PHYSICS PDF

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UNITS & MEASUREMENT

All the quantities in terms of which laws of physics are described and whose measurement is essential are called physical quantities like mass, length, time, light, current electricity, temperature, etc.

UNIT

The fixed part of a Physical quantity by dint of which comparision could be made of the magnitudes of the same quantity contained in different substances is termed as a unit.

International System of Units (S.I.)

The system is a modification over the MKS system and hence, is known as rationalised MKS System.

There are seven fundamental and two supplementary units in S. I. System :

Physical	Fundamental	Symbol
1. Mass	Kilogram	kg
2. Length	Metre	m
3. Time	Second	s
4. Tempertature	Kelvin	K
5. Electric-current	Ampere	A
6. Luminous intensity	Candela	Cd
7. Quantity of matter	Mole	mol

Supplementary Physical quantity	Supplementary Unit	Symbol
1. Plane angle	Radian	rad.
2. Solid angle	Steradian	sr

The units of three quantities viz mass, length and time are called fundamental units because all physical quatities can be expressed in terms of mass, length and time and remaining all units are called derived units.

Systems of units	Length	Mass	Time
1. C.G.S. System	Centimetre	Gram	Second
2. F.P.S. System	Foot	Pound	Second
3. M.K.S. System	Metre	Kilogram	Second

The measurement of a physical quantity requires a unit and the comparision of unit to the quantity & the number of the units obtained gives the measured value of the quantity e.g. when we say that the length of a rod is 5 metres it means that the length of the rod is 5 times the unit of length, metre.

FUNDAMENTAL UNITS

(i) **Metre (m) :** 1 metre is equal to the length of the path travelled by light in vacuum in 1 / 2 99792458 of a second where speed of light is 299792458 m / s. Recently, the definition of 1 metre of length is realized by using the iodine stabilized helium neon lasers.

(ii) **Kilogram (kg) :** A standard block of Platinum Iridium alloy preserved in the International Bureau of Weights & Measures at Sevres, near Paris, France is used as a prototype of unit of mass and one kilogram is equal to the mass of this alloy.

(iii) **Second (s) :** The definition of second is based on an atomic clock which works on energy radiation from an isotope of caesium (Cs-133). One second is equal to the duration of 9, 192, 631, 770 periods of radiation corresponding to unperturbed transition between the two specific energy levels of the ground gaseous state of Cs-133 isotope. The caesium atoms in the atomic clock act like a pendulum in a pendulum clock. The atomic clock gives the most accurate time with an error of 1 second only in 5000 years.

IMPORTANT PRACTICAL UNITS

For Lengths : (i) Astronomical Unit (A.U) : It is equal to the distance between the centre of the earth and the centre of the sun. One A.U. = 1.5×10^{11}m.

(ii) Light Year (ly) : It is equal to the distance travelled by light in vacuum in one year. 1 light year = 9.46×10^{15}m.

(iii) Par sec. (Parallactic second) : 1 Par sec = 3.1×10^{16}m = 3.26 ly

(iv) 1 micrometre or 1 micron = 10^{-6}m

(v) 1 nanometre (1nm) = 10^{-9}m

(vi) 1 Angstrom (1A°) = 10^{-10}m

For Masses : (i) 1 tonne or 1 metric ton = 1000 kg

(ii) 1 pound (lb) = 0.4536 kg.

(iii) The largest unit of mass is Chandra Shekher Limit (C.S.L) 1 C.S.L. = 1.4 times the mass of the Sun.

(iv) **For small masses** atomic mass unit (a.m.u.) is used. 1 a.m.u = 1.6×10^{-27}kg.

For Area : (i) 1 acre = 4047 m^2.

(ii) 1 hectare = $10^4 m^2$.

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MOTIONS

A body is said to be in motion if it changes its position with respect to its surroundings as time goes on. A body is said to be at rest if it does not change its position with time, with respect to its surroundings.

TYPES OF MOTION

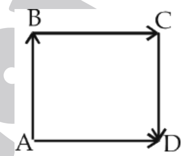
(i) When a particle or a bo d y moves along a straight path, its motion is Rectilinear or translatory motion.

(ii) When a particle or a body moves in a circular path, its motion is circular motion. When a body spins about its own axis, it is said to be in rotational motion.

(iii) When a body moves to and fro or back and forth repeatedly about a fixed point in a definite interval of time, it is said to be in vibrational or oscillatory motion.

The path travelled by an object during its motion is called trajectory. The actual path length during the motion is called distance and, the straight distance between the initial and final position of the motion in a particu- lar direction is called displacement.

Let a particle travel, starting from point A and go to point D along the path A B C D in a given interval of time. The total path length (= AB + BC + CD) is the distance travelled and the shortest path length (AD) in the direction A to D is the displacement within the same time-interval.



SPEED

The time rate of change of position of an object in any direction i.e. the rate of change of distance of an object with respect to time is known as speed.

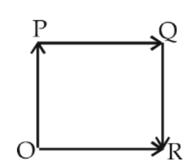
$$\boxed{\text{Speed} = \frac{\text{displacement}}{\text{time taken}}}$$

VELOCITY

The rate of change of displacement of an object with respect to time is known as velocity.

$$\boxed{\text{Velocity} = \frac{\text{displacement}}{\text{time}}}$$

Let a square OPQR of side length 2 metre. A particle travels along its side starting from O to R via P and Q. It takes a total time of 2 seconds. The total distance travelled is OP + PQ + QR = 2 + 2 + 2 = 6 metres whereas the total displacement is OR = 2 metres. Hence



Average Speed $= \frac{\text{distance}}{\text{time}} = \frac{6}{2} = 3\text{m / s}$

Average Velocity

$= \frac{\text{displacement}}{\text{time}} = \frac{2}{2} = 1\text{m / s.}$

ACCELERATION

The rate of change of velocity with respect to time is called acceleration.

$$\boxed{\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{time taken}}}$$

When a body completes equal displacement in equal interval of time, its velocity is constant and hence, it does not have an acceleration. When a body shows equal change in velocity in equal interval of time its velocity is not constant but it has a constant acceleration.

EQUATIONS OF MOTION

(i) **For a body moving with a uniform velocity:** If a body completes a displacement 'S' in time 't' with a uniform velocity 'V', then,

displacement = velocity × time

or $\boxed{S = vt}$ ...(i)

(ii) **For a body moving with a uniform acceleration :** If a body starting with an initial velocity 'u' moves with a uniform acceleration 'a' for a time 't' and attains a final velocity 'v' after travelling a displacement 's' then,

$\boxed{S = ut + \frac{1}{2}at^2}$ ....(ii) $\boxed{v = u + at}$ ....(iii)

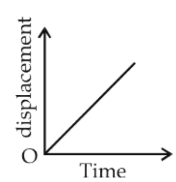
and $\boxed{v^2 = u^2 + 2as}$ ...(iv)

When the velocity of a body increases, it has a positive acceleration and when the velocity decreases, it has a negative acceleration. This negative acceleration is called deceleration or retardation.

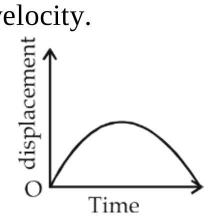
When a body is released from a height, its velocity increases by 9.8 m / s in every second and when a body is thrown above the earth's surface, its velocity decreases by 9.8 m / s in every second. This change in velocity every second is called acceleration due to gravity which is denoted by 'g'. Its average value at the earth's surface is 9.8 m / s^2. It is always directed towards the centre of the earth because of the gravitational pull. For a freely falling body, its acceleration is 9.8 m / s^2.

POSITION (DISPLACEMENT)-TIME GRAPHS

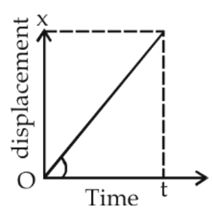
(i) **For a body moving with a uniform velocity:** This graph comes as a straight line because in a uniform velocity the particle completes equal displacement in an equal interval of time.



(ii) **For the motion of a body thrown vertically upwards :** When the body moves up, its velocity continuously decreases due to gravity and finally becomes zero at the maximum height. Then, the body falls with an increasing velocity.



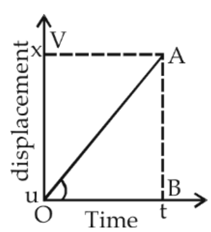
The slope of the position time graph is equal to the uniform velocity.



$$\boxed{\text{Slope} = \frac{\text{Displacement}}{\text{Time}}} \text{ or } \boxed{V = \frac{x}{t}}$$

VELOCITY-TIME GRAPH

For a uniformly accelerated motion the velocity-time graph is a straight line.



The area under the velocity-time graph is equal to displacement.

$\therefore$ Displacement = Area under velocity time graph

$= \text{Area of } \Delta OAB = \frac{1}{2} \times AB \times OB$

Where $\frac{AB}{2}$ = Average velocity (Var.)

$= \frac{\text{Initial velocity} + \text{Final velocity}}{2}$

or $V_{av} = \frac{u+v}{2}$ and OB = time (t)

$\therefore S = \left(\frac{u+v}{2}\right)t$

$\therefore$ V = u + at

$\therefore S = \left(\frac{u+u+at}{2}\right)t = ut + \frac{1}{2}at^2$

The slope of the velocity time graph is equal to acceleration.

