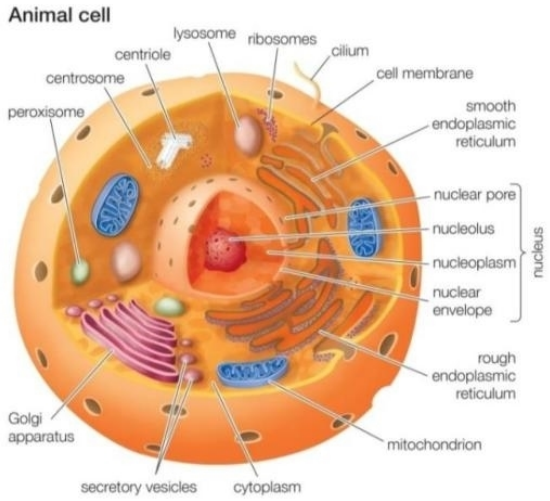

Oral cavity
Nasopharynx
Tongue
Oropharynx
Laryngopharynx
Liver
Esophagus
Gallbladder
Stomach
Duodenum
Spleen
Common bile duct
Transverse colon
Pancreas
Jejunum
Ascending colon
Small intestine
Cecum
Descending colon
Vermiform appendix
Rectum

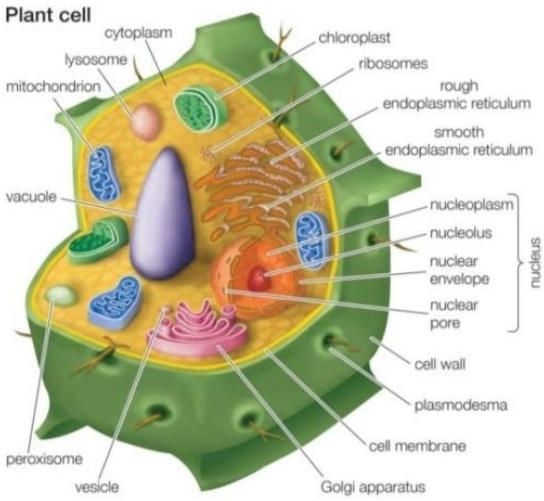

prostate gland
seminal vesicle
penis
vas deferens
testis
scrotum
urethra
fallopian tube
uterus
ovary
cervix
vagina
Inside View


Aorta
Vena cava
Renal artery
Renal vein
Kidney
Ureter
Bladder
Urethra


Capillary bed of lungs where gas exchange occurs
Pulmonary arteries
Pulmonary veins
Pulmonary circuit
Aorta and branches
Vena cavae
Left atrium
Left ventricle
Right atrium
Right ventricle
Systemic arteries
Systemic veins
Oxygen poor, CO_2 - rich blood
Systemic circuit
Oxygen rich, CO_2 - poor blood
Capillary bed of all body tissues where gas exchange occurs


Cerebrum
Cranium (skull)
Mid-brain
Fore-Brain
Hypothalamus
Pituitary gland
Hind-brain
Pons
Medulla
Cerebellum
Spinal cord


Animal cell
lysosome
ribosomes
cilium
centriole
centrosome
cell membrane
peroxisome
smooth endoplasmic reticulum
nuclear pore
nucleolus
nucleoplasm
nuclear envelope
nucleus
rough endoplasmic reticulum
Golgi apparatus
mitochondrion
secretory vesicles
cytoplasm


Plant cell
cytoplasm
chloroplast
lysosome
ribosomes
mitochondrion
rough endoplasmic reticulum
smooth endoplasmic reticulum
vacuole
nucleoplasm
nucleolus
nuclear envelope
nuclear pore
nucleus
cell wall
plasmodesma
cell membrane
peroxisome
vesicle
Golgi apparatus

BASIC MATHEMATICS

1. **Fundamental or basic S.I. units:**
   (a) length → (m) metre
   (b) mass ⟶ kilogram (kg)
   (c) time ⟶ second (s),
   (d) temperature ⟶ Kelvin (K),
   (e) electric current ⟶ ampere (A),
   (f) luminous intensity ⟶ candela (Cd) and
   (g) amount of substance. ⟶ mole (mol)
2. **Supplementary S.I. units:**
   (a) Plane angle : radian (rad)
   (b) Solid angle : steradian (sr).
3. **Vectors and Scalars**
   (a) Scalars:- Scalars are quantities that are fully described by a magnitude (or numerical value) alone.
   (b) Vectors:- Vectors are quantities that are fully described by both a magnitude and a direction.
   (i) Notation: $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$,
   (ii) Magnitude: $A = \left|\vec{A}\right| = \sqrt{(A_x^2)+(A_y^2)+(A_z^2)}$
   (iii) Dot or Scalar product of Vectors: $\vec{A}\cdot\vec{B} = |A|.|B|\cos\theta$.
   Where, θ is angle between $\vec{A}$ & $\vec{B}$ measured from *A* to B.
   |A| = modulus of $\vec{A}$, |B| = modulus of $\vec{B}$.
   (iv) Vector or cross product: $\vec{C} = \vec{A}\times\vec{B} = |A|.|B|\sin\theta\hat{n}$.

MOTION

- **Distance**(s) = It is the actual path length covered by a moving particle in a given interval of time.
- **Displacement** (y) = Shortest length of path followed by particle.
- **Speed** (*v*)= Speed of an object in motion is defined as the ratio of total path length (i.e. actual distance covered) and the corresponding time taken by the object i.e.

$$\text{Speed} = \frac{\text{total path length}}{\text{Time taken}}$$

- **Average Speed** = $\dfrac{\text{total distance travelled}}{\text{total time taken}}$
- **Velocity** (v)=Rate of change of position *i.e.* rate of displacement with time is called velocity i.e.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}} = \frac{\text{Change in position}}{\text{time}}$$

- **Instantaneous velocity** Instantaneous velocity is defined as rate of change of position vector of particles with time at a certain instant of time.

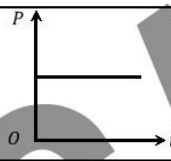
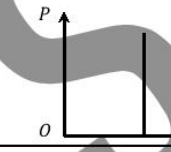
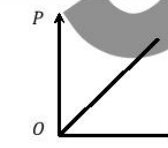
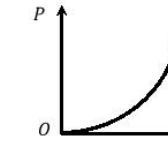
$$\text{Instantaneous velocity } \vec{v} = \lim_{t\to 0}\frac{\Delta\vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$$

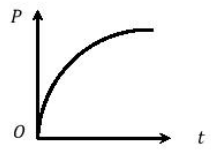
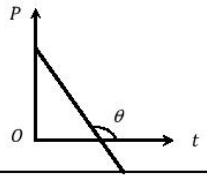
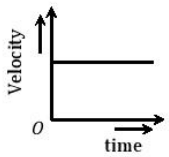
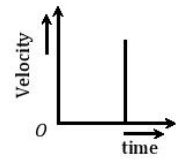
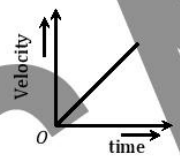
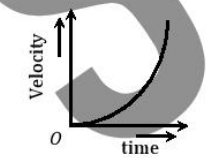
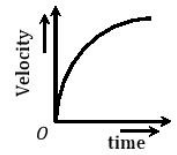
- **Average velocity** $(\vec{v}_{av}) = \dfrac{\text{total displacement}}{\text{total time taken}} = \dfrac{y_2 - y_1}{t_2 - t_1} = \dfrac{\Delta\vec{y}}{\Delta t}$.
- **Change in velocity** $(\Delta\vec{v})$ = final velocity $(\vec{v}_2)$ – initial velocity $(\vec{v}_1)$.
- **Acceleration** ($\vec{a}$)= It is the time rate of change of velocity of an object $\vec{a} = \dfrac{v-u}{t}$
- **Average acceleration** $= \dfrac{\text{change in velocity}}{\text{time interval}} = \dfrac{\Delta\vec{v}}{\Delta t}$.
- **Instantaneous acceleration** = $\vec{a} = \lim\limits_{\Delta t\to 0}\dfrac{\Delta\vec{v}}{\Delta t} = \dfrac{d\vec{v}}{dt} = \dfrac{d^2\vec{x}}{dt^2}$ {As $\vec{v} = \dfrac{d\vec{x}}{dt}$}
- **Equation of Motion-** In horizontal plane, with uniform velocity and retardation/acceleration:

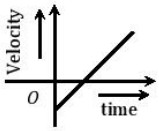
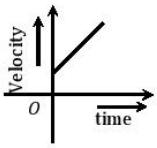
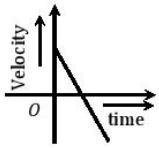
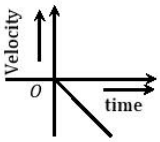
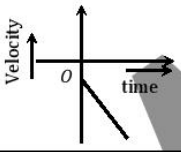
Equations of motion in scalar from	Equation of motion in vector from
$v = u + at$	$\vec{v} = \vec{u} + \vec{a}t$
$s = ut + \frac{1}{2}at^2$	$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
$v^2 = u^2 + 2as$	$\vec{v}.\vec{v} - \vec{u}.\vec{u} = 2\vec{a}.\vec{s}$

- The distance travelled in n^{th} second, $S_n = u \pm \frac{1}{2}(2n-1)a$ .Here, $(-ve)$ sign is used for retardation.

Various Position – Time Graphs and Their Interpretation

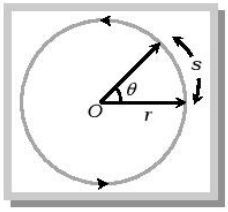
	$\theta = 0^\circ$ so $v = 0$ *i.e.*, line parallel to time axis represents that the particle is at rest.
	$\theta = 90^\circ$ so $v = \infty$ *i.e.*, line perpendicular to time axis represents that particle is changing its position but time does not changes it means the particle possesses infinite velocity.
	θ = constant so v = constant, $a = 0$ *i.e.*, line with constant slope represents uniform velocity of the particle.
	θ is increasing so v is increasing, a is positive. *i.e.*, line bending towards position axis represents increasing velocity of particle. It means the particle possesses acceleration.

	θ is decreasing so v is decreasing, a is negative *i.e.,* line bending towards time axis represents decreasing velocity of the particle. It means the particle possesses retardation.
	θ constant but > 90° so v will be constant but negative *i.e.,* line with negative slope represent that particle returns towards the point of reference. (negative displacement).
	$\theta = 0$, $a = 0$, v = constant *i.e.,* line parallel to time axis represents that the particle is moving with constant velocity.
	$\theta = 90°$, $a = \infty$, v = increasing *i.e.,* line perpendicular to time axis represents that the particle is increasing its velocity, but time does not change. It means the particle possesses infinite acceleration. Practically it is not possible.
	θ =constant, so a = constant and v is increasing uniformly with time *i.e.,* line with constant slope represents uniform acceleration of the particle.
	θ increasing so acceleration increasing *i.e.,* line bending towards velocity axis represent the increasing acceleration in the body.
	θ decreasing so acceleration decreasing *i.e.* line bending towards time axis represents the decreasing acceleration in the body

	Positive constant acceleration because θ is constant and < 90° but initial velocity of the particle is negative.
	Positive constant acceleration because θ is constant and < 90° but initial velocity of particle is positive.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is positive.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is zero.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is negative.

Uniform Circular Motion

- **Angular Displacement (θ) :** The angle turned by a body moving on a circle from some reference line is called angular displacement.



- **Angular velocity** $\omega = \frac{\text{Total Angular displacement}}{\text{Total time taken}}$, $\omega = \frac{2\pi}{T} = 2\pi n$,

  Where, T = Time, n = Frequency, $v = r\omega$, r = Radius, v = Velocity

- **Radial or centripetal acceleration** $(a_c) = -\frac{v^2}{r} = -r\omega^2 = v\omega$ (Numerically).
  - Tangential acceleration $(a_t) = \frac{dv}{dt} = r\frac{d\omega}{dt} = r\alpha$. Where, α = angular acceleration.
  - Instantaneous acceleration $(a) = \sqrt{a_t^2 + a_c^2}$.
- **Centripetal force** = $F_c = \frac{mv^2}{r} = mr\omega^2 = mv\omega$ = **centrifugal reaction** in opposite direction.
- **Motion of a cyclist**: $\tan\theta = \frac{v^2}{rg}$. Where, θ = angle of inclination from vertical.