In the figure, slope $= \frac{AB}{OB}$ = acceleration

and OB = time (t)

$\therefore a = \frac{v-u}{t}$

or, $\boxed{V = u + at}$

Example 1 : A car is travelling with a velocity of 20 m / s at a uniform acceleration of 1 m / s^2. Fin d out its velocity after 10 seconds.

Solution : Given, the initial velocity = u = 20 m / s. acceleration = a = 1 m / s^2. time interval = t = 10 seconds.

hence, the final velocity = v = u + at

or v = 20 + 1 × 10 = 20 + 10 = 30 m / s.

Example 2 : A bus moving at 10 m / s experiences a constant retardation of 2 m / s^2. due to applied brakes. How much distance does it cover and how much time does it take before it stops ?

Solution : Given, initial velocity = u = 10 m /s

Final velocity (when the bus stops) = v = 0

retardation = – 2 m / s^2.

v = u + at or $t = \frac{v-u}{a} = \frac{0-10}{-2} = \frac{-10}{-2}$ = 5 sec.

It takes 5 seconds to stop.

$s = ut + \frac{1}{2}at^2$

$= 10 \times 5 + \frac{1}{2} \times (-2) \times 5^2$

= 50 – 25 = 25m

or, $v^2 - u^2 = 2as$

$\therefore s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 10^2}{-2 \times 2} = \frac{100}{4} = 25m.$

It covers a distance of 25 m before it stops.

Example 3 : A train travelling with an initial velocity of 4 m / s accelerates uniformly at a rate of 2m / s^2. for 20 seconds. Calculate the distance covered.

Solution : Given, the initial velocity = u = 4m / s

acceleration = a = 2m / s^2. interval

of time = t = 20 second

$\therefore$ Displacement, $s = ut + \frac{1}{2}at^2$

$= 4 \times 20 + \frac{1}{2} \times 2 \times (20)^2$

or s = 80 + 400 = 480m.

Example 4 : A stone is dropped from rest from the top of a tower. What will be its velocity after 2 seconds and what is the height of the tower if the stone falls in 5 seconds onto the ground ?

Solution : Here a = g = 9.8 m / s^2.

u = 0

Hence, after t = 2 seconds, the stone has a velocity of v = u + at = u + gt = 0 + 9.8 × 2 = 19.6 m / s.

Let height of the tower = h

$\therefore$ The distance travelled in time = t = 5 sec. will be, s = h

$\therefore s = ut + \frac{1}{2}at^2 \qquad \therefore h = 0 \times t + \frac{1}{2}gt^2$

or $h = \frac{1}{2}gt^2$

$= \frac{1}{2} \times 9.8 \times 5^2 = 4.9 \times 25 = 122.5m$

Example 5. A stone is thrown vertically upwards with a velocity of 98 m / s. What will be its maximum height attained and time taken to achieve this height ?

Solution : a = g = – 9.8 m / s^2, u = 98 m / s^2.

At the maximum height (h) = s = h and v = 0

$\therefore v^2 - u^2 = 2as$

$\therefore 0 - (98)^2 = (-)2 \times 9.8 \times h$

$h = \frac{+98 \times 98}{+2 \times 9.8} = 49 \times 10 = 490m$

$\therefore v = u + at$

$\therefore 0 = 98 - 9.8 \times t$ or $t = \frac{98}{9.8}$ = 10 seconds

PHYSICAL QUANTITIES

(i) **Vectors :** They have a definite magnitude and a definite direction, e.g. displacement, velocity, acceleration, force etc.

(ii) **Scalars :** They have d efinite magnitudes only and not direction. e.g. distance, speed, work, energy, power, electric charge etc.

(iii) **Tensors :** They have different magnitudes in different directions, e.g. Moment of interia, stress etc.

In a motion, a body can have a constant speed but variable velocity like the motion of a body along a circular path. A particle may have zero displacement an d zero velocity but non-zero distance and speed. When a body completes one revolution along a circular path in a given time period, the net displacement and velocity of the body will be zero but the distance and speed of the body must be non-zero.

The velocity and acceleration of a body may not necessarily be in the same direction and may not be zero simultaneously. The body in equilibrium may be at rest or may move with a constant velocity. When a body is thrown upwards, it will go vertically until its vertical velocity becomes zero and it will return to the ground with the same velocity with which it was thrown.

When a body is thrown horizontally from a height or dropped from the same height in both cases it will be reaching to the ground simultaneously because in both the cases the body will be acted upon by the same vertically downward acceleration due to gravity (g).

A physical quantity having direction may or may not be a vector e.g. time, pres- sure, current-electricity, surface-tension etc. They have direction but are not vectors.

Linear-Momentum : It is the quantity of motion which a body possesses and is measured as the product of the mass and velocity of the body.

Linear momentum = mass × velocity.

Impulse : The total change in momentum is called the impulse. If a very large force acts for a very small time, the product of force and the time is equal to the impulse.

Inertia : The inability of a body to change by itself its state of rest or state of uniform motion along a straight line is called inertia of the body. The inertia of a body is measured by its mass. Heavier the body, greater is the force required to change its state and hence greater is its inertia. Inertia of a body may be inertia of rest, inertia of motion or inertia of direction.

NEWTON'S LAWS OF MOTION

First Law of Motion

Every body continues to be in a state of rest or uniform motion in a straight line, except in so far as it may be compelled by force to change that state.' Newton's first law of motion defines inertia.

1. Inertia of Rest : the inability of a body to change by itself its state of rest.

- When a branch of a fruit tree is shaken, the fruits fall down. This is because the branch comes in motion and the fruits tend to remain at rest. Hence, they get detached.
- The dirt particles in a durree fall off if it is stricken by a stick. This is because the striking sets the du rree in motion whereas the dirt-particles tend to remain at rest and hence fall.
- When a train starts suddenly, the passenger sitting inside tends to fall backwards. This is so because the lower part of the passenger's body starts moving with the train but the upper part tends to remain at rest.
- If a smooth paper having a coin on it placed on a table is suddenly drawn, the coin remains at the same place on the table due to inertia of rest.
- When a horse starts suddenly, the rider tends to fall backwards due to inertia of rest

2. Intertia of Motion : The inability of a body to change by itself its state of uniform motion.

- When a horse at full gallop stops suddenly, the rider on it falls forward because of inertia of motion of the upper part of the rider's body.
- When an athelete takes a long jump, he runs first for a certain distance before the jump. This is because his feet come to rest on touching the ground and the remaining body continues to move owing to inertia of motion.
- When train stops suddenly, a passenger sitting inside tends to fall forward. It happens because the lower part of the passenger's body comes to rest with the train but the upper part tends to continue its motion due to inertia of motion.
- A person jumping out of a speeding train may fall forward due to inertia of motion of his body. Hence, he should run a few steps on the platform in the direction of motion of train.

3. Inertia of Direction : The inability of a body to change by itself its direction of motion.

- The wheels of any moving vehicle throw out mud, if any, tangentially, due to the inertia of direction. The mud-guards over the wheels stop this mud, protecting the clothes, etc. of the person sitting on the bike.
- Use of an umbrella to protect us from rain is based on the property of inertia of direction because the rain drops cannot change their direction of motion.
- When a bus or a car rounds a curve suddenly, the person sitting inside is thrown outwards. It happens so because the person tries to maintain his direction of motion due to directional inertia while the vehicle turns.
- When a knife is sharpened by pressing it against a grin ding stone, the sparks fly off tangentially because of the inertia of direction.
- When a stone tied to one end of a string is whirled and the string breaks suddenly, the stone spins off along the tangent of its circular path. It happens so because of the pull in the string was forcing the stone to move in a circle. As soon as the string breaks, the pull disappears. The stone becomes free and in a bid to move along the straight line flies off tangentially.

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 an d this change takes place always in the direction of the applied force'.

The second law gives us a measure of force. When a force is applied on a body, its momentum and hence, velocity change. The change in velocity produces an acceleration in the body. The rate of change of linear momentum with time is equal to the product of the mass of the body and its acceleration which measures the magnitude of the applied force i.e.

$$\text{Force} = \frac{\text{Change in linear momentum}}{\text{time interval}}$$

$$= \text{mass} \times \text{acceleration}$$

or, $\boxed{F = ma}$

When a body is moving with a uniform velocity along a straight line, it neither experience nor require an external force. This is because, the acceleration is due to change in the velocity of the body and the velocity remains constant for a body moving with a uniform velocity along a straight line.

When a body changes its velocity or direction of its motion, its velocity changes too. It results in an acceleration which is possible only by the action of an external applied force. Hence, an accelerated motion is always due to an external force.