Work, Energy and Power

- **Work done by a force**

  (a) Work $(W) = \vec{F} \times \vec{d}$=Fdcos$\theta$

  F = Force, d = displacement, θ = Angle between displacement to the direction of force.

  (b) $W = \int dW = -\int F.dr$

- **Spring force** $(F) = \pm Kx$. Where, K = spring constant and $\pm x$ = stretched or compressed distance respectively.
- P.E. stored in a spring compressed through the distance $x = \frac{1}{2} Kx^2$.
- **Work done by a variable force** $(W) = \int F \cdot dx$.
- **Kinetic Energy (K.E.)** $E_K = \frac{1}{2}mv^2 = \frac{P^2}{2m}$, $P = \sqrt{2mE}$, P = Momentum, m = Mass, E = Energy
- **Potential Energy (P.E.)** $P_E = mgh$, Where m = mass of particle, g= gravitational acceleration, h=height.
- Work done by the resultant force $(W) = F \times x = \frac{1}{2}m(v_2^2 - v_1^2)$.
- **Stopping distance** $(d) = \frac{\frac{1}{2}mv^2}{F} = \frac{\text{Initial K.E.}}{\text{Retarding force}}$.
- **Conservation of Energy:** In a frictionless gravitational field, $K.E.\left(\frac{1}{2}mv^2\right) + P.E.(mgh) =$ constant.
- **Energy** $E = mc^2$
- **Power** $(P) = \frac{W}{t} = \vec{F} \cdot \vec{v} = F \cdot v\cos\theta$ = Force×Velocity.

GRAVITATION

- **Newton's Law of gravitation**: $F = \frac{Gm_1m_2}{r^2}$, where G=Gravitational Constant=6.67×10^{-11} Nm^2/kg^2
- **Acceleration due to gravity:** $g = \frac{GM}{R^2} = \frac{4}{3}\pi GR\rho$ .Where, ρ is the density of earth; M = mass of earth; R = Radius of earth.
- **Variation of g :**

  (a) The value of ***g*** is maximum at poles and minimum at equator.

  (b) **Above the surface of the earth at a height h :** $g' = g\frac{R^2}{(R+h)^2} \equiv g\left(1 - \frac{2h}{R}\right)$.

  (c) **At a depth *d* below the surface of the earth:**

  $$g' = g\left\{1 - \frac{d}{R}\right\}.$$

  (d) **At the centre of the earth**, $g' = 0$.

  (e) **Due to rotation of the earth :** $g' = g\left(1 - \frac{R\omega^2\cos^2\lambda}{g}\right)$.

  Where, ω = angular velocity of the earth & λ = latitude.

- **Intensity (I) of gravitational field** at a distance *r* from a body of mass m : $I = \frac{G}{r^2} = -\frac{dV}{dr} = \frac{F}{m}$.
- **Gravitational potential energy:** Gravitational potential at a point *r* distance apart from a body of mass m:

$$V = -\frac{GM_e}{r}. \text{ [romanat ¥, } V_{max} = 0].$$

- **Motion Under Gravity (Free Fall):** In the absence of air resistance, it is found that all bodies (irrespective of the size, weight or composition) fall with the same acceleration near the surface of the earth. This motion of a body falling towards the earth from a small altitude ($h << R$) is called free fall.

  Equation of motion :

  - $v = u + g\,t$
  - $h = ut + \frac{1}{2} g\,t^2$,
  - $v^2 = u^2 + 2gh$
  - $h_n = u + \frac{g}{2}(2n - 1)$

  Where u is initial velocity; v is the final velocity after t second and *h* is the height covered in this time; *g* is acceleration due to gravity. For a freely falling body, $g = +9.8 \text{ m/s}^2$ and for a body thrown vertically upwards; $a = -g = -9.8 \text{ m/s}^2$; *u* and *v* are in metre/sec; *h* is in metre.
- According to Kepler's third law of planetary motion,

$$r^3 \propto T^2 \text{ or } \frac{r^3}{T^2} = \text{constant}$$

Where, *r*= radius of orbit=mean distance of planet from the Sun (in metre)
T= time period of revolution of planet around the Sun (in second).

Difference between Mass and Weight

Mass	Weight
Mass is the quantity of matter possessed by a body.	Weight is the gravitational force by which earth attracts towards it.
It is a scalar quantity, which has magnitude only.	It is a vector quantity, which means that it has magnitude and direction.
Its unit is kilogram (kg).	Its unit is newton (N).
It is not changed by changing the position.	It is changed by changing the position.
It is calculated by the formula: m=w/g	It is calculated by the formula: **w=mg**
It is measured by physical balance, beam balance, electronic balance, etc.	It is measured by a spring balance.

FLOATATION

Fluid is the name given to a substance which begins to flow when external force is applied on it. Liquids and gases are fluids.

- **Thrust** = Pressure × Area

- **Pressure:** If *F* be the normal force acting on a surface of area *A* in contact with liquid, then pressure exerted by liquid on this surface is $P = F/A$
- **Atmospheric Pressure**: The gaseous envelope surrounding the earth is called the earth's atmosphere and the pressure exerted by the atmosphere is called atmospheric pressure.

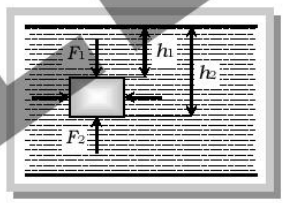
$$1atm = 1.01 \times 10^5 Pa = 1.01\,\text{bar} = 760\ \text{torr}$$

- **Density**: In a fluid, at a point, density ρ is defined as: $\rho = \frac{m}{V}$
- **Pressure inside the liquid:** The pressure due to liquid act on the surface below depth h is given by

$$P = h\rho g$$

Where, ρ is the density of liquid and *g* acceleration due to gravity.

- **Relative density of a body** (R.D.)= $\frac{\text{density of substance}}{\text{density of water at } 4^oC}$
- Density of water at $4^oC = 1\,g/cm^3 = 1000\,kg/m^3$
- **Pascal's Law:** According to Pascal's Law the pressure at every point inside the liquid is same in the absence of gravity.
- **Archimedes Principle**: When a body is immersed partly or wholly in a fluid, at rest, it is buoyed up with a force equal to the weight of the fluid displaced by the body. This principle is called Archimedes principle and is a necessary consequence of the laws of fluid statics.
- **Buoyant force**, F_B = weight of the liquid displaced (W_l)
  = volume of liquid displaced × density of liquid (d_l)×*g*



- **Apparent weight** = true weight (*W*) – buoyant force (F_B)
- Loss in weight when a body a immersed in a liquid = buoyant force (F_B)

FORCE AND NEWTON'S LAWS

- **Linear Momentum**: It is measured as the product of the mass of the body and its velocity *i.e.*,
  Momentum = mass × velocity
  (*P*) = *mv*
- **Conservation of Linear Momentum**: According to the law of conservation of linear momentum
  Total momentum before collision = Total momentum after collision

$$p = m_1v_1 = m_2v_2 = \text{constant}$$

$$\therefore \quad \frac{v_1}{v_2} = \frac{m_2}{m_1} \quad i.e. \quad v \propto \frac{1}{m} \quad \text{[As } p \text{ is constant]}$$

- **Newton's First Law:** If no net force acts on a body, then the velocity of the body cannot change i.e. the body cannot accelerate.
- **Newton's Second Law of Motion:** The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change takes place always in the direction of the applied force.

$$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}$$

Where, *m* is the mass and *a* is the acceleration of the body.

(i) $(F) = \frac{dP}{dt} = \frac{d}{dt}(mv) = m\frac{dv}{dt} + v\frac{dm}{dt}$ (for variable *m)*

(ii) $F = \frac{mdv}{dt}$

(iii) $F = \frac{m(v-u)}{t} = \frac{m\Delta v}{\Delta t}$.

- **Newton Third Law of Motion**: Every action has its equal and opposite reactions. i.e., $\vec{F}_{AB} = -\vec{F}_{BA}$
- **Impulse** = F.Δt=P_2-P_1 =change in momentum.
- **Work-Energy Theorem**: For a body or an isolated system by work-energy theorem we have $K_2 - K_1 = \int \vec{F}.d\vec{r}$
- **Inertial mass**: $m = \frac{F}{a} \Rightarrow \frac{m_1}{m_2} = \frac{a_2}{a_1}$ [*F* is same]
- **Gravitational mass**: $\frac{m_A}{m_B} = \frac{\Delta l_A}{\Delta l_B}$. Where, *m* = mass, *a* = acceleration, *v* = final velocity, *u* = initial velocity, *t* = time, Δl_A and Δl_B are extensions produced in the same string, *n* = frequency.
- **Power**: Power of a body is defined as the rate at which the body can do the work.
  - Average power $(P_{av.}) = \frac{\Delta W}{\Delta t} = \frac{W}{t}$
  - Instantaneous power $(P_{inst.}) = \frac{dW}{dt} = \frac{\vec{F}.d\vec{s}}{dt}$ [As $dW = \vec{F}.d\vec{s}$]

    $P_{inst} = \vec{F}.\vec{v}$ [As $\vec{v} = \frac{d\vec{s}}{dt}$]

SOUND

According to their frequencies, waves are divided into three categories :

(1) **Audible or sound waves :** Range 20 *Hz* to 20 *KHz*. These are generated by vibrating bodies such as vocal cords, stretched strings or membrane.

(2) **Infrasonic waves :** Frequency lie below 20 *Hz*.

Example : waves produced during earth quake, ocean waves *etc.*

(3) **Ultrasonic waves :** Frequency greater than 20 *KHz*. Human ear cannot detect these waves, certain creatures such as mosquito, dog and bat show response to these.

As velocity of sound in air is 332 *m*/sec so the wavelength of ultrasonic $\lambda < 1.66\,cm$ and for infrasonic $\lambda > 16.6\,m$.

- **Relation between speed of sound, frequency and wavelength**

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

Where, *v* is the speed of sound, λ is the wavelength of sound wave, *T* is the time taken and *n* is the frequency of sound wave.

- Speed of sound in various media:-
  - In air $v = 355\,m/s$
  - In Water $v = 1440\,m/s$

- In Iron & Steel (Solids) $v = 5000\,m/s$

- In general, speed of sound in solids > speed of sound in liquids > speed of sound in gases.
- **Noise :** A noise consists of a series of waves following each other at irregular intervals of time with sudden changes in amplitude.
- **Pitch :** The pitch of a sound is the characteristic which distinguishes between a shrill (or sharp) sound and a grave (or flat) sound.
- **Intensity of Sound**: The intensity of sound at any point in space is defined as the amount of energy passing per unit time per unit area in a direction perpendicular to the area.

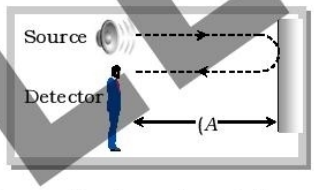
$$\textbf{Intensity} = \frac{Energy}{Area \times Time} = \frac{Power}{Area}$$

- **Reflection of Sound:** The following two laws are for the reflection of sound waves. These laws are as follows:-
  - The angle of reflection (r) is always equal to the angle of incidence (i), i.e.,

$$\angle r = \angle i \text{ or } i = r$$

  - The incident wave, the reflected wave and the normal (at the point of incidence), all lie in the same plane.
- **Echo**: An echo is simply the repetition of speaker's own voice caused by reflection at a distant surface *e.g.* a cliff. a row of building or any other extended surface.
  If there is a sound reflector at a distance *d* from source, then the time interval between original sound and it's echo at the site of source will be

$$t = \frac{d}{v} + \frac{d}{v} = \frac{2d}{v}$$



- **SONAR**: It is an acronym which means **SO**und **N**avigation **A**nd **R**anging used to measure distance, direction and speed of objects lying under sea. It is also used in ship-to-ship communication.