Application of the change in linear momentum (impluse) and second law of motion :

- Bogies of a train are provided with the buffers. These buffers avoid severe jerks during shunting of the train. Since force = change in momentum / time and the time of impact increases due to presence of buffers. Hence, force during jerks decrease. It results in decrease in the chances of damage.
- Crockery items are wrapped in paper or straw pieces before packing because paper or straw acts as buffers. It changes the time of impact and hence, avoids the chances of damage during the jerks.
- An athlete should stop slowly, after finishing a fast race, so that the time of impact of his run increases at stop and hence, force experienced by him decreases.
- In cricket, a player lowers his hands while catching a cricket ball to avoid injury. In doing so, he increases the time of impact of the ball which in turn reduces the effect of the force on his hands.
- Shockers in the motor-vehicles reduce the effect of jerk / force by increasing the time of impact of the jerks given by an uneven road.
- In a head-on collision between two vehicles, change in linear momentum is equal to the sum of the linear momenta of the two vehicles. Since time impact is very small, hence an extra large force develops which results in maximum damage to the vehicles.
- When a person falls from a height on a concrete floor, the floor does not yield. The total change in linear-momentum is produced in a very small interval of time. Hene, the floor exerts a much larger force and the person receives more injury. But when a person falls on a heap of sand, the sand yields. The same change in linear momentum is produced in a much longer time. The average force exerted on the person by the heap of sand is, therefore, much smaller and hence the person is not hurt.

Third Law of Motion

''To every action, there is always, an equal and opposite reaction.''

Here, the action is the force exerted by one body on the other body while the reaction is the force exerted by the second body on the first.

Significance of Third Law : It signifies that forces in nature are always in pairs. A single isolated force is not possible. Force of action and reaction act always on different bodies. They never cancel each other and each force produces its own effect. The forces of action and reaction may be due to actual physical contact of the two bodies or even from a distance. But they are always equal and opposite. This third law of motion is applicable whether the bodies are at rest or they are in motion. This law is applied to all types of forces e.g. gravitational, electric or magnetic forces, etc.

Example and application of the third law of motion :

- A book placed on a table exerts a force as an action on the table. This action is equal to the weight of the book. The table exerts a force of reaction equal and opposite to the reaction to support the book.
- When a gun fires a bullet, it moves forward due to a force exerted by the gun. The bullet exerts a reaction due to which the gun recoils backward.
- We can walk on a ground easily if it is tough because the ground provides sufficient reaction against our push. But it is difficult to walk on sand or ice. This is because on pushing, sand gets displaced and reaction from sandy ground is very little. In case of ice, force of reaction is again small, because friction between our feet and ice is very little.
- When a rubber ball is struck against a wall or floor, it exerts a force as an action on the wall. The ball rebounds with an equal and opposite force as reaction exerted by the wall on the ball.
- A swimmer pushes the water with a force of action in backward direction while water pushes the swimmer with a force of reaction in the forward direction. Consequently, the swimmer is able to swim.
- When a jet-plane or rocket moves in the sky, the gases produced due to combustion of fuel escape through the nozzle in the backward direction due to the force of action exerted by the engine. The escaping gases exert a force of reaction on the jet-plane or rocket in the forward direction. Consequently, the jet-plane or rocket moves.

PRINCIPLE OF CONSERVATION OF LINEAR MOMENTUM

The total sum of the linear momentum of all bodies in a system remains constant and is not affected due to their mutual action and reaction. It means in a system of the two bodies, the total momentum of the bodies before impact is equal to the total momentum of the two bodies after impact. The law of conservation of linear momentum is universal i.e. it applies to both, the microscopic as well as macroscopic system.

Some common applications of the principle of conservation of linear momentum:

- When a person is lying on a frictionless surface at rest, his momentum is zero. As soon as he blows air out of his mouth or throws an object, he moves in the opposite direction. The total sum of momentum of the person and air blown or object thrown remains zero due to opposite directions.
- When a man jumps out of a boat to the shore, the boat is pushed slightly away from the shore. The initial momentum of the man and boat remains equal to that of the final value.
- The gun must be held tightly to the shoulder when the gun is fired. It would save hurting the shoulder
- Motion of rocket and jet planes is based on the conservation of linear momentum.

Out of the three laws of motions, the second law is the real law because it includes remaining both the first law and the third law.

UNIFORM CIRCULAR MOTION

When a body moves along a circular path or a curve with a uniform circular speed, the body is acted upon by an in- ward acceleration. This acceleration acts towards the centre of a circular path or curve and is called as radial or centripetal acceleration which gives rise to the cen- tripetal force. The centripetal force is an essential condition of the circular motion. Centripetal force (F_c) = mass of the body (m) × centripetal acceleration (a_c)

or, $\boxed{F_c = ma_c}$

centripetal acceleration (a_c) $= \frac{v^2}{r} = vw = rw^2$.

where v = linear speed, w = angular speed or, r = radius of circular path or curve.

$$\therefore \boxed{F_c = ma_c = \frac{mv^2}{r} = mvw = mrw^2}$$

The centripetal force acting on a body is an action and an equal and opposite force called centrifugal force appears as a reaction.

Application of centripetal force :

- When a bucket containing water is whirled in a horizontal or vertical direction water does not fall down on the ground.
- In a circus, a motor cyclist is able to perform the feat of driving the motor cycle along a vertical circle in a cage. The motor cyclist does not fall down even at the highest point.
- A pilot of an aircraft can successfully loop a vertical loop without falling at the top of the loop being without belt.
- **Motion of vehicles on a curved road :**

(a) **Level Curved Road :** A level curved road is constructed where the speed of the vehicles is slow. Here, the force of friction between the road and tyre of the wheel of the vehicle provides the necessary centripetal force.

(b) **Banking of Roads :** At the highways where vehicles run fast, the frictional force is not a reliable source for providing the required centripetal force to the vehicle. Hence, at such curved roads, a safer course of action is to raise the outer edge of the curved road above the inner edge. It is known as banking of roads. The banking of roads provides the required centripetal force.

- A cyclist leans forward while going along a curve. By doing so, the ground provides him the centripetal force which he requires for turning. Hence, the cyclist leans inwards from his vertical position.
- In an atom, the required centripetal force for an electron in its circular orbit is provided by the electrostatic force of attraction between the electron and nucleus.
- The force of gravitation provides the essential centripetal force when a satellite revolves around a planet or a planet revolves around the sun.

ROTATIONAL MOTION

Torque (Moment of Force)

The product of force acting on a body and perpendicular distance of line of action of the force from the axis of rotation is called moment of force or torque.

Torque = Force × Perpendicular distance from axis rotation

Applications of Torque :

Torque due to a force is maximum, the distance from the axis of rotation is maximum. We can open or close a door easily by applying force near the edge of the door i.e. at maximum distance from the hinges. Hence, a handle or knob is fitted near the free edge of the plank of the door. A wrench with a long arm is required to unscrew a nut fitted tightly to a bolt. Longer the arm of the wrench, smaller is the required force to give sufficient turning effect.

Angular Momentum

It is equal to the product of linear momentum of a body and the perpendicular distance from the axis of rotation. It follows the principle of conservation. It means the total angular moment of an isolated system remains always constant.

Applications of conservation of Angular Momentum :

(i) The angular velocity of revolution of a planet around the sun in an elliptical orbit increases, when the planet comes closer to the sun and vice-versa.

(ii) A circus acrobat performs feats involving spin by bringing his arms and legs closer to his body and vice-versa. It is because in doing so the angular speed increases.

(iii) Consider a ballet dancer is rotating with her arms and legs stretched outwards. When she folds her arms and brings the stretched legs close to the other leg, her angular speed increases.

(iv) Due to the same reason, the angular speed of the inner layer of the tornado (whirlwind) is extremely high.

(v) All helicopters are provided with two propellers. If there was one single propeller, the helicopter would rotate itself in an opposite direction in accordance with the laws of conservation of angular momentum.

FRICTION

When a body moves (slides or rolls) or even tries to move over the surface of another body a tangential force comes into action between their surfaces in contact, against their relative motion. This opposing force is termed as the force of friction.

The force of friction depends upon the mass of the body on a surface and roughness of the surfaces in contact between them and the magnitude of friction, which increases with increase in roughness and mass.

When a body is at rest on a surface, the friction is called *static friction* which is a self adjusting force. When the body is on the verge to move (slide or roll), the friction is called *limiting friction* but when the body moves, it gives rise to dynamic friction. The *limitting friction* is the maximum force of friction and it is always more than static or dynamic friction.

Usually, smoothness decreases the force of friction. However, when the surfaces in contact are made too smooth by polishing, the binding force of adhesion increases and hence, the frictional force increases. This is called 'cold welding'.

Friction is a non-conservative force and hence, the mechanical energy (potential and kinetic energy) is not conserved. In fact, friction converts mechanical energy partly into heat, light (spark), sound, electricity, etc.

Generally, friction opposes motion. However, in certain cases friction is essential for motion. Without friction, motion cannot be started, stopped or transferred from one body to the other. Thus, friction is a necessary evil.

Advantages of Friction

- When a person pushes the ground backward, the rough surface of the ground exerts a forward force due to friction. It makes possible a person to move on the ground. Due to lack of sufficient friction on ice or wet soil, it is difficult to walk.
- Two bodies stick together due to friction.
- The working of the brakes of vehicles is possible due to friction only.
- The friction between the tyres of vehicles and road makes the motion of the vehicles possible.
- The cleaning action of sand-paper occurs due to friction only.
- In absence of friction, we would not be able to hold a pen and if we could, the pen would not write on paper.
- Writing on the black board with a chalk is possible due to friction.
- The transfer of motion from one part of a machine to the other part through belts is possible by friction.
- The working of nuts and bolts for holding parts of machinery together is based on friction.
- The knots in woven clothes are possible due to friction.