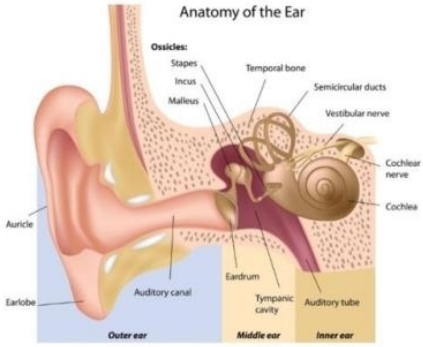
$$d = \frac{vt}{2}$$

  The above formula determine the depth of the sea, called echo depth ranging.
- **Mach number:** It is the ratio of velocity of source to the velocity of sound.

$$\text{Mach Number} = \frac{\text{Velocity of source}}{\text{Velocity of sound in air}}.$$

- The human ear can be divided into three parts:
  - **The outer ear**- which collects sound waves and transmits these to the ear drum.
  - **The middle ear**- which amplifies these sound waves about 60 times
  - **The inner ear**- which converts the amplified sound energy into electrical energy and conveys to the brain as nerve impulses for interpretation.

Human Range of Hearing:- People can hear sound at frequency from about 20 Hz to 20,000 Hz



ELECTRIC CURRENT

- **Origin of Electric Charge :** Every atom is electrically neutral, containing as many electrons as the number of protons in the nucleus.
  - Mass of electron $= 9.1 \times 10^{-31} Kg$,
  - Charge of electron= 1.6×10^{-19} C.
- **Type :** There exist two types of charges in nature (i) Positive charge (ii) Negative charge
  Like charges repel each other and unlike charges attract each other

- **Quantization of Charge** : Quanta(smallest particle of charge) of charge is electron
  If the charge of an electron $(= 1.6 \times 10^{-19} C)$ is taken as elementary unit *i.e.* quanta of charge the charge on any body will be some integral multiple of *e i.e.,* $\boxed{Q = \pm ne}$ with $n = 1, 2, 3 \ldots.$
- **Electric Current:** The rate of flow of charge with respect to time is called current.

$$i = \frac{Q}{t}$$

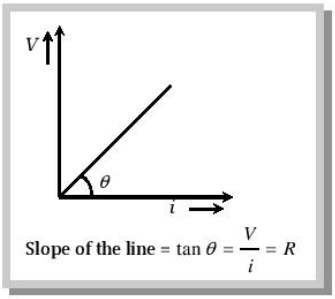
  Here Q is the charge that passes through a place in time t. Current is a scalar quantity. It's S.I. unit is *ampere* (*A*).

- **Ohm's Law:** When the physical circumstances of the conductor (length, temperature, mechanical strain etc.) remains constant, then the potential difference across the conductor is directly proportional to the current flowing through it *i.e.*

$$V \propto I$$

$$\Rightarrow V = IR \quad \text{or} \quad \frac{V}{I} = R \ ;$$

  Where *R* is proportionality constant, known as electric resistance.



- **Resistance:** The property of substance by virtue of which it opposes the flow of current through it, is known as the resistance.
- **Resistance Formula :** For a conductor if *l* = length of a conductor *A* = Area of cross-section of conductor, *n* = No. of free electrons per unit volume in conductor, τ= relaxation time then resistance of conductor

$$R = \rho \frac{l}{A} = \frac{m}{ne^2\tau} \cdot \frac{l}{A}$$

  where ρ = resistivity of the material of conductor. It's S.I. unit is *Volt/Amp.* or *Ohm* (Ω).

  Resistance of a conductor depends on the following factors.

  (i) Length of the conductor : $R \propto l$

  e.g. a conducting wire having resistance *R* is cut in *n* equal parts. So resistance of each part will be $\frac{R}{n}$.

  (ii) Area of cross-section of the conductor : $R \propto \frac{1}{A}$

(iii) **Material of the conductor** : Resistance of conductor also depends upon the nature of material . Different material has different resistance because each material has different resistivity.

(iv) **Temperature** : **Resistance** $\propto$ **temperature** .

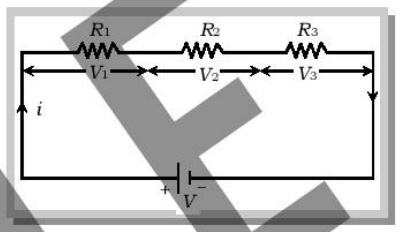
- **Combination of Resistance:**
  - **Series Combination**: Current remains constant but voltage varies

$$V = V_1 + V_2 + V_3$$

The total potential difference across the combination of resistors connected in series is equal to the sum of the potential differences across the individual resistors

$$R_{eq} = R_1 + R_2 + R_3$$

Equivalent resistance is greater than the largest value of resistance in the combination.

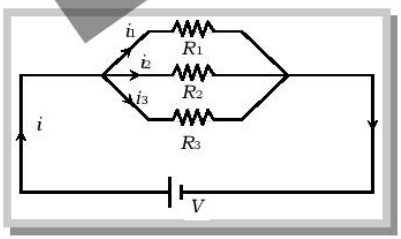


  - **Parallel Combination:** Voltage remains constant but current varies

$$I = I_1 + I_2 + I_3$$

If resistors are connected in such a way that the same potential difference gets applied to each of them, they are said to be connected in parallel

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

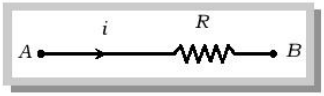


Equivalent resistance is smaller than the smallest value of resistance in the combination.

- **Conductance (*G*) :** Reciprocal of resistance is known as conductance. $G = \frac{1}{R}$ It's unit is $\frac{1}{\Omega}$ or Ω^{-1} or "Siemen".
- **Resistivity or Specific Resistance (ρ)**: As $R = \rho\frac{l}{A}$; If l = 1*m*, A = 1 m^2 then $R = \rho$ *i.e.* resistivity is numerically equal to the resistance of a substance having unit area of cross-section and unit length. Its S.I. unit is *ohm* × *m*.

  Resistivity is the intrinsic property of the substance. It is independent of shape and size of the body (*i.e.* l and A).
  - After stretching if length increases by n times then resistance will increase by n^2 times *i.e.* $R_2 = n^2 R_1$. Similarly if radius be reduced to $\frac{1}{n}$ times then area of cross-section decreases $\frac{1}{n^2}$ times so the resistance becomes n^4 times *i.e.* $R_2 = n^4 R_1$.
  - After stretching if length of a conductor increases by x% then resistance will increases by 2x % (valid only if x < 10%)
- **Heating Effect of Current and Power:** When some potential difference V is applied across a resistance R then the work done by the electric field on charge q to flow through the circuit in time t ,

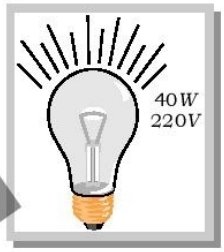
$$W = qV = Vit = i^2Rt = \frac{V^2t}{R} Joule .$$



This work appears as heat energy in the resistor.

Heat produced by the resistance R is $H = \frac{W}{J} = \frac{Vit}{4 \cdot 2} = \frac{i^2Rt}{4 \cdot 2} = \frac{V^2t}{4 \cdot 2R} Cal.$ This is called joules heating.

- **Electric Power:** Rate of doing work is called electric power or The rate at which electrical energy is dissipated into other forms of energy is called electrical power *i.e.*



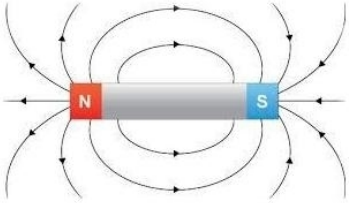
$$P = \frac{W}{t} = Vi = i^2R = \frac{V^2}{R}$$

  - S.I. unit is *Joule/sec* or *Watt*
  - Bigger S.I. units are *KW*, *MW* and *HP*, 1 *HP* = 746 *Watt*.

- **Specific use of Conducting Material**
  - **Filament of Electric Bulb :** Is made up of tungsten which has high resistivity, high melting point.
  - **Element of Heating Devices (such as heater, geyser or press) :** Is made up of nichrome which has high resistivity and high melting point.
  - **Resistances of Resistance Boxes (standard resistances) :** Are made up of manganin, or constantan as these materials have moderate resistivity which is practically independent of temperature.
  - **Fuse-Wire :** Is made up of tin-lead alloy (63% tin + 37% lead). It should have low melting point and high resistivity. It is used in series as a safety device in an electric . The function of a fuse is independent of its length.
  - Safe current of fuse wire relates with it's radius as $i \propto r^{3/2}$.
  - **Thermistors** : A thermistor is a heat sensitive resistor usually prepared from oxides of various metals such as nickel, copper, cobalt, iron etc. Thermistors are used to detect small temperature change and to measure very low temperature.
- **Commercial Units of Energy**
  - 1 *KWH* or 1 unit is the quantity of electrical energy which dissipates in one hour in an electrical circuit when the electrical power in the circuit is 1 *KW* thus 1 *KW* = 1000 *W* × 3600 *sec* = 3.6×10^6 *J*.
  - No. of consumed units is $n = \frac{\text{Total } watt \times \text{Total } hours}{1000}$
  - The price of electricity consumed is calculated on the basis of electrical energy and not on the basis of electrical power.
  - The unit *Joule* for energy is very small hence a big practical unit is considered known as *kilowatt hour* (*KWH*) or board of trade unit (B.T.U.) or simple unit.

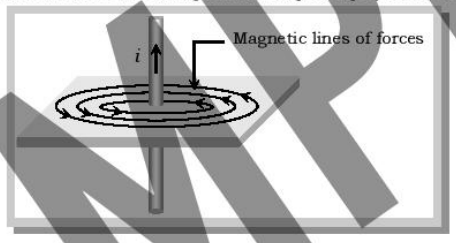
MAGNETIC EFFECT OF CURRENT

- **Magnetic Field**: It is the space around a magnetic pole or a magnet in which its effect is experienced by another magnetic pole or magnet. Magnetic field is a quantity which has both direction and magnitude.
- **Magnetic lines of Force**: A magnetic line of force is a line, straight or curved, in the magnetic field tangent to which at any point gives the direction of the magnetic field at that point. A free unit north pole (test pole) will move along the magnetic line of force in direction of the field if it is free to do so.



- **Properties of Magnetic Field Lines**: Magnetic lines of force have the following properties:
  - All field lines are closed curves. They come out of magnet from the side of the north pole and go into it on the side of the south pole. i.e. They start from a north (positive) pole and end at a south (negative) pole. They continue inside the magnet too. Inside the magnet the direction of field lines is from its south pole to its north pole.
  - They are always normal to the surface of the magnet at every point.
  - Two lines of force do not intersect each other
  - The field lines are close together near the poles and spread out away from them. The field is stronger where the field lines are more closely spaced. So, the field is stronger near the poles than at other point.
  - The number of magnetic lines of force passing normally per unit area about a point, gives the intensity of the magnetic field at that point.

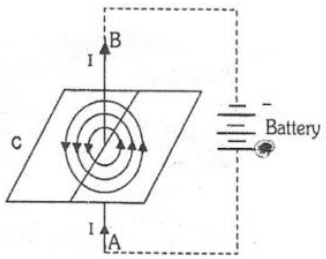
- **Magnetic Field due to Electric Current (Oersted's Experiment):** Oersted found that a magnetic field is established around a current carrying conductor. Magnetic field exists as long as there is current in the wire. When direction of current was reversed, magnetic field direction change. A moving charge produces magnetic as well.



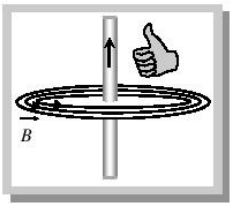
- **Conductor (Wire) and Current Carrying Circular Coil**
  - **Case 1. When Current carrying conductor is Straight, Magnetic Field is Circular**: The plane of circular lines is perpendicular to the length of the wire. Their direction is marked by arrows.
    When current I flows through a straight wire, the magnetic field strength (B) at a small distance r from it is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

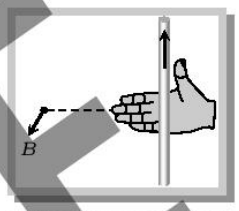
    From the above expression we see that magnitude of magnetic produced by a straight carrying wire at a given point is :
    (i) directly proportional to the quantity of current flowing through the wire.
    (ii) inversely proportional to the distance of point from the wire. Thus, if current is more, magnetic field will be stronger and vice versa.



- **Direction of Magnetic Field:** The direction of magnetic field is determined with the help of the following simple laws :
  - **Right hand thumb rule:** According to this rule if a current carrying conductor is held in the right hand such that the thumb of the hand represents the direction of current flow, then the direction of folding fingers will represent the direction of magnetic lines of force.