Disadvantages of Friction

- Since, the force of friction opposes the relative motion between any two bodies in contact, hence, extra work is done to overcome the force of friction. It involves extra loss of energy. About 20% of the petrol used in an automobile is used up to overcome the force of friction in the engine and in driving.
- The force of friction results in heating the working parts of the machinery that may damage the parts.
- Friction causes wear and tear of the parts of the machinery.

The force of friction can be reduced :

- ***By polishing*** **:** polishing causes smoothness.
- ***By lubricating*** **:** The lubricants, oils, grease etc. fill up the irregularities of the surfaces and hence, the surfaces become smoother.
- By using ball-bearings

The force of friction can be increased :

- by applying sand on the slippery ground.
- by applying sand on the road covered with snow.
- by making depressions, projections, etc. in the tyres during manufacturing.

Order of the magnitude of the force of friction is:

Rolling friction < sliding friction < limiting friction.

Owing to least value of rolling friction wheels are used in vehicles.

TRIVIA

- When a particle goes from one point to another, the actual length of the path is called distance covered. The average speed is defined as the distance covered per unit time. In the above case, the straight line distance between the initial and final positions is called magnitude of displacement. The average velocity is defined as magnitude of displacement per unit time.
- Distance covered is always a + VE quantity. And it never decreases with time. For a moving particle it cannot be zero.
- Distance covered ≥ magnitude of displacement.
- Speed is always a + VE quantity. However, it can increase or decrease with time.
- When a particle returns to the starting point its average velocity is zero but average speed is not zero.
- For uniform motion distance covered = magnitude of displacement. The motion is along a straight line and its direction cannot change.
- If a body covers first half distance with speed v_1, and the second half distance with speed v_2, then average speed $= \frac{2v_1v_2}{v_1 + v_2}$ = Harmonic mean.

■■■

WORK, ENERGY AND POWER

WORK POWER

When a force is applied on a body and a displacement is carried out in any direction except in a direction perpendicular to the direction of the force, an amount of work is done by the force.

The amount of work done is equal to the product of the force and the distance travelled in the direction of the applied force i.e.

$$\boxed{\text{Work} = \text{Force} \times \text{distance travelled}}$$

or, $\boxed{W = F \times S}$

Unit of work is Joules(s) 1 joule = Newton × 1 metre.

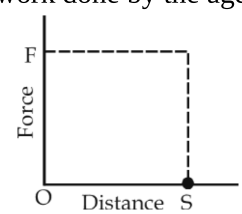
Work done by a force may be zero, positive or negative depending upon the direction of the applied force and displacement.

When a coolie is carrying some load on his head and is waiting for the arrival of the train, he is not doing any work. No mechanical work is done by a teacher teaching a class. When a body falls freely under the action of gravity, work done by gravity on the body is positive. When a body is pushed or pulled by a force, work done is positive. The force of friction acts against the motion, hence the work done by the frictional force is negative.

The time rate of change of work is power. When a body takes less time to do a certain work, its power is said to be more and vice-versa.

$$\text{Power} = \frac{\text{work}}{\text{time}} \text{ or } P = \frac{W}{t}$$

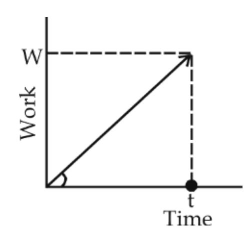
Its unit is watt (w). One kilowatt (1 kw) is equal to 1000 watt. One horse power (h.p.) is equal to 746 watt. Power of an agent measures how fast it can do the work. The area under the force versus distance graph is numerically equal to the work done by the agent.



Work = Force × Distance

$\boxed{W = F \times S}$

The area under power-time graph gives the work done while the slope of work versus time graph gives the power.



Work = power × time = area under w-t graph

or, $\boxed{w = pt}$

Power = $\frac{\text{work}}{\text{time}}$ or, $p = \frac{w}{t}$ = slope of w-t graph.

ENERGY

The ability of a body to do work is called energy. When a body can do more work, it is said to have more energy and vice versa. Energy is different from power. Energy refers to the total amount of work a body can do and power determines the rate of doing work. Both the energy of a body and work done by the body are equivalent and are measured in Joule (J).

Kinetic Energy (K.E.)

It is the energy possessed by the body by virtue of its motion. The kinetic energy of a body is given as

$$\boxed{K.E. = \frac{1}{2}mv^2}$$

Where m = mass of the body and v = velocity of the body. Thus, K.E. of a body is equal to half the product of mass of the body and square of velocity of the body. The change in K.E. of a body measures the work done by the body.

$$\boxed{\text{Work} = \text{change in K.E. of the body}}$$

or, $\boxed{W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2}$

Where u and v are initial and final velocities of the body of mass m.

When a heavy and a tight body are moving with same K.E. and same retarding force is applied on each, both the bodies will stop after travelling the same distance.

K.E. of a body is also given as :

$$K.E. = \frac{(\text{Linear momentum})^2}{2 \times \text{mass of the body}}$$

or, $\boxed{K.E. = \frac{P^2}{2m}}$

Hence, when a light and a heavy body are moving with the same linear momentum, the light body will have more K.E.

Every moving system is associated with a definite amount of K.E. e.g. a moving vehicle, wind, water flow, etc.

Potential Energy (P.E.)

The energy possessed by a body by virtue of its position or configuration is known as its potential energy. The mechanical P.E. is of two types viz., gravitational P.E. and elastic P.E. The gravitational P.E. of a body at a certain height is due to gravity whereas the elastic P.E. is due to its property of elasticity.

Gravitation P.E. = mass × acceleration due to gravity × height = mgh

At the surface of the earth, h = 0, $\therefore$ P.E. = 0

Different Forms of Energy

(i) **Heat :** It is the energy possessed by a body by virtue of random motion of the molecules or particles of the body.

(ii) **Internal Energy :** It is the energy of a bo d y du e to the m olecular configuration and molecular motion.

(iii) **Electrical Energy :** This energy arises due to work done in moving free charge carriers in a particular direction through a conductor.

(iv) **Chemical Energy :** It is the energy possessed by the body by virtue of chemical bonding of its atoms.

(v) **Nuclear Energy :** It is the energy released during the nuclear reaction due to conversion of mass into energy.

Mass-Energy Equivalence

Mass and energy are equivalent to each other and can be interconverted according to Einstein's equation $\boxed{E = mc^2}$ or $m = E/c^2$.

Where E = energy, m = mass and, c = speed of light in vacuum = 3×10^8 m/s.

If mass = 1 kg, the energy released is

$E = 1\ \text{kg} \times (3 \times 10^8)^2\ \text{m/s}^2 = 9 \times 10^{16}$ Joule

This law unifies the two laws viz the law of conservation of mass and the law of conservation of energy. Most of the energy in the universe i.e. energy in stars is obtained due to conversion of mass into energy.

Principle of Conservation of Energy

The total sum of all kinds of energy of an isolated system remains constant at all times. Energy neither can be created nor be destroyed but can be transformed from one form to another. The amount of energy appearing in one form is exactly equal to the energy disappearing in some other form always.

When a body is at rest at a certain height above the surface of the earth, it only has an amount of potential energy. As soon as the body is released from that height, its P.E. begins to decrease and this decrease in P.E. appears as an increase in its K.E. When the body arives at the ground, its P.E. becomes zero and this appears as K.E.

Sources of Energy

The sources of energy are immense and they are divided into two groups viz.

(i) **Renewable Source :** These sources of energy are inexhaustible and are being continuously supplied by nature e.g. wind, flowing water, the sun, ocean tides, biogas, plants and vegetable waste, etc.

(ii) **Non-renewable Source :** They are exhaustible and have been formed in nature long ago e.g. coal, petroleum, natural gas, fissionable materials like uranium.

Wind Energy

Air in motion is wind which has kinetic energy called wind energy.

Causes of Wind

The equatorial region receiving perpendicular sun-rays has warmer air than that in the polar region where sun-rays are slanting. The warm air rises up in the equatorial region. The air from polar regions rushes towards the equatorial region to fill the gap. This causes the air to move. Moreover, local weather conditions also contribute to the movement of air. If the speed of air is small, then the wind is known as breeze. On the other hand, if the speed of air is very large, then the wind is known as storm or tornado.

Uses of Wind Energy

(i) **Sail Boats :** A boat can be rowed with oars using muscular energy which is a tiresome job for a longer distance. Hence, a sail is used by utilizing K.E. of the wind to move the boat. A sail is a large sheet of thick cloth spread over a boat in such a way that maximum wind falls on it. The sail boat moves due to wind. The speed and direction of motion of the soil boat depend mainly upon the wind.

To m ove the boat in any d esire d direction, two sails at right angles to each other are attached to the same pole fixed on the pole . A steering device known as rudder is used to turn these two sails through any angle. One of the sails is used to direct the wind and the other sail collects this wind. The kinetic energy of the wind collected by the second sail (propeller) moves the boat in th desired direction.