  - **Right hand palm rule:** If we stretch our right hand such that fingers point towards the point. At which magnetic field is required while thumb is in the direction of current then normal to the palm will show the direction of magnetic field.



    when current flows vertically upward then direction of magnetic field produced is anticlockwise and when current flows vertically downward then direction of magnetic field is clockwise.

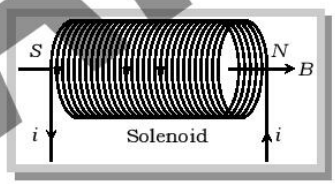
Case-2 When Current is Circular, Magnetic Field is Straight: It is found that magnitude of the magnetic field (B) at the centre of a circular coil carrying currents is directly proportional to amount of current flowing through the wire (I), inversely proportional to the radius of the coil (r) and directly proportional to the number of turns in the coil.

Mathematically, $B = \frac{\mu_0 nI}{2r}$.

Here, n is number of turns of the coil.

Magnetic Field due to current in a Solenoid: A cylindrical coil of many tightly wound turns of insulated is called solenoid. For long solenoid $l >> r$ (radius).

One end of the solenoid behaves like the North pole and opposite end behaves like the South pole. As the length of the solenoid increases, the interior field becomes more uniform and the external field becomes weaker. (approach to zero)



Here clockwise current shows south polarity and anti-clockwise shows north polarity.

the magnetic field around a current carrying solenoid $B = \mu_0 \mu_r nI$

Where B depends upon

- Number of turns per unit length (n) of the solenoid and $B \propto n$
- Strength of the current (I) in the solenoid and $B \propto I$

Nature (relative permeability, μ_r) of the core material and μ_0 represents permeability of free space.

Electromagnet: Strong magnetic field which can be produced due to the flow of current can be used to magnetise a piece of magnetic material like steel rod, soft iron etc, when placed inside the coil. Magnet so produced is called electromagnet.

Difference between an Electromagnet and a Permanent magnet

	Electromagnet	Permanent magnet
1	It behaves as a magnet as long as electric current passes through the solenoid surrounding it. It is demagnetised when electric current stops passing through the solenoid. Thus, electromagnet is a temporary magnet.	It cannot be demagnetised easily
2	Electromagnet gives a strong magnetic field and the strength of the magnetic field produced by these electromagnet can be increased or decreased by increasing or decreasing electric current through the solenoid.	Magnetic field of a permanent magnet is weak. The strength of magnetic field of the permanent magnet cannot be changed.
3	The polarity (i.e. North and South poles) of an electromagnet can be reversed by reversing the direction of electric current through the solenoid.	The polarity of a permanent magnet cannot be reversed.

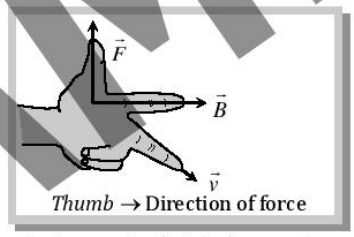
Force on a current carrying conductor placed in a magnetic field: A current carrying conductor produces a magnetic field around it. When it is placed in a magnetic field, the two magnetic fields interact with each other and a net force acts on the conductor. If the conductor of length carrying current I is lying inside a magnetic field of intensity B and is making an angle with it, then force acting on the conductor is given by

$$F = IBl\sin\theta$$

Conditions: 1. If the conductor is lying perpendicular to the magnetic field, then $\theta = 90^o$ (sin θ =1) and the force becomes $F = IBl$.

Condition: 2 If the conductor is lying parallel to the magnetic field, then $\theta = 0^o$ (sin θ =0) and the force becomes zero and is minimum.

Direction of the force action on a current carrying conductor : When placed in a magnetic field is given by **Fleming's left hand rule**, which states that :If the forefinger, second finger and thumb of the left hand are stretched at right angles to each other, with the forefinger in the direction of the field and the second finger in the direction of the current then the thumb indicates the direction of the force.



Electric Motor: An electric motor is a device that converts electrical energy to mechanical energy. The principle of electric motor is based on the fact that a current carrying conductor produces a magnetic field around it. A current carrying conductor placed perpendicular to magnetic field experiences a force.

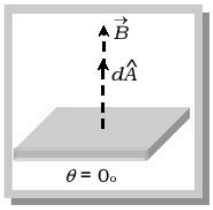
Magnetic Flux: The total number of magnetic lines of force passing normally through an area placed in a magnetic field is equal to the magnetic flux. For elementary area *dA*: flux linked

$$d\phi = BdA\cos\theta$$

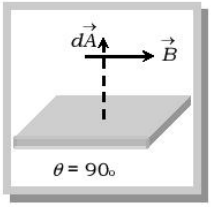
Conditions:

1. If $\theta = 0^o$, flux from the surface is maximum and
2. If $\theta = 90^o$;flux linked with the surface is zero.

$\phi_{max} = BA$



$\phi = 0$



Faradays First Law: Whenever the number of magnetic lines (magnetic flux) passing through a circuit changes an emf is induced in the circuit (or emf induces across the ends of the conductor) called induced emf. The induced emf persists only as long as there is change of flux.

Faradays Second Law: The induced emf is given by rate of change of magnetic flux linked with the circuit *i.e.*

$$e = -\frac{d\phi}{dt}.$$

If N is number of turns, then $e = -\frac{N\,d\phi}{dt}$; Negative sign represents that induced emf (e) opposes the change of flux.

Induced Current: If circuit is closed, then $i = \frac{e}{R} = -\frac{N}{R}.\frac{d\phi}{dt}$; where R is the resistance of circuit

Induced Charge: $i = \frac{dq}{dt}$; $dq = i\,dt = -\frac{N}{R}\cdot d\phi$ *i.e.* the charge induced does not depend on the time interval in which flux through the circuit changes. It simply depends on the net change in flux and resistance of the circuit.

Induced Power: $P = ei = \frac{e^2}{R} = i^2R = \frac{N^2}{R}\left(\frac{d\phi}{dt}\right)^2$.

AC Generator or Dynamo: An electrical machine used to convert mechanical energy into electrical energy is known as ac generator. It works on the principle of electromagnetic induction *i.e.*, when a coil is rotated in uniform magnetic field, an induced emf is produced in it.

Alternating Current: In alternating current, the electric charges flow changes its direction periodically. AC is the most commonly used and most preferred electric power for household equipment, office, and buildings, etc.

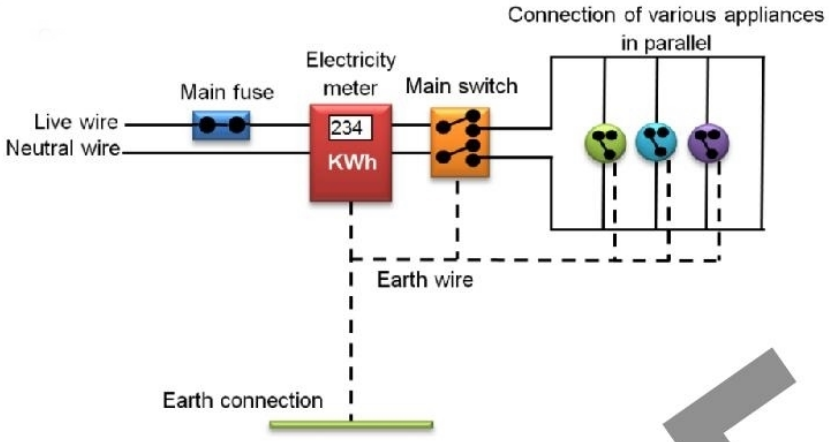
Direct Current: The flow of current in direct current does not change periodically. The current electricity flows in a single direction in a steady voltage. The major use of DC is to supply power for electrical devices and also to charge batteries. For example, mobile phone batteries, flashlights

Alternating Current	Direct Current
AC can carry and safe to transfer longer distance even between two cities, and maintain the electric power.	DC cannot travel for a very long distance. It does, it loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is depended upon the country. But, generally, the frequency is 50Hz or 60Hz.	DC has no frequency of zero frequency.
In AC the flow of current changes its direction backwards periodically.	It flows in a single direction steadily.
Electrons in AC keep changing its directions – backward and forward	Electrons only move in one direction – that is forward.

Domestic Electrical Circuits:

Supply From Power Stations: Electricity is generated at power station. In our homes, we receive the supply of electric power either supplied through overhead poles or underground cables using two thick aluminium wires.

Main Board: It is provided outside the building. It contains the meter (energy-meter) and the main switch. From the street electric pole, a thick rubber insulated cord reaches the main board. It contains two thick copper or aluminium wires, one covered with red and the other covered with black (or brown) plastic covering



They form the live line wire (L) and neutral line wire (N) respectively. Live line wire has a potential or 220 V whereas the neutral wire has zero potential (with respect to the earth). They enter the main board and are connected to the meter.

Wiring ahead is provided by the house owner himself. These wires are also red black plastic covered. From the meter the wires enter the main switch. In the main switch, a fuse F is provided in the path of live wire.

From outside the main switch, the wires become free to be used inside the building as required.

A third wire is a thick bare wire of copper called earth wire E. It is connected to an earth connection which consists of a thick copper plate P buried deep inside the moist earth.

Inside the Building : It is a well known fact that inside the house, connections to all the devices are made in parallel, each having independent switch and fuse (if necessary). Thus, whenever some fault occurs in circuit of one particular device in one room, devices in other rooms do not suffer.

Function of Earth Wire : Due to the long use, some covered wires inside the appliance may become bare and may make contact with metallic body of the appliance. In such a case the appliance gives a shock if not earthed. The earth wire keeps the potential of the appliance zero and shock is avoided

Use of Switch: All electrical appliances are provided with separate switches. All switches are connected with live wire as well as with neutral wire. When we switch off an appliance, then it gets disconnected from the live wire. Now if one touches the metallic body of the appliance there is no danger of electric shock. But, if connections to the switch are in such a way that on switching off the appliance, neutral wire gets disconnected but not live wire, then is danger of electric shock.

SHORT CIRCUIT: When the live wire and the neutral wire come into direct contact. This occurs when the insulation of wires is damaged or there is a fault in the appliance. In such a situation, the current in the circuit abruptly increases. This is called short-circuiting. When short circuiting occurs, the resistance of the circuit becomes very small and hence huge amount of current flows through it. Large amount of current in the circuit produces large amount of heat which raises the temperature of circuit to very high value. As a result of this, the circuit catches fire.

Overloading: means flow of large amount of current in the circuit beyond the permissible value of current. It occurs when many electrical appliances of high power rating like geyser, heater, refrigerator, motor etc. are connected in a single socket or in a single circuit. High current flowing in the circuit due to overloading causes fire.

Light

Light: Light is form of energy which enables us to see objects which emit or reflect light.

Ray of Light: A straight line show the direction moment of light is called ray of light.

Beam of Light: A bunch of light rays or bundle of rays at a point is called beam of light.

Reflection of Light: When rays of light fall on any object it returns back in the same medium from the surface this phenomenon is called reflection of light. Due to reflection of light we can see all the nature.

Law of Reflection

1. The incident ray, the reflected ray and the normal to the surface at the point of incidence all lie in the same plane.
2. The angle of incidence ($\angle i$) is always equal to the angle to reflection ($\angle r$) i.e. $\angle i = \angle r$.

Image: When light rays meet or appear to meet after reflection from a mirror, then it is called an image.

(i) Real Image: It is a kind of image which is formed by actual intersection of light rays after reflection.

(ii) Virtual Image: It is a kind of image which is formed by producing the reflected rays backward after reflection.

Difference between Real and Imaginary image

S.No	Real image	Virtual image
(1)	When reflected or refracted light rays actually intersect at a point.	When reflected or refracted light rays do not actually intersect at a point but appear to meet at a point
(2)	It can be obtained on a screen.	It can not be obtained on a screen.
(3)	It is always inverted.	It is always erect.
(4)	It is always formed in front of mirror.	It is always formed behind the mirror.

Plane Mirror: Plane mirror is a piece of glass whose one side is polished by using silver paint, which is covered by a coating of red paint to protect the silver layer.

Spherical Mirrors: It is part of hollow glass sphere whose one surface is polished.

There are two types of spherical mirror.

(i) Concave Mirror : It is a spherical mirror whose outer surface is polished and inner or concave side is reflecting surface.

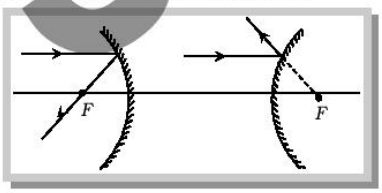
(ii) Convex Mirror : It is a spherical mirror whose inner is polished and outer side or convex side is the reflecting surface.

Principal Focus : A point on the principal axis of a spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the mirror.

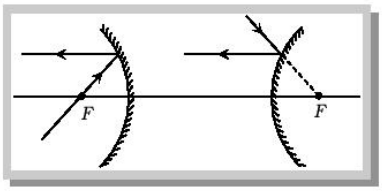
Focal Length : The distance between the pole (P) and principal focus(F) of a spherical mirror is called the focal length of the mirror. It is denoted by f.

Rules of Image Formation and sign Convention :

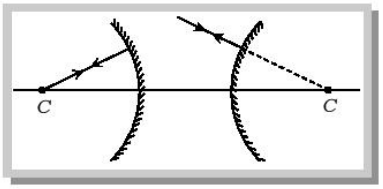
Rule (i)



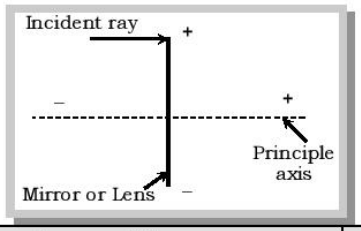
Rule (ii)



Rule (iii)



Sign Conventions : Same sign conventions are also valid for lenses.



Concave Mirror		Convex Mirror
Real Image ($u \geq f$)	Virtual Image ($u < f$)	
Distance of object $u \rightarrow -$	$u \rightarrow -$	$u \rightarrow -$
Distance of image $v \rightarrow -$	$v \rightarrow +$	$v \rightarrow +$
Focal length $f \rightarrow -$	$f \rightarrow -$	$f \rightarrow +$
Height of object $O \rightarrow +$	$O \rightarrow +$	$O \rightarrow +$
Height of image $I \rightarrow -$	$I \rightarrow +$	$I \rightarrow +$
Radius of curvature $R \rightarrow -$	$R \rightarrow -$	$R \rightarrow +$
Magnification $m \rightarrow -$	$m \rightarrow +$	$m \rightarrow +$

Uses of Concave Mirror :

(i) It is used as a shaving mirror because when it is placed close to the face, it forms a large image.

(ii) It is used in solar heating devices like solar cooker, because it converges Sun's rays over a small area to produce high temperature.

(iii) It is used for security checking purposes.

Uses of Convex Mirror :

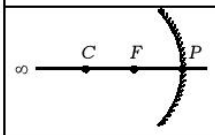
(i) It is used as rear view mirror in automobiles because it gives erect image as well as diminished due to which Pt has wider field of view.

(ii) It is also used in street lights.

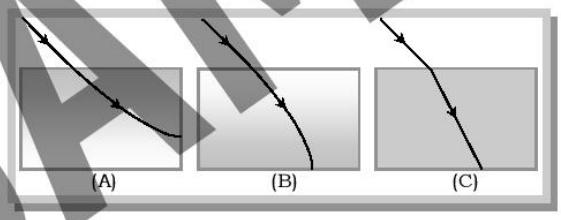
Mirror Formula : It is a relation between distance of object, distance of image from the pole of the mirror and it's focal length, i.e., relation between 'u', 'v and f .It is given by $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Magnification : It is defined as the ratio of height of image to the height of the object. It is denoted by letter m.

$$Magnification\ m = \frac{Height\ of\ image(I)}{Height\ of\ object(O)}$$

Mirror	Location of the Object	Location of the Image	Magnification, Size of the Image	Nature	
				Real / Virtual	Erect / Inverted
(a) Concave	At infinity *i.e.* $u = \infty$	At focus *i.e.* $v = f$	$m \ll 1$, diminished	Real	inverted
	Away from centre of curvature ($u > 2f$)	Between f and $2f$ *i.e.* $f < v < 2f$	$m < 1$, diminished	Real	inverted
	At centre of curvature $u = 2f$	At centre of curvature *i.e.* $v = 2f$	$m = 1$, same size as that of the object	Real	inverted
	Between centre of curvature and focus : $F < u < 2f$	Away from the centre of curvature $v > 2f$	$m > 1$, magnified	Real	inverted
	At focus *i.e.* $u = f$	At infinity *i.e.* $v = \infty$	$m = \infty$, magnified	Real	inverted
	Between pole and focus $u < f$	$v > u$	$m > 1$ magnified	Virtual	erect
(b) Convex	At infinity *i.e.* $u = \infty$	At focus *i.e.*, $v = f$	$m < 1$, diminished	Virtual	erect
	Anywhere between infinity and pole	Between pole and focus	$m < 1$, diminished	Virtual	erect

Refraction of Light : The bending of ray of light when it passes from one medium to another is called refraction of light.



Laws of Refraction :

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

(ii) When a ray of light undergoes refraction then the ratio of sine of angle of incidence to the sine of angle of refraction is constant.

Snell's Law : The ratio of sine of the angle of incidence to sine of angle of refraction (r) is a constant called refractive index

$$\frac{\sin i}{\sin r} = \mu$$

For two media, Snell's law can be written as $_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r}$

$$\Rightarrow \mu_1 \times \sin i = \mu_2 \times \sin r \text{ i.e. } \mu \sin\theta = \text{ constant}$$

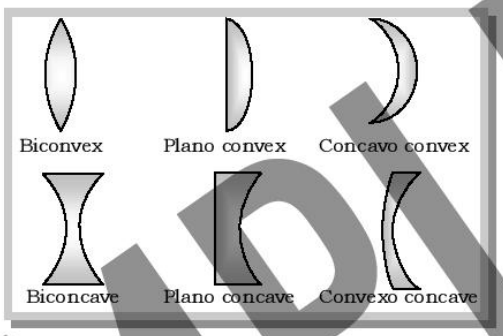
The Refractive Index : The refractive index of medium 2 with respect to medium is given by the ratio of the speed of light in medium 1 and the speed of light in medium 2. This is usually represented by the symbol n_{21}. This can be expressed in an equation form as

$$n_{21} = \frac{Speed\ of\ light\ in\ medium\ 1}{Speed\ of\ light\ in\ medium\ 2} = \frac{v_1}{v_2}$$

Refraction by spherical lenses : Lens is a transparent medium which is formed by joining two pieces of spherical glass. There are two types of lenses.

(i) Convex Lens : It is a lens which is thicker at the centre and thinner at the edges.

(ii) Concave Lens : It is a lens which is thinner at the centre and thicker at the edges.

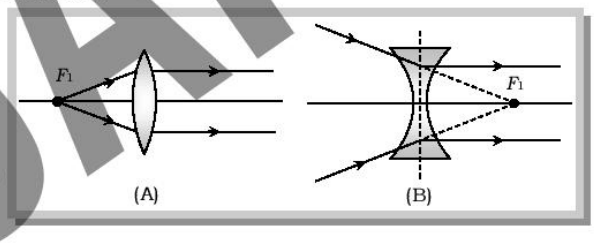


Terms related to a lens

Optical Centre of Lens : It is the centre of the lens through which light can pass without any deviation.

Principal Axis : It is the line passing through optical centre and is perpendicular to the line joining its edges.

Principal Focus : It is a point on the principal axis where all light rays which are parallel to principal axis either converge or appear to diverge from, after refraction.



Lens formula : The expression which shows the relation between *u*, *v* and *f* is called lens formula.

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

Magnification : Magnification, $m = h_2/h_1$. Ratio of height of image to the height of object.

It is also given by v/u i.e., Ratio of distance of image to the distance of object.

$$\therefore \frac{h_2}{h_1} = \frac{v}{u}$$

Power of a lens : A beam of light parallel to principal axis either gets converged or diverged after refraction by a lens. Some lenses converge the beam of light to a small extent and some lenses converge it to a large extent. This ability of lens to converge or diverge a beam of light is known as the power of lens.

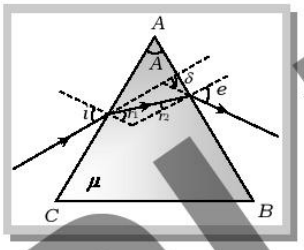
Si unit of power of lens is dioptre : One dioptre is the power of a lens whose focal length is 1 m.

Power of a combination of two or more lenses : If two or more lenses are placed together to form a combined lens then the power of this combined lens is equal to the sum of the powers of individual lenses.

$$P = P_1 + P_2 + P_3 + ...$$

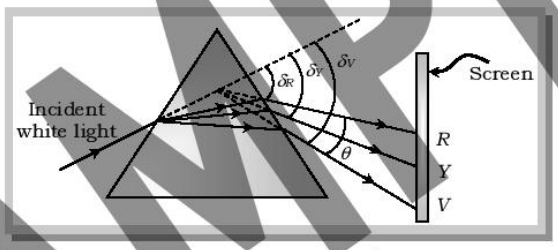
Refraction through a Prism: $A = r_1 + r_2$ and $i + e = A + \delta$

For surface AC $\mu = \frac{\sin i}{\sin r_1}$; For surface AB $\frac{1}{\mu} = \frac{\sin r_2}{\sin e}$



i – Angle of incidence,
e – Angle of emergence,
A – Angle of prism or refracting angle of prism,
r_1 and r_2 – Angle of refraction,
δ – Angle of deviation

Dispersion Through a Prism: The splitting of white light into it's constituent colours is called dispersion of light.
Angular separation between extreme colours *i.e.* $\theta = \delta_V - \delta_R = (\mu_V - \mu_R)A$. It depends upon μ and A.



Dispersive Power (ω) : $\omega = \frac{\theta}{\delta_y} = \frac{\mu_V - \mu_R}{\mu_y - 1}$; where $\left\{\mu_y = \frac{\mu_V + \mu_R}{2}\right\}$

$\Rightarrow$ It depends only upon the material of the prism *i.e.* μ and it doesn't depends upon angle of prism A

Two prisms (made of crown and flint material) are combined to get either dispersion only or deviation only.

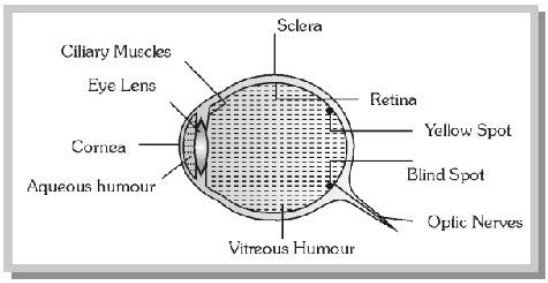
Scattering of Light: Molecules of a medium after absorbing incoming light radiations, emit them in all direction. This phenomenon is called Scattering.

Rayleigh Scattering: Intensity of scattered light $\propto \frac{1}{\lambda^4}$

- Sky looks blue due to scattering.
- At the time of sunrise or sunset sun looks reddish.

Rainbow is formed due to the dispersion of light suffering refraction and TIR in the droplets present in the atmosphere.

Human Eye:



Retina : Real and inverted, image of an object, obtained at retina, brain sense it erect.

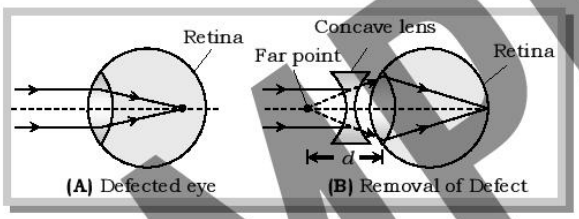
Blind Spot : Optic nerves go to brain through blind spot. It is not sensitive for light.

Ciliary Muscles : Eye lens is fixed between these muscles. It's both radius of curvature can be changed by applying pressure on it through ciliary muscles.

Power of Accommodation : The ability of eye to see near objects as well as far objects is called power of accommodation.