(ii) **Wind Mill :** A device used to convert wind energy into the mechanical energy of the machine is called wind mill.

Win d energy is pollution free an d economical. However, it is limited to certain places where wind is in plenty and blows most of the time. In India, there are some high wind energy regions like Islands of Bay of Bengal and Arabian Sea, coastal parts of Gujarat and Tamil Nadu, some parts of Rajasthan, Karnataka and Western Parts of Madhya Pradesh. Government of India has proposed to install a number of projects to tap the wind energy. In Gujarat, t w o win d p o w er energy stations are operating. One is at Lamba in Porbandar district. This power station is producing about 2000 million units of power every year. The second power station operating with wind energy is in Okha.

Tidal Energy

The alternate rise and fall of water of the ocean twice in nearly 24 hours is known as a tide. The tides are produced due to the gravitational force of attraction exerted by moon and to some extent by the sun on the water of the ocean. At the time of new and full moon, when the sun and the moon are in a straight line, tides are very high. When the sun and the moon are at right angle from the earth, tides are low. The K.E. of the water during tides is used to produce electricity.

Tidal power plant is made near narrow bays. During tides, the gates of the dam are opened. The rising water is allowed to fall on the turbine of the generator which produces electricity and the K.E. of the water is converted into electrical energy. During low tides, gates of the dam are closed and hence the water level behind the dam rises. This raised water has high potential energy. Again the gates are opened and the water falls on the turbine. Th us, the electricity is p ro duce d continuously.

France an d Canada are the leading countries which harness the tidal energy. In India, three sites viz. Gulf of Kutch (Gujarat), Gulf of Cambay (Gujarat) and Su n d erbans (West Bengal) have been identified to construct tidal power plants.

Ocean Thermal Energy

It is heat energy obtained due to the te mp erat u re difference bet w een the different layers of water in the ocean. The surface temperature of the ocean is much more than the inner deep ocean. Due to this temperature difference, heat energy can be drawn to produce electricity.

The vegetation and biomass found at the sea bed can be used to produce heat. Different oceans have different concentrations of salt. Hence, electricity can be produced at the site where different oceans meet.

Geothermal Energy

The inner part of the earth is very hot and hence, hot underground water comes automatically out of the earth's surface in certain regions in the form of fountains known as hot water springs or geysers. The steam of these springs under high pressure can be used to rotate the turbines of the generator to produce electricity.

Biogas

Biogas is a mixture of gases like methane (65%), CO_2, H_2 & H_2S formed when the animal dung mixed with water is allowed to ferment in the absence of air (Oxygen) and it is produced in a biogas plant. Biogas is a very good fuel to produce heat.

The arrangement of producing biogas from animals dung, human excreta and industrial and domestic wastes is known as biogas plant. There are two types of biogas plants which have been used in our country. These are :

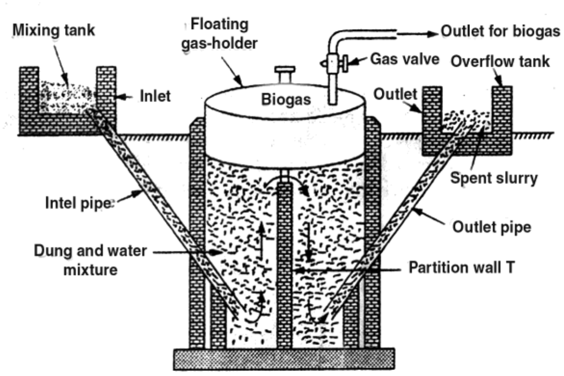
(i) Fixed-dome type biogas plant.

(ii) Floating gas holder type biogas plant.

Fixed-Dome Type Biogas Plant : It consists of a well like underground tank made of bricks and cement. This tank is called digester and has inlet and outlet valves. The roof the tank is dome shaped. There is a gas outlet pipe at the top of the dome. The dome of the digester acts as a storage tank of biogas. Thus, the gas-holder (i.e., dome) is fixed. There is a mixing tank made above the ground level. On the other side of the digester, a rectangular tank called outlet chamber is constructed with bricks and cement. This outlet chamber is connected to the overflow tank w hich collects the used slurry.

Floating Gas Holder Type Biogas Plant : It consists of a well shaped tank inside the ground called digester. Digester is divided into t w o cha m bers with a partition wall. A drum shaped gas holder made of steel in the inverted position over the mouth of the digester acts as a storage tank for biogas. This tank moves up and down over the slurry in the digester tank and hence this gas plant is called floating gas holder type. The motion of the drum is controlled by a pipe.

Mixing tank is connected to the digester with the help of the inlet pipe. The overflow tank used to collect the used slurry is also connected by a pipe. The biogas collected in the floating tank is taken out with a pipe having a gas valve.



MACHINE

Machine is a device to overcome load or resistance applied to it at some point by a relatively small effort applied to it at some convenient point.

Lifting machine : It is a device to lift heavy load by applying comparatively smaller force like lever, wheel and axle, inclined plane, etc.

Effort : The force applied to a machine to overcome load (resistance) is called effort.

Load : The resistance (force) to be overcome by a machine is called load.

Mechanical Advatnage (M.A.): $= \frac{\text{Load}}{\text{Effort}}$

Velocity Ratio (V.R) or Ideal Mechanical Advantage (IMA)

$$= \frac{\text{Displacement of effort}}{\text{Displacement of load in the sametime}}$$

Efficiency of a machine

$$= \frac{\text{Useful work}}{\text{Total work done}}$$

$$= \frac{\text{Mechanical Advantage (M.A.)}}{\text{Velocity ratio (V.R.)}}$$

Efficiency is always less than one or less than 100%. Ony for ideal machines, the efficiency is one or 100%.

V.R. or I.M.A. for some simple machines—

(i) **Lever :** I.M.A. $= \frac{\text{Effort arm}}{\text{Load arm}}$

(ii) Whel nd Ale :

$$\text{I.M.A.} = \frac{\text{Radius of Wheel}}{\text{Radius of axle}}$$

CONSERVATION

- Conservation laws can be used to describe the behaviour of a mechanical system even when the exact nature of the forces involved is not known.
- Although the exact nature of the nuclear forces is not known, yet we can solve problems regarding the nuclear forces with the help of the laws of conservation.
- Violation of the laws of conservation indicates that the event cannot take place.
- Work done depends on the frame of reference.
- Work done is path independent only in a conservative field.
- Stopping distance of a body

$$= \frac{\text{Kinetic energy}}{\text{Retarding force}}$$

- When the water is flowing through a pipe with speed v, then its power is proportional to v^3.
- If kinetic energy of body is doubled, the its momentum becomes $\sqrt{2}$ times.
- If an elastic collision of two equal masses, their kinetic energies are exchanged.
- If a light and a heavy body have equal momenta, then lighter body has greater kinetic energy.
- Potential energy of a system increases when a conservative forces does work on it.
- If a body of mass 'm' moving with velocity 'v', collides elastically with a rigid ball, then the change in the momentum of the body is 2 mv.
- Work done by a centripetal force is always zero.
- When the moment um of a body increase by a factor n, then its kinetic energy is increased by factor n^2.
- If the speed of a vehicle is made n times, then its stopping distance becomes n^2 times.

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Gravitation

The force of attraction between any two bodies in the universe is called gravitation. The force of gravitation is the weakest force in the nature. However, it is the most important force in the universe because it plays an important role in planetary motion, the birth of a star, etc.

NEWTON'S LAW OF GRAVITATION

The gravitational force of attraction between any two bodies in the universe is directly proportional to the product of their masses and inversely proportional to the square of distance between them.

Let two bodies of masses m_1 and m_2 respectively having a separation of r between them.

Then from the Newton's law of gravitation, we get the gravitational force between them

$$F \propto \frac{m_1 m_2}{r^2} \text{ or } \boxed{F = G\frac{m_1 m_2}{r^2}}$$

Where G is the universal gravitational constant. $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$. The value of G remains constant anywhere in the universe.

The Newton's law of gravitation explains the rotation of the moon around the earth or earth around the sun. It correctly predicts the solar and lunar eclipses, and the orbits and time period of the modern artificial satellites. The cause behind the tides in the oceans is mainly the gravitational force of attraction between the moon and ocean water.

GRAVITY

It is the force of attraction exerted by the earth towards its centre on a body lying on or near the surface of the earth. It is called earth's gravitational pull. Thus, the gravity is a special case of gravitation.

The force of gravity acting on a body is the measure of weight of the body. The force of gravity produces an acceleration in a body and it is known as acceleration due to gravity. It is denoted by 'g'. If a body is of mass 'm', then its weight at the surface of the earth is mg.

Weight = mass × acceleration due to gravity.

$$\boxed{w = mg}$$

The acceleration due to gravity decreases above and below the earth's surface. Hence, the weight of a body decreases with increase in height above the earth's surface or increase in depth below the earth's surface. The value of 'g' is maximum at the poles and minimum at the equator of the earth. At the centre of the earth 'g' is zero.