Eye Defects

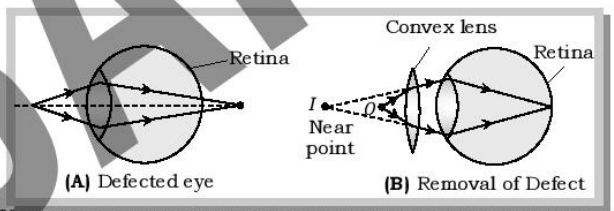
Myopia (short sightedness) : A short-sighted eye can see only nearer objects. Distant objects are not seen clearly.



Focal length of used lens $f = -d = -$ (defected far point)

A person can see upto distance $\rightarrow x$, wants to see distance $\rightarrow y$ $(y > x)$ so $f = \frac{xy}{x-y}$ or power of the lens $P = \frac{x-y}{xy}$

Hypermetropia (long sightedness) : A long-sighted eye can see distant objects clearly but nearer object are not clearly visible.



If a person cannot see before distance 'd' but wants to see the object placed at distance D from eye so $f = \frac{dD}{d-D}$ and power of the lens $P = \frac{d-D}{dD}$

Presbyopia : In this defect both near and far objects are not clearly visible. It is an old age disease. It can be removed by using bifocal lens.

Astigmatism : In this defect eye cannot see horizontal and vertical lines clearly, simultaneously. It is due to imperfect spherical nature of eye lens. This defect can be removed by using cylindrical lenses.

UNIT I: NUMBER SYSTEM

1. REAL NUMBER

S.No.	Type of Numbers	Description
1	Natural Numbers	N={1, 2, 3, 4, 5, …….} It is the counting numbers
2	Whole Numbers	W= {0, 1, 2, 3, 4, 5, ……..} It is the counting numbers+Zero
3	Integers	Z= {….−7, −6, −5, −4, −3, −2, −1, 0, 1, 2, 3, 4, 5, 6, 7….}
4	Positive Integers	Z= {1, 2, 3, 4, 5, 6, 7….}
5	Negative Integers	Z= {….−7, −6, −5, −4, −3, −2, −1}
6	Rational Numbers	A number is called rational if it can be expressed in the form p/q where p and q are integers (q>0) Example : ½ ; 4/3 ; 5/7 ; 1 etc.
7	Irrational Numbers	A number is called irrational if it can not be expressed in the form p/q where p and q are integers (q>0). Example : $\sqrt{2}, \sqrt{3}, \sqrt{5}, \pi$ ...
8	Real Numbers	All rational and irrational number makes the collection of real number. It is denoted by the letter R.

1. Euclid's Division Algorithm (lemma): According to Euclid's Division Lemma if we have two positive integers a and b, then there exist unique integers q and r such that a = bq + r, where $0 \le r \le b$. (Here, a = dividend, b = divisor, q = quotient and r = remainder.)

$$Dividend = (divisor \times quotient) + remainder$$

2. HCF (Highest common factor): HCF of two positive integers can be find using the Euclid's Division Lemma algorithm.

We know that for any two integers a, b. we can write following expression $a=bq + r$, $0 \le r \le b$

If $r=0$,then HCF(a, b) $=b$ If $r \neq 0$, then HCF (a, b) = HCF (b,r). Again expressing the integer b, r in Euclid's Division Lemma, we get $b=pr + r_1$HCF (b,r)=HCF (r,r_1) Similarly successive Euclid 's division can be written until we get the remainder zero, the divisor at that point is called the HCF of the a and b.

3. HCF (a,b) =1 Then a and b are co primes.

4. Fundamental Theorem of Arithmetic: Composite number = Product of primes

5. HCF and LCM by prime factorization method:

- HCF = Product of the smallest power of each common factor in the numbers
- LCM = Product of the greatest power of each prime factor involved in the number

6. Important Formula: HCF (a,b) × LCM (a,b) =a × b

UNIT II: ALGEBRA

1. POLYNOMIALS

A polynomial expression S(x) in one variable x is an algebraic expression in x term as

$$S(x) = a_n x^n + a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots\ldots + ax + a_0$$

Where a_n, a_{n-1}, a, a_0 are constant and real numbers and a_n is not equal to zero.

Some Important Points:

1. $a_n, a_{n-1}, \ldots a, a_0$ are called the coefficients for $x^n, x^{n-1}, \ldots x^1, x^0$

2. n is called the degree of the polynomial.

3. when $a_n, a_{n-1}, a_{n-2}, \ldots a, a_0$ all are zero, it is called zero polynomial.

4. A constant polynomial is the polynomial with zero degree, it is a constant value polynomial.

5. A polynomial of one item is called monomial, two items binomial and three items as trinomial.

6. A polynomial of one degree is called linear polynomial, two degree as quadratic polynomial and degree three as cubic polynomial

Important Concept on Polynomial:

1. Zero's or roots of the polynomial It is a solution to the polynomial equation S(x) =0 i.e. a number "a" is said to be a zero of a polynomial if S(a) = 0. If we draw the graph of S(x) =0, the values where the curve cuts the X-axis are called Zeroes of the polynomial.

2. Remainder Theorem's If p(x) is an polynomial of degree greater than or equal to 1 and p(x) is divided by the expression (x−a), then the remainder will be p(a).

3. Factor's Theorem's If x−a is a factor of polynomial p(x) then p(a)=0 or if p(a) =0, x−a is the factor the polynomial p(x).

Some Important Formulae and Identities

(i) $(a + b)^2 = a^2 + 2ab + b^2$

(ii) $(a - b)^2 = a^2 - 2ab + b^2$

(iii) $a^2 - b^2 = (a + b)(a - b)$

(iv) $(a + b)^3 = a^3 + b^3 + 3ab(a + b)$

(v) $(a - b)^3 = a^3 - b^3 - 3ab(a - b)$

(vi) $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$

(vii) $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$

(viii) $a^4 - b^4 = (a^2)^2 - (b^2)^2 = (a^2 + b^2)(a^2 - b^2) = (a^2 + b^2)(a + b)(a - b)$

(ix) $(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ac$

(x) $(a + b - c)^2 = a^2 + b^2 + c^2 + 2ab - 2bc - 2ca$

(xi) $(a - b + c)^2 = a^2 + b^2 + c^2 - 2ab - 2bc + 2ca$

(xii) $(a - b - c)^2 = a^2 + b^2 + c^2 - 2ab + 2bc - 2ca$

(xiii) $a^3 + b^3 + c^3 - 3abc = (a + b + c)(a^2 + b^2 + c^2 - ab - bc - ca)$

Basic formulas for powers

- $p^m \times p^n = p^{m+n}$
- $\{p^m\}/\{p^n\} = p^{m-n}$
- $(p^m)^n = p^{mn}$
- $p^{-m} = 1/p^m$
- $p^1 = p$
- $P^0 = 1$

2. PAIR OF LINEAR EQUATIONS IN TWO VARIABLES

For the pair of linear equations $a_1 + b_1y + c_1 = 0$ and $a_2 + b_2y + c_2 = 0$,

the nature of roots (zeroes) or solutions is determined as follows:

(i) If $a_1/a_2 \neq b_1/b_2$ then we get a unique solution and the pair of linear equations in two variables are consistent. Here, the graph consists of two intersecting lines.

(i) If $a_1/a_2 \neq b_1/b_2 \neq c_1/c_2$, then there exists no solution and the pair of linear equations in two variables are said to be inconsistent. Here, the graph consists of parallel lines.

(iii) If $a_1/a_2 = b_1/b_2 = c_1/c_2$, then there exists infinitely many solutions and the pair of lines are coincident and therefore, dependent and consistent. Here, the graph consists of coincident lines.

3. QUADRATIC EQUATIONS

- General form of the quadratic equation is; $ax^2 + bx + c = 0$; Where, a, b, c are constants and $a \neq 0$.
- If α and β be the roots of equation, $ax^2 + bx + c = 0$; then

$$\alpha = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \text{ and } \beta = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

This formula can be written as $x = \dfrac{-\text{Coefficient of } x \pm \sqrt{(\text{Coefficient of } x)^2 - 4(\text{Coefficient of } x^2) \times (\text{Constant term})}}{2(\text{Coefficient of } x^2)}$

- A quadratic equation has two and only two roots $\alpha+\beta=\frac{-b}{a}$ and $\alpha\times\beta=\frac{c}{a}$
- If α and β be the roots of equation $ax^2+bx+c=0$; and $a\alpha^2+b\alpha+c=0$ and $a\beta^2+b\beta+c=0$
- The quadratic equation whose roots are α and β, is given by $x^2-(\alpha+\beta)x+\alpha\times\beta=0$.
- If a, b, c are rational and one of the roots of $ax^2+bx+c=0$ is $\alpha+\sqrt{\beta}$; then the other root is $\alpha-\sqrt{\beta}$; Where, $\sqrt{\beta}$ is irrational.
- b^2-4ac is called the **discriminant (D)** of the quadratic equation; $ax^2+bx+c=0$.

(a) If $b^2-4ac<0$; then roots are imaginary and unequal.

(b) If $b^2-4ac>0$; then roots are real and unequal.

(c) If $b^2-4ac>0$ and is a perfect square; roots are rational and unequal.

(d) If $b^2-4ac>0$ and is not a perfect square; roots are irrational and unequal.

(e) If $b^2-4ac=0$; roots are real and equal and each equal to $-b/2a$.

4. ARITHMETIC PROGRESSIONS

(a) If $a, b, c, \ldots\ldots$ are in A. P.; then $b-a=c-b=\ldots\ldots\ldots\ldots=d$ (common difference); and $la\pm k,\ lb\pm k,\ lc\pm k, \ldots\ldots$ are also in A. P.

(b) The arithmetic series is $a,\ a+b, \ldots\ldots\ a+(n-1)d$.

(c) The nth term of an A. P., $t_n=a+(n-1)d$.

(d) r^{th} term from the last $=(n-r+1)^{th}$ from the start.

(e) Sum of the first n terms of an A. P.,

$$S_n=\frac{n}{2}\{2a+(n-1)d\}=\frac{n}{2}(a+l);$$

where n = number of terms. a = first term and l = last term.

(f) Arithmetic mean between a and b; $A=\frac{a+b}{2}$.

(g) Sum of n arithmetic means between a and $b=\frac{a+b}{2}\times n$.

UNIT III: COORDINATE GEOMETRY

1. LINES (In Two-Dimensions)

(a) The equations of a straight line which passing through two given points (x_1,y_1) and (x_2,y_2) is given by :

$$(y-y_1)=m(x-x_1).$$

(b) The equation of a straight line passing through two given points (x_1,y_1) and (x_2,y_2) is given by :

$$y-y_1=\frac{y_2-y_1}{x_2-x_1}(x-x_1).$$

(c) Every first-degree equation namely $ax+by+c=0$, represents a straight line.

(d) The angle θ between the lines $y_1=m_1x+c_1$ and $y_2=m_2x+c_2$ is given by: $\tan\theta=\pm\frac{m_1-m_2}{1+m_1m_2}$

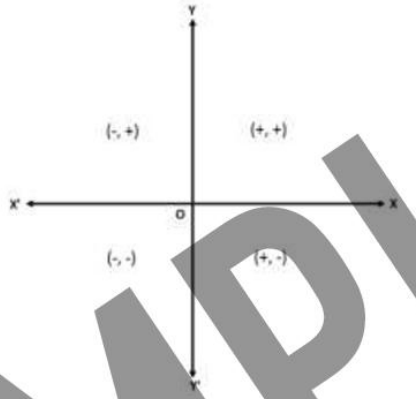
(e) Two lines are parallel if $m_1=m_2$ and they are perpendicular to each other iff $m_1m_2=-1$.

(f) The angle θ between the lines, $a_1x+b_1y+c_1=0$ and $a_2x+b_2y+c_2=0$ is given by : $\tan\theta=\dfrac{a_1b_2-a_2b_1}{a_1a_2+b_1b_2}$

(g) The lines are parallel if $\dfrac{a_1}{a_2}=\dfrac{b_1}{b_2}$ and they are perpendicular to each other if $a_1a_2+b_1b_2=0$.

2. COORDINATE GEOMETRY

- We require two perpendicular axes to locate a point in the plane. One of them is horizontal and other is Vertical.
- The plane is called Cartesian plane and axis are called the coordinates axis.
- The horizontal axis is called x-axis and Vertical axis is called Y-axis.
- The point of intersection of axis is called origin.