Acceleration due to gravity is independent of mass, shape, size, etc. of a falling body i.e. a light and a heavy freely falling body will attain an equal acceleration which is equal to the acceleration due to gravity (g). The average value of 'g' at the surface of the earth is 9.8 m / s^2. Heavier a planet or satellite, higher is its 'g'. The value of 'g' at the surface of the moon is 1 / 6th of the value at the earth's surface. The value of acceleration due to gravity is minimum at planet Mercury and maximum at planet Jupiter.

SATELLITE

The body revolving around a planet continuously in an orbit is called a satellite. Moon is a natural satellite of the earth. Since 1957, many man made satellites have been put in different orbitals around the earth. They are called Artificial Satellites.

A satellite revolves around the planet in an orbit under the effect of the centripetal force provided by the gravitational force of attraction between the satellite and the planet. The minimum velocity with which a satellite is put into its orbital is called orbit velocity which is given as

$$\boxed{V = \sqrt{\frac{gR^2}{R+h}}}$$

Where g = acceleration due to gravity, R = radius of the earth and h = height of the satellite above the earth's surface. If h << R, then $V = \sqrt{gR}$ = 8 km /s.

(i) **Geostationary Satellite :** It appears always at a fixed location above the earth in its orbit. Its time period of revolution around the earth is 24hrs and its height is 36000 km above the equator of the earth. It rotates around the earth from west to east, similar to that of the earth. Its speed is 3.1 kms / s. Its orbit is coplaner to the equatorial plane of the earth.

It is also known as a geosynchronous satellite.

(ii) **Polar Satellite :** It revolves around the earth in a polar orbit which is at 90° to the equatorial plane. It passes over both the north and south poles of the earth once per orbit. Hence, every location on earth lies with the observation of polar satellite twice each day. It is also known as the sun synchrononous satellite.

In order to monitor 100% earth's surface, three geostationary satellites are required while a single polar satellite can do the same job.

ESCAPE VELOCITY

The minimum velocity required to throw a body so that it becomes free from the earth's gravitational pull is called escape velocity. It is given as $V = \sqrt{2gR}$ = 11.2 km / s for the earth where g is acceleration due to gravity and R, the radius of the earth.

EFFECT OF GRAVITY ON WEIGHT OF A BODY

When a body falls freely, its weight becomes zero. This situation is known as weightlessness. In a spacecraft or satellite, the effective weight of a body is zero because the gravitational force is balanced by the centrifugal force.

When a lift is at rest or is moving up / down with a uniform velocity, the weight of a body inside it remains unchanged.

But, when the lift accelerates upwards,

the weight of a body in it increases while downwards the weight of a body decreases.

KEPLER'S LAWS OF PLANETARY MOTION

(i) **The First Law :** Every planet revolves around the sun in an elliptical orbit.

(ii) **The Second Law :** The average radius of the elliptical orbit of the planet sweeps out equal areas in equal intervals of time.

(iii) **The Third Law :** The square of the time period of revolution of a planet is directly proportional to the cube of average radius of its elliptical orbit i.e. $T^2 \mu R^3$.

TRIVIA

- Planets revolves around the sun in elliptical orbits with the sun at one of the focii.
- The gravitational force is much smaller than the electrical force because the value of G is very small.
- Gravitation is a conservative force.
- Gravitation is a central force.
- G is a scalar quantity.
- Work done in moving unit mass from infinity to any point in space is called gravitational potential at that point.
- Gravitational potential is a scalar quantity.
- Gravitational potential due to the earth at its surface is given by : $V_e = - GM_e | R_e$ where M_e = mass of the earth and R_e = radius of the earth.
- Unit of gravitational potential is J / kg.
- The gravitational intensity inside a hollow spherical shell is zero.
- Variation of g inside the earth is linear. That is, it increase in direct proportion to the distance from the centre of the earth.
- Decrease in acceleration due to gravity at a depth d is given by : gd / R, where R = radius of the earth.
- Orbital velocity very near the surface of the earth is 7.92 km /s.
- Greater the height of the satellite smaller is the orbital velocity.
- Time period of the satellite very near the surface of the earth is about 84.6 minutes.
- No energy is dissipated in keeping the satellite in orbit round a planet.
- If the total energy (KE + PE) of a satellite is negative, its orbit is either circular or elliptical. In this case PE > KE.
- If the total energy of the satellite is zero, it escapes away along a parabolic path. In this case PE = KE.
- When the total energy of a satellite is positive, it escapes along a hyperbolic path. In this case KE > PE.
- The escape velocity from the surface of the earth is 11.2 km /s.
- If a body falls freely from infinite height, then it reaches the surface of the earth with velocity 11.2 km /s.
- Kinetic energy of escape for a satellite = 2 × kinetic energy of orbital motion.
- A body in gravitational field has maximum binding energy when it is at rest.
- A hydrogen baloon released at a height on the moon will fall with an accleration nearly 1.6 m / s^2.

■■■

PROPERTIES OF MATTER

Matter is broadly divided into three categories, viz. Solid, Liquid and Gas. Due to the strongest intermolecular force of attraction in solids, they are tough and have a definite shape and size. This force is relatively weak in liquids and so the shape is easily changed but liquids have a definite volume. In gases, the intermolecular force of attraction is minimum and hence, they do not have a definite shape, size and volume.

There is a fourth state of matter called plasma state in which matter exists in ionised state. Plasma state is common in stars.

SOLIDS

In solids the constituent particles (atoms, molecules or ions) are held strongly at the position of minimum potential energy. Solids are of two categories :

(i) **Crystalline Solids :** They have a regular pattern of constituent particles in three dimensional space. Hence, they have a definite external geometrical shape and a shar p melting point. They are an isotropic i.e. their physical properties like con ductivity (ther m al an d electrical), refractive index, mechanical strength etc. have different values in different directions e.g. rice, su gar, q u artz, dia m on d, rocksalt, m ost of metals & their compounds, etc.

(ii) **Amorphous or Glassy Solids :** They have irregular arrangement of particles. Hence, they d o not have a definite external geometrical shape and sharp melting point. They are isotropic i.e. their physical properties have the same value in all directions e.g glass, ce m ent, rubber, paraffin, plastic, etc.

LIQUIDS

Pressure due to a liquid column depends upon its density and height $\boxed{P = h\delta g}$

Where h = height of liquid column and d = density of liquid. If equal amounts of a liquid are kept in two containers one with broad base and another with a narrow base, the height of liquid column will be more in the container with the narrow base and hence, the liquid pressure exerted will be more on the narrow base than that on the broad base.

Pascal's Law : 'If the effect of gravity is neglected the pressure at every point of a liquid in equilibrium of rest is the same.'' It means, in a liquid content, the effect of pressure is equally trasmitted through out the liquid system.

Hydraulic lift, Hydraulic press or Brahma press, etc. work on the Pascal's law.

Pressure is equal to the force acting per unit area i.e. pressure $= \frac{\text{Force}}{\text{Area}}$

Let a liquid system having two open surfaces one with a narrow cross sectional area and other with a broad cross section and provided with pistons. Since pressure remains the same in every section of the liquid system, hence, by putting a small load on the piston of small cross section a heavy load placed at the piston of the broad cross-section can be uplifted.

Buoyancy : Whenever a bo d y is immersed in a fluid, the displaced fluid has a tendency to occupy the original position. Hence, an upward force is experienced by the body. This upward force acting on the body inside a fluid is called bouyancy or buoyant force or upthrust.

Archimedes Principle : 'When a body is partially or completely immersed in a fluid, it loses some of its weight which is equal to the weight of the fluid displaced by the body.''

Law of Floatation : A body will float in a liquid, if weight of liquid displaced by the immersed part of the body is at least equal to or greater than the weight of the body.

Applications are discussed as below :

- A wooden block or a big ship can float but an iron pin sinks in water because the weight of w ater displaced by a wooden block or a ship is either equal to or more than their respective weights whereas the weight of water displaced by the pin is less than the weight of the pin. Due to the same reason, a metallic bowl can float on the water surface.
- An iceberg having an iron pin floats on the water surface but the pin sinks in water after melting the iceberg. This is because the density of ice is less than that of water and the weight of water displaced by the iceberg is more than the weight iceberg containing an iron pin but the weight of water displaced by the iron pin is less than the weight of the pin.
- Initially, a balloon filled with helium gas rises in the air because the weight of the air displaced by the balloon is greater than the weight of the balloon. As it goes up, the weight of air displaced decreases due to decrease in the density of air and hence, the balloon halts at a height where the weight of air displaced by the balloon becomes equal to the weight of the balloon.

ATMOSPHERIC PRESSURE

Air content above the earth exerts force due to its weight on the ground. This force on the ground gives rise to the atmospheric pressure. At the sea level the value of atmospheric pressure is one atmosphere.

1 atmosphere = 760 mm of Hg = 76 cm of Hg = 1.013×10^5 N / m^2

= 1.013×10^5 pascal = 760 torr.

Barometer is a device that measures pressure. Mercury barometer is the most common type.

Pressure : Pressure is equal to the normal force acting per unit area. If the handles of the bags and suitcases are broad, the pressure on the hand carrying them will be small.

Railway tracks are laid on large sized wooden, iron or cement sleepers so that the thrust due to weight of train is spread over a large area. This reduces the pressure on the ground which would prevent the yielding of ground. Pins and nails are pointed so that on pressing on a surface they exert high pressure on the surface and hence, easily penetrate the surface. The pointed end has least the surface area and it provides greater pressure on applying a normal force because pressure is equal to force devided by area. Due to the same reason, it is painful to walk bare footed on a road covered with edgy pebbles.

Vander Waal Force of Attraction : It is the minimum force of attraction between any two neutral particles (atoms or molecules). It may be of two types viz. cohesive force (between similar molecules) and adhesive force (between dissimilar molecules).

ELASTICITY

The ability of a body to regain its original configuration after removal of an applied deforming force is called elasticity and the body is termed elastic. Quartz and phospher bronze are nearly perfectly elastic bodies. Steel is more elastic than rubber. Most of the metals are elastic.

When a body does not regain its original configuration at all on the removal of the deforming force, it is called a plastic body. e.g. plastic paraffin, putty, etc.

When a deforming force is applied on an elastic body, its configuration changes and after the removal of the force the body regains the original form. The force applied per unit area is called stress and the ratio of the change in configuration to the original configuration is called strain.

Hooke's Law : Within the elastic limit, the stress developed is directly proportional to the strain produced in a body i.e. stress a strain or stress = E × strain or $\boxed{E = \frac{\text{stress}}{\text{strain}}}$

Where E is a constant for a given body and known as the co-efficient of elasticity or modulus of elasticity. The modulus of elasticity is a measure of elasticity of a body.

Ductile Materials : These materials show a large plastic range beyond the elastic limit.They are used in making springs and sheets e.g. coppers, iron, silver, aluminium, etc.

Brittle Materials : These materials show a very small plastic range beyond elastic limit e.g. glass, cast iron, etc.

Elastomers : These materials have no plastic range. In such materials even a small stress can produce a large strain e.g. rubber, the elastic tissue of aorta in the human blood circulatory system, etc.

$$\text{Safety factor} = \frac{\text{breaking stress}}{\text{working stress}}$$

When a material is used in a certain construction, the working stress is kept much lower than that of breaking stress so that the safety factor may have a large value.

The metallic parts of the machinery are never subjected to a stress beyond the elastic limit, otherwise they will get permanently deformed.

The bridges are designed in such a way that they do not bend much or break under the load of heavy traffic, force of strongly blowing wind and its own weight. In order to minimise the depression in the beam of given length and material the depth of the beam is kept large as compared to its breadth. However, too large a depth of the beam may cause bending, called buckling. Hence, a compromise between breadth and depth of a beam is made by using an ''I shaped girder'' with a large load bearing surface.

A hollow shaft is found to be stronger than a solid shaft made of the same equal material.

The material used to construct a spring should be of higher elasticity. Hence, steel having higher elasticity is used to construct a spring. Rubber is of lower eleasticity and hence, it cannot be used to construct a spring.

If a material is subjected to repeated strains, it losses its elasticity over a long period of time. After a long use, the bridges are declared unsafe.

- The modulus of elasticity has the same units and dimensional formula as that of strees or pressure.
- The material is more elastic if its value of modulus of elasticity is large.
- Young's modulus of elasticity-Y and modulus of rigidity h exist only for solids as liquids and gases cannot be deformed along one dimension only and also cannot undergo shear strain. However, the bulk modulus of elasticity K exists for all the three states of mater; viz; solid, liquid and gas.
- The solids are more elastic and gases are least elastic. It is so because for the given stress applied the gases are more compressible than that of solids.
- Young's modulus of the material of a wire is numerically equal to the stress which will double the length of a wire.

TRIVIA

- Young's modulus is defined only for the solids.
- Bulk modulus is defined for all types of materials : solids, liquids and gases.
- Reciprocal of bulk modulus is called compressibility.
- Hooke's law is obeyed only for small values of strain (say of the order of 0.01).
- Higher values of the elasticity (modulus) means greater force is required for producing a given change.
- The materials which break as soon as the stress goes beyond the elastic limit are called brittle.
- The materials which do not break well beyond the elastic limit are called ductile.
- The deformation beyond elastic limit is called plasticity
- Rubber sustains elasticity even when stretched several times its length. However it is not ductile. It breaks down as soon as the elastic limit is crossed.
- Breaking stress does not depend on the length or area of cross section of the wire. However it depends on the material of the wire.
- Breaking force depends on the area of cross section. Breaking stress of a wire is called tensile strength.
- Elastic after effect is temporary absence of the elastic properties.
- Temporary loss of elastic properties due to continuous use for a long time is called elastic fatigue.
- Thermal stress in a rod is independent of the area of cross section or length of the rod.
- When a body is sheared, two mutually perpendicular strains are produced. They are called longitudinal strain and compressional strain. Both are equal in magnitude.

- Quartz is the best available example of perfectly elastic material.
- The pressure is perpendicular to the surface of the fluid.
- The upthrust on a body immersed in a liquid does not depend on the mass, density or shape of the body. It only depends on the volume of the body.
- The weight of the plastic bag full of air is same as that of the empty bag because the upthrust is equal to the weight of air enclosed.
- The wooden rod cannot float vertically in a pond of water because centre of gravity lies above the metacentre.
- The cross-section of the water stream from a tap decreases as it goes down in accor d ance with the eq u ation of continunity.
- We cannot sip a drink with a straw on the m oon, beca use there is no atmosphere on the moon.
- The line joining the centre of gravity and centre of buoyance is called central line.
- The point where the vertical line through centre of buoyancy intersects the central line is called metacentre.
- The floating body is in stable equilibrium when the metacentre is above the centre of gravity. (Centre of gravity is below the centre of buoyancy)
- The floating bo d y is in u nstable equilibrium when the metacentre lies below the centre of gravity. (Centre of gravity is above the centre of boyancy).
- The floating bo d y is in the neu tral eq uilibrium w hen centre of gravity coincides with the metacentre. (Centre of gravity coincides with the centre of buoyancy).
- If a body just floats in a liquid (density of the body is equal to the density of liquid) then the body sinks if it is pushed downwards.
- The hydrometer can be used to measure density of the liquid or fluid.
- When a gale blows over a roof, the force on the roof is upwards.
- Sudden fall in atmospheric pressure predicts possibility of a storm.
- If two bodies have equal upthrust in a liquid, both have the same volume.
- If one floats on one's back on the surface of water, the apparent weight is zero.
- If a beaker is filled with liquid of density p up to a height h, then the m ean pressure on the walls of the beaker is hp g / 2.
- Stress and pressure have the same units an d dimensions, but the pressure is always normal to the surface but the stress may be parallel or perpendicular to the surface.
- Isothermal elasticity = pressure (p)
- Adiabatic elasticity = Ratio of specific heats × pressure.
- Normal stress is also called tensile stress when the length of the body tends to increase.
- Normal stess is called compressive stress w hen length of the bo d y ten d s to decrease.
- Tangential stress is also called shearing stress.
- When the deforming force is inclined to the surface, both the tangential as well as normal stress are produced.

- Diamon d an d carboru n dum are the nearest approach to the rigid body.
- Elasticity is meaningless for the rigid bodies. That is, the elastically is the property of the non rigid bodies.
- Compressibility = $\frac{1}{\text{Bulk modulus}}$
- Breaking stress is independent of the length of the wire.
- Breaking stress depends on the material of the wire.
- Breaking load depends on the area of cross-section of the wire.
- Bulk modulus was first defined by Max well.
- In the stretched spring, tensile strain is produced.
- Breaking stress for a wire of u nit crosssection is called tensile strength.
- If a beam of rectangular cross-section is loa d e d its d ep ression is inversely proportional to the cube of thickness of the beam.
- If a beam of a circular cross-section is loa d e d, its d ep ression is inversely proportional to the cube of radius.
- If we double the radius of a rope its breaking stress becomes four times, but breaking stress remains unchanged.
- When a beam is bent, both extensional as w ell as co mp ressional strain is produced.
- When there is no external force, the shape of a liquid drop is determined by the surface tension of the liquid.
- Soap helps in better cleaning of clothes because it reduces the surface tension of the liquid.
- A liquid does not wet the containing vessel if its angle of contact is obtuse.
- In case of liquids which do not wet the walls of the containing vessel, the force of adhesion is less than $1/\sqrt{2}$ times the force of cohesion.
- The height of the liquid column in a capillary tube on the moon is six times that on the earth.
- Soldering of t w o metals is possible because of cohesion.
- When the liquid drops merge into each other to form a larger drop, energy is released.
- The liquid rises in a capillary tube, when the angle of contact is acute.
- Surface tension of molten ca dmium increase with the increase in temperature.
- The coefficient of viscosity of gases increase with the rise in temperature but that of liq uid s d ecreases with the increase in temperature.
- The streamlined or turbulent nature of flow depends on the velocity of flow of the liquid.
- Reynold number is low for liquids of higher viscosity.
- Bernoulli’s theorem is based on the conservation of energy.
- Bernoulli’s theorem is strictly applicable to non viscous fluids.
- Viscosity is due to the transport of momentum.
- Maximum possibility of streamlined flo w is for lo w d ensity an d high viscosity fluids.