The coordinates of the points in the four quadrants will have sign according to the below table

Quadrant	X-Coordinate	Y-Coordinate
1st Quadrant	+	+
2nd Quadrant	−	+
3rd Quadrant	−	−
4th Quadrant	+	−

- Distance between two points $P(x_1,y_1)$ and $Q(x_2,y_2)$: $PQ=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$.
- Co-ordinates of the point which divides (internally) the line joining the points $P(x_1,y_1)$ and $Q(x_2,y_2)$ in the ration $m:n$, are given by: $\left(\dfrac{mx_2+nx_1}{m+n}.\dfrac{my_2+ny_1}{m+n}\right)$.
- The three points; *A*, *B*, *C* will be collinear only when area of the $\triangle ABC$. The slope (m) of the line joining the points (x_1,y_1) and (x_2,y_2) : $m=\dfrac{y_2-y_1}{x_2-x_1}$.

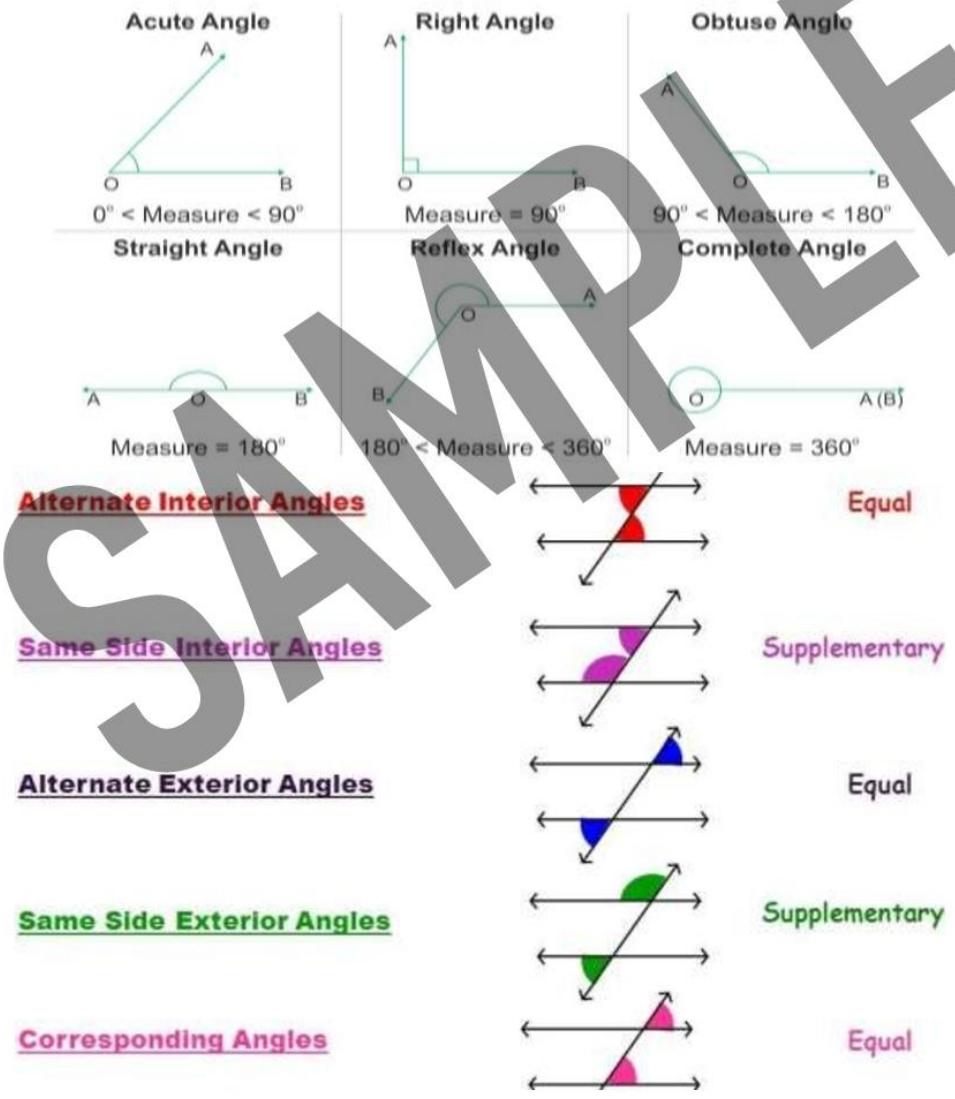
UNIT IV: GEOMETRY

1. LINES & ANGLES

- If a ray stands on a line, then the sum of the two adjacent angles so formed is 180° and vice-versa. This property is called as the Linear pair axiom.
- If two lines intersect each other, then the vertically opposite angles are equal.

- If a transversal intersects two parallel lines, then
  (i) each pair of corresponding angles is equal,
  (ii) each pair of alternate interior angles is equal,
  (iii) each pair of interior angles on the same side of the transversal is supplementary.
- If a transversal intersects two lines such that, either
  (i) any one pair of corresponding angles is equal, or
  (ii) any one pair of alternate interior angles is equal, or
  (iii) any one pair of interior angles on the same side of the transversal is supplementary, then the lines are parallel.
- Lines which are parallel to a given line are parallel to each other.
- The sum of the three angles of a triangle is 180°.
- If a side of a triangle is produced, the exterior angle so formed is equal to the sum of the two interior opposite angles.

Figure related to Lines and Angles



2. CIRCLES

Important properties related to circles:

- The equation of the circle whose centre is (0, 0) and radius is a; is given by $x^2 + y^2 = a^2$.
- Equal chord of a circle are equidistant from the centre.
- The perpendicular drawn from the centre of a circle, bisects the chord of the circle.
- The angle subtended at the centre by an arc = Double the angle at any part of the circumference of the circle.
- Angles subtended by the same arc in the same segment are equal.
- To a circle, if a tangent is drawn and a chord is drawn from the point of contact, then the angle made between the chord and the tangent is equal to the angle made in the alternate segment.
- **Other important formulae**
  - Circumference of the circle = $2\pi r$
  - Area of the circle = πr^2
  - Area of the sector of angle $\theta = (\theta/360) \times \pi r^2$
  - Length of an arc of a sector of angle $\theta = (\theta/360) \times 2\pi r$ (r = radius of the circle)

3. CONSTRUCTIONS

Construction in Geometry is related to drawing shapes, angles or lines accurately. These geometric constructions are carried out with the help of a compass, a ruler, and a pencil.

(i) Division of a Line Segment

Let us see how this method gives us the required division.

Since A_3C is parallel to A_5B, therefore,

$$\frac{AA_3}{A_3A_5} = \frac{AC}{CB}$$ (By the Basic Proportionality Theorem)

By construction, $\frac{AA_3}{A_3A_5} = \frac{3}{2}$. Therefore, $\frac{AC}{CB} = \frac{3}{2}$.

This shows that C divides AB in the ratio 3 : 2.

Alternative Method

Steps of Construction :

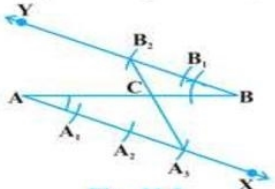


Fig. 11.2

1. Draw any ray AX making an acute angle with AB.
2. Draw a ray BY parallel to AX by making $\angle$ ABY equal to $\angle$ BAX.
3. Locate the points A_1, A_2, A_3 ($m = 3$) on AX and B_1, B_2 ($n = 2$) on BY such that $AA_1 = A_1A_2 = A_2A_3 = BB_1 = B_1B_2$.
4. Join A_3B_2. Let it intersect AB at a point C (see Fig. 11.2).

Then AC : CB = 3 : 2.

Why does this method work? Let us see.

Here ΔAA_3C is similar to ΔBB_2C. (Why ?)

Then $$\frac{AA_3}{BB_2} = \frac{AC}{BC}.$$

(ii) Construction of a Triangle Similar to a Given Triangle as per a Given Scale Factor

Example 1 : Construct a triangle similar to a given triangle ABC with its sides equal to $\frac{3}{4}$ of the corresponding sides of the triangle ABC (i.e., of scale factor $\frac{3}{4}$).

Solution : Given a triangle ABC, we are required to construct another triangle whose sides are $\frac{3}{4}$ of the corresponding sides of the triangle ABC.

Steps of Construction :

1. Draw any ray BX making an acute angle with BC on the side opposite to the vertex A.
2. Locate 4 (the greater of 3 and 4 in $\frac{3}{4}$) points B_1, B_2, B_3 and B_4 on BX so that $BB_1 = B_1B_2 = B_2B_3 = B_3B_4$.
3. Join B_4C and draw a line through B_3 (the 3rd point, 3 being smaller of 3 and 4 in $\frac{3}{4}$) parallel to B_4C to intersect BC at C′.
4. Draw a line through C′ parallel to the line CA to intersect BA at A′ (see Fig. 11.3).

Then, Δ A′BC′ is the required triangle.

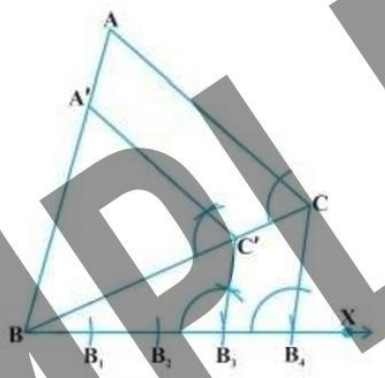


Fig. 11.3

(iii) Construction of Tangents to a Circle

Steps of Construction:

1. Join PO and bisect it. Let M be the mid-point of PO.
2. Taking M as centre and MO as radius, draw a circle. Let it intersect the given circle at the points Q and R.
3. Join PQ and PR.

Then PQ and PR are the required two tangents (see Fig. 11.5).

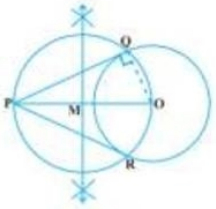


Fig. 11.5

Now let us see how this construction works. Join OQ. Then ∠ PQO is an angle in the semicircle and, therefore,

$$\angle PQO = 90°$$

Can we say that PQ ⊥ OQ?

Since, OQ is a radius of the given circle, PQ has to be a tangent to the circle. Similarly, PR is also a tangent to the circle.

Note : If centre of the circle is not given, you may locate its centre first by taking any two non-parallel chords and then finding the point of intersection of their perpendicular bisectors. Then you could proceed as above.

4. QUADRILATERALS

- Sum of the angles of a quadrilateral is 360°.
- A diagonal of a parallelogram divides it into two congruent triangles.
- In a parallelogram,

  (i) opposite sides are equal

  (ii) opposite angles are equal

  (iii) diagonals bisect each other
- A quadrilateral is a parallelogram, if

  (i) opposite sides are equal or

  (ii) opposite angles are equalor

  (iii) diagonals bisect each otheror

  (iv) a pair of opposite sides is equal and parallel
- Diagonals of a rectangle bisect each other and are equal and vice-versa.
- Diagonals of a rhombus bisect each other at right angles and vice-versa.
- Diagonals of a square bisect each other at right angles and are equal, and vice-versa.
- The line-segment joining the mid-points of any two sides of a triangle is parallel to the third side and is half of it.
- A line through the mid-point of a side of a triangle parallel to another side bisects the third side.
- The quadrilateral formed by joining the mid-points of the sides of a quadrilateral, in order, is a parallelogram.
- If two triangles are similar then ratio of their sides are equal.

  $$i.e.,\ \Delta ABC \sim \Delta PQR \text{ then } \frac{AB}{PQ} = \frac{BC}{QR} = \frac{AC}{PR}$$
- Theorem on the area of similar triangles: If two triangles are similar, then the ratio of the area of both triangles is proportional to the square of the ratio of their corresponding sides.

  $$\frac{\text{area of } \Delta ABC}{\text{area of } \Delta PQR} = \left(\frac{AB}{PQ}\right)^2 = \left(\frac{BC}{QR}\right)^2 = \left(\frac{CA}{RP}\right)^2$$
- **Area of a Triangle**: Consider the triangle formed by the points A(x_1, y_1) and B(x_2, y_2) and C(x_3, y_3) then the area of a triangle is given as-

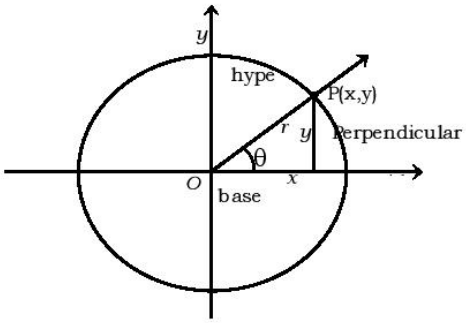
  $$Area(\Delta ABC) = \frac{1}{2}\left[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)\right]$$

UNIT V: TRIGONOMETRY

1. INTRODUCTION TO TRIGONOMETRY

- In a right-angled triangle, the Pythagoras theorem states

  $(\text{Perpendicular})^2 + (\text{Base})^2 = (\text{Hypotenuse})^2$



- Important trigonometric properties: (with P = perpendicular, B = base and H = hypotenuse)

(a) $\sin\theta = \frac{p}{h}, \cos\theta = \frac{b}{h}$ and $\tan\theta = \frac{p}{a}$;

Where, p = perpendicular, b = base and h = hypotenuse.

(b) $\sin\theta = \frac{1}{\operatorname{cosec}\theta}, \cos\theta = \frac{1}{\sec\theta}, \tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{1}{\cot\theta}$.

(c) $\sin^2\theta + \cos^2\theta = \sec^2\theta - \tan^2\theta = \operatorname{cosec}^2\theta - \cot^2\theta = 1$

Trigonometrical ratio of some important angles:

Degree	0°	30°	45°	60°	90°	120°	180°
Radians	0	π/6	π/4	π/3	π/2	2π/3	π
sin θ	0	1/2	$1/\sqrt{2}$	$\sqrt{3}/2$	1	$\sqrt{3}/2$	0
cos θ	1	$\sqrt{3}/2$	$1/\sqrt{2}$	½	0	– 1/2	– 1
tan θ	0	$1/\sqrt{3}$	1	$\sqrt{3}$	∞	$-\sqrt{3}$	0

$\sin 18° = \frac{\sqrt{5}-1}{4}$, $\cos 36° = \frac{\sqrt{5}+1}{4}$, $\sin 22\frac{1}{2}° = \frac{\sqrt{2-\sqrt{2}}}{2}$, $\cos 22\frac{1}{2}° = \frac{\sqrt{2+\sqrt{2}}}{2}$, $\sin 36° = \frac{\sqrt{10-2\sqrt{5}}}{4}$ and $\cos 18° = \frac{\sqrt{10+2\sqrt{5}}}{4}$

2. TRIGONOMETRIC IDENTITIES

1. Trigonometrical Ratios of Compound Angles:

(a) $\sin(A \pm B) = \sin A.\cos B \pm \cos A.\sin B$

(b) $\cos(A \pm B) = \cos A.\cos B \mp \sin A.\sin B$

(c) $\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A.\tan B}$

(d) $\cot(A \pm B) = \frac{\cot A.\cot B \mp 1}{\cot B \pm \cot A}$

(e) $\sin(A+B+C) = \sin A.\cos B.\cos C + \sin B.\cos C.\cos A + \sin C.\cos A.\cos B - \sin A.\sin B.\sin C.$

(f) $\cos(A+B+C) = \cos A.\cos B.\cos C - \sin A.\sin B.\cos C - \sin B.\sin C.\cos A - \sin C.\sin A.\cos B$

(g) $\tan(A+B+C)=\dfrac{\tan A+\tan B+\tan C-\tan A.\tan B.\tan C}{1-\tan B.\tan C-\tan C.\tan A-\tan A.\tan B}$

(h) $\sin(A+B).\sin(A-B)=\sin^2 A-\sin^2 B=\cos^2 B-\cos^2 A$

(i) $\cos(A+B).\cos(A-B)=\cos^2 A-\sin^2 B=\cos^2 B-\sin^2 A$

2. Transformation Formulae:

(a) $2\sin A\ .\ \cos B=\sin(A+B)+\sin(A-B)$.

(b) $2\cos A.\sin B=\sin(A+B)-\sin(A-B)$.

(c) $2\cos A.\cos B=\cos(A+B)+\cos(A-B)$.

(d) $2\sin A.\sin B=\cos(A-B)-\cos(A+B)$.

(e) $\sin C+\sin D=2\sin\dfrac{C+D}{2}.\cos\dfrac{C-D}{2}$

(f) $\sin C-\sin D=2\cos\dfrac{C+D}{2}.\sin\dfrac{C-D}{2}$

(g) $\cos C-\cos D=2\sin\dfrac{C+D}{2}.\sin\dfrac{D-C}{2}$

(h) $\cos C+\cos D=2\cos\left(\dfrac{C+D}{2}\right)\cos\left(\dfrac{C-D}{2}\right)$

3. Multiple Angles:

(a) $\sin 2A=2\sin A\cos A=\dfrac{2\tan A}{1+\tan^2 A}$

(b) $\cos 2A=\cos^2 A-\sin^2 A-\sin^2 A=1-2\sin^2 A=2\cos^2 A-1=\dfrac{1-\tan^2 A}{1+\tan^2 A}$

(c) $\tan A=\dfrac{2\tan\dfrac{A}{2}}{1-\tan^2\dfrac{A}{2}}$

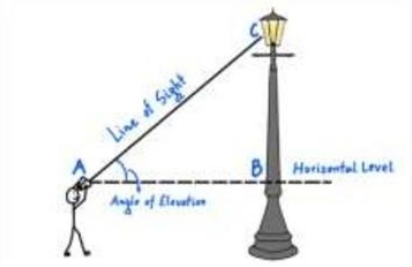
(d) $\tan^2\dfrac{A}{2}=\dfrac{1-\cos A}{1+\cos A}$

(e) $2\cos^2\dfrac{A}{2}=1+\cos A$

(f) $2\sin^2\dfrac{A}{2}=1-\cos A$

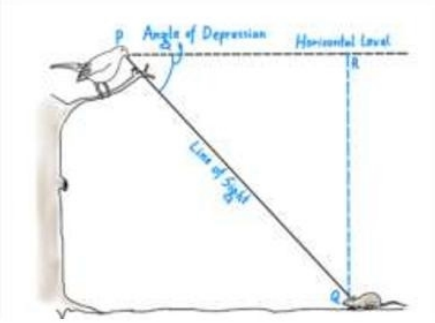
3. HEIGHTS AND DISTANCES: Angle of Elevation, Angle of Depression

- **Angle of Elevation:** Let us consider a situation where a person is standing on the ground and he is looking at an object which is at some height say the top of the building. The line joining the eye of the man with the top of the building is called the line of sight. The angle made by the line of sight with the horizontal line is called **angle of elevation**.



In this figure the line of sight is making an angle θ with the horizontal line. This angle is the angle of elevation.

- **Angle of Depression:** Now let us take another situation where the person is standing at some height with respect to the object he is seeing. In this case again the line joining the eye of the man with the bottom of the building is called the line of sight. The angle made by the line of sight with the horizontal line is called angle of depression.



In the above figure 'θ' is the angle of depression.

Note: The angle of elevation is equal to the angle of depression.

UNIT VI: MENSURATION

1. AREA RELATED TO CIRCLES

- A circle is a collection of all the points in a plane, which are equidistant from a fixed point in the plane.
- Equal chords of a circle (or of congruent circles) subtend equal angles at the center.
- If the angles subtended by two chords of a circle (or of congruent circles) at the center (corresponding center) are equal, the chords are equal.
- The perpendicular from the center of a circle to a chord bisects the chord.
- The line drawn through the center of a circle to bisect a chord is perpendicular to the chord.
- There is one and only one circle passing through three non-collinear points.
- Equal chords of a circle (or of congruent circles) are equidistant from the center (or corresponding centers).
- Chords equidistant from the center (or corresponding centers) of a circle (or of congruent circles) are equal.
- If two arcs of a circle are congruent, then their corresponding chords are equal and conversely, if two chords of a circle are equal, then their corresponding arcs (minor, major) are congruent.
- Congruent arcs of a circle subtend equal angles at the center.
- The angle subtended by an arc at the center is double the angle subtended by it at any point on the remaining part of the circle.
- Angles in the same segment of a circle are equal.
- Angle in a semicircle is a right angle.
- If a line segment joining two points subtends equal angles at two other points lying on the same side of the line containing the line segment, the four points lie on a circle.
- The sum of either pair of opposite angles of a cyclic quadrilateral is 180°.
- If the sum of a pair of opposite angles of a quadrilateral is 180°, then the quadrilateral is cyclic.

2. SURFACE AREAS AND VOLUMES

- **Sphere Formula**

Diameter of sphere	$2r$
Circumference of Sphere	$2\pi r$
Surface area of sphere	$4\pi r^2$
Volume of Cylinder	$4/3\pi r^2$

- **Cylinder Formulas**

Circumference of Cylinder	$2\pi rh$
Curved surface area of Cylinder	$2\pi r^2$
Total surface area of Cylinder	Circumference of Cylinder + Curved surface area of Cylinder = $2\pi rh + 2\pi r^2$
Volume of Cylinder	$\pi r^2 h$

- **Cone Formulas**

Slaint height of cone	$l = \sqrt{(r^2 + h^2)}$
Curved surface area of cone	πrl
Total surface area of cone	$\pi r (l + r)$
Volume of cone	$\frac{1}{3} \pi r^2 h$

- **Cuboid Formulas**

Perimeter of cuboid	$4(l + b + h)$
Length of the longest diagonal of a cuboid	$\sqrt{(l^2 + b^2 + h^2)}$
Total surface area of cuboid	$2(l \times b + b \times h + l \times h)$
Volume of Cuboid	$l \times b \times h$

- Area of square = $(\text{side})^2$
- Area of rectangle = length × breadth
- Area of triangle = $\frac{1}{2} \times \text{base} \times \text{height}$
- Area enclosed by a circle = πr^2; where r is radius
- Volume of cube = L^3

UNIT VII: STSTISTICS & PROBABILITY

1. STSTISTICS

For Ungrouped Data:

Mean: The mean value of a variable is defined as the sum of all the values of the variable divided by the number of values.

$$a_m = \frac{a_1 + a_2 + a_3 + a_4}{4} = \frac{\sum_0^n a}{n}$$

Median: The median of a set of data values is the middle value of the data set when it has been arranged in ascending order. That is, from the smallest value to the highest value.

Median is calculated as $\frac{1}{2}(n+1)$

Where n is the number of values in the data. If the number of values in the data set is even, then the median is the average of the two middle values.

Mode: Mode of a statistical data is the value of that variable which has the maximum frequency

For Grouped Data:

Mean: If $x_1, x_2, x_3, \ldots\ldots x_n$ are observations with respective frequencies f1, f2, f3,.....fn then mean is given as:

$$\bar{x} = \frac{f_1x_1 + f_2x_2 + f_3x_3 + \ldots\ldots + f_nx_n}{f_1 + f_2 + f_3 + \ldots\ldots + f_n} \text{ or } \bar{x} = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i}; \text{where} \sum_{i=1}^{n} f_i = f_1 + f_2 + f_3 + \ldots\ldots f_n$$

Median: For the given data, we need to have class interval, frequency distribution and cumulative frequency distribution. Then, median is calculated as

$$Median = l + \left(\frac{\frac{n}{2} - cf}{f}\right) h$$

Where,

l = lower limit of median class,

n = number of observations,

cf = cumulative frequency of class preceding the median class,

f = frequency of median class,

h = class size (assuming class size to be equal)

Mode:

Modal class : The class interval having highest frequency is called the modal class and Mode is obtained using the modal class.

$$M_o = l + \left(\frac{f_1 - f_0}{2f_1 - f_0 - f_2}\right) h$$

Where

l = lower limit of the modal class,

h = size of the class interval (assuming all class sizes to be equal),

f_1 = frequency of the modal class,

f_0 = frequency of the class preceding the modal class,

f_2 = frequency of the class succeeding the modal class.

1. PROBABILITY

The probability formula is defined as the possibility of an event to happen is equal to the ratio of the number of outcomes and the total number of outcomes.

Probability of event to happen P(E) = Number of favourable outcomes/Total Number of outcomes

$$\text{Probability of event } E\text{: } P(E) = \frac{n(E)}{n(S)}.$$

1. $0 \le P(E) \le 1$.

2. $P(E') = 1 - P(E)$.