- Gases cannot be liquified above the critical temperature.
- Above critical temperature a substance is in gaseous state and below critical temperature it can be in vapour state.
- The branch of thermal physics that deals with measurement of the amou nt of w ater va p o u rs p resent in the atmosphere is called hygrometry.
- Saturated and unsaturated air :

(i) The air is said to be saturated when the maximum possible amou nt of water vapours are present in it.

* The pressure of the water vapours in the saturated air is called saturation vapour pressure.

(ii) If the air contains vapours less than the maximum possible amount possible in t he air, t hen it (air) is said to be unsaturated.

- The humidity refers to the presence of water vapours in the atmosphere. It is defined in the atmosphere. It is defined in the following two ways.

* Absolute humidity : It is the amount of water vapour preseent in $1m^3$ of the air.

* Relative humidity =

$$\frac{\text{Mass of the water vapours present in } 1\text{m}^3 \text{ of air at a certain temperature}}{\text{Mass of the water vapour required to saturate } 1\text{m}^3 \text{ of the air at the same temperature.}}$$

* The relative h umidity is generally expressed in percentage.

- Relative humidity may also be defined as :

Relative humidity =

$$\left[\frac{\text{Water vapour pressure at the given temp.}}{\text{Saturation vapour pressure at the same temp.}}\right]\times 100\%$$

- Dew point

It is the te mp erat u re at w hich the a m o u nt of w ater va p o u r act u ally present in a certain volume of the air is sufficient to saturate that volume of air.

* At the dew point the actual vapour pressure becomes the saturation vapour pressure.

- Relative humidity can also be defined as:

Relative humidity =

$$\left[\frac{\text{Saturation vapour pressure at dew point}}{\text{Saturation vapour pressure at the given temp.}}\right]\times 100\%$$

- Relative humidity is low when the air is dry.
- Relative humidity is high if the air is moist.
- Hygrometer :

It is the device to measure the amount of water vapours in the air or the relative humidity.

- Saturation vapour pressure changes with the increase in temperature.
- At 0°C, the saturation vapour pressure is 4.6 mm of H g. Therefore, w ater vapours are always present around the ice.

* It increases with the increase in temperature.

- When the te mp erat u re of the atmosphere is equal to the dew point, the relative humidity is 100%.

- The study of low temperature is called cryogenics.
- Maximum value of relative humidity is 100%.
- The saturation vapour pressure of water at 100°C is 760 mm of Hg at sea level.
- As the temperature rises, the absolute humidity may increase and the relative humidity may remain constant or may even decrease.
- Let the saturation vapour pressure at temperature t°C is p. If the atmospheric pressure is reduced to p, the water starts boiling at t°C.
- At the same temperature one feels hotter if the relative humidity is high.
- If the air is absolutely dry, the dew point is not observed.
- The dew point does not change if the temperature of the room is changed.
- The relative humidity decreases with the increase in temperature.
- If water is sprinkled in the room, both relative humidity as well as the dew point increase.
- Dew appears on the leaves of the trees, etc. due to the condensation of saturated vapours.
- Small droplets of water formed due to the condensation of water vapours near the surface of the earth constitute mist or fog.
- Mist or fog formed much high above the surface of earth is called cloud.
- Human beings feel comfortable when the relative humidity is between 50% to 60%.
- When the air is saturated with water vapours, the relative humidity is 100% an d dew point is equal to the room temperature.
- When the relative humidity is 100%, the reading of the dry an d wet bulbs is same.
- Sm aller the difference in the temperature of dry and wet bulbs, larger is the relative humidity.
- Water vapours are always seen around the ice, because the temperature around it is less than the dew point.

■■■

SURFACE TENSION

The molecules at the surface of a liquid have a higher potential energy than those of the inner molecules. P.E. = mgh where m is mass of a molecule, g is acceleration due to gravity and h is the height of the molecule above the bottom of the liquid. Due to maximum height the surface molecules of the liquid have maximum P.E. Hence, in order to have higher stability, the liquid surface tries to minimize its P.E. In doing so, it tends to contract to have minimum surface area, number of molecules and hence, minimum P.E. and maximum stability. Consequently, the liquid surface behaves as if convered with a stretched membrane. This property of the liquid by virtue of which the free surface of the liquid has a tendency to contract so that it can have minimum surface area is called surface tension.

The surface tension is measured as the force acting per unit length at the liquid surface.

$$\text{Surface tension} = \left(\frac{\text{Force}}{\text{Length}}\right)$$

The surface molecules of the liquid are always under the effect of an inward force due to force of cohesion between the surface molecules and inner molecules. That imparts surface tension. The surface tension of a liquid decreases with rise in temperature and becomes zero at the boiling points.

Some common examples of surface tension :

- The hairs of a shaving brush when taken out of water are pressed together. Inside water, hairs spread out. On taking out the brush from water, the water film forms between the hairs while tending to make its surface area minimum due to surface tension brings the hairs closer to each other.
- In soldering, addition of flux reduces the S.T. of molten tin, hence, it spreads.
- The liquid drop has a tendency to have minimum surface area due to the surface tension of the liquid and hence, it becomes spherical.
- The surface tension of oil is less than that of cold water hence an oil drop spreads on cold water while the surface tension of oil is more than that of hot water, hence oil drop remains as a drop on hot water.
- In order to spread more, the surface tension of lubricants and paints is kept low. Bees like insects can float on water surface because the weight of the insect is balanced by the force of surface tension of water. Due to the same reason, a greased iron needle can float on water surface.
- Stormy waves at sea are calmed by pouring oil on sea water because oil has low surface tension.

- When a wire loop is dipped into a soap solution and taken out, a soap film is formed on the loop due to surface tension.
- The bits of camphor are seen dancing on the surface of water. The bits of camphor reduce the surface tension of water where they are dipped. Due to irregular shape of the camphor bits, unequal forces of surface tension act on them. Hence, they move erratically on the surface of water.
- It is better to wash clothes in hot soap solution. Hot solution has lower surface tension. Hence, the solution spreads over a larger area or clothes and cleaning action increases.

  Action of detergent or soap solution : When detergents or soaps are dissolved in water, the surface tension of water decreases. Hence, a detergent / soap solution spreads more quickly over the clothes. Consequently, more dirt come in contact with the solution and cleansing action enhances. Fu rt her, hot soution has lower surface tension than a cold one which gives extra cleaning ability to the detergent / soap solution.
- Warm food taste better on our tongue because the warm food on chewing spreads more on the tongue due to lower surface tension. Consequently, more food content comes in contact with the taste buds on the tongue. Hence, warm food is tastier than the same food when cold.

CAPILLARITY

The phenomenon of natural rise or fall of liquid column in a narrow tube is called capillarity and the tube is known as the capillary tube. The capillarity increases with increase in surface tension of the liquid.

Examples of capillary action :

- The tip of of the nib of a pen is split in order to provide a capillary which helps the ink to rise to the end of the nib and enables it to write continuously.
- When a chalk piece is dropped into water, air bubbles come out. The pores in the chalk containing air act as narrow capillaries. Hence, water enters these pores due to capillary action and air bubbles come out.
- A blotting paper has fine pores that act as capillaries. Hence, ink rises in them leaving the paper dry.
- The capillary action of narrow capillaries in the threads of a towel enables the towel to soak water.
- The wooden door swells in the rainy season because of the capillary action of moisture available in the air through the pores in the wood.
- Molten wax in candles or oil in lamps rises through threads due to capillary action.
- Clay soil has capillaries but sand does not have capillaries. Hence, u n derground water rises in a clay soil while sand remains relatively dry.
- In order to preserve moisture in the soil, ploughing of fields is essential. Ploughing breaks the fine capillaries in the soil. It prevents the rise of water and reduces evaporation of water content in the soil.
- The transport of water and minerals from the soil to plants is favoured by the capillary action in the conduction tissues called Xylems in the plants.

VISCOSITY

It is fluid friction that arises due to inter molecular forces which are effective when the different layers of the fluid are moving with different velocities. It gives rises to a backward dragging force between the fluid layers moving with respect to each other. Viscosity of a liquid decreases with increase in temperat u re but viscosity of gases increase, under similar conditions.

- The phenomenon of viscosity plays an important role in the circulation of blood through arteries and veins of human body.
- At railway terminals, the liquids of high viscosity are used as buffers.
- Water flows faster than honey because viscosity of water is lower than that of honey hence, a small dragging force appears during the flow of water.
- In an industry, the measurement of viscosity an d its variation with te mperat u re are useful in jud ging whether a given lubricant oil is useful for a machine or not.
- Chemists use the knowledge of viscosity to determine molecular mass and shape of large organic molecules like proteins and cellulose.

FLOW OF FLUID

The rate of flow of a fluid through a tube is inversely proportional to the area of cross section of the tube. It means narrower the tube, higher will be the velocity of fluid through it. Hence, deep water runs slow in a river. Similarly, the jet of falling water becomes narrow as it goes down because the velocity of falling water increases and hence, its area of cross-section decreases. If the mouth of the tube used to water plants in the garden is pressed, the speed and range of the water flow increases, because on pressing the cross sectional area of the mouth of the tube decreases. Due to similar reason the velocity of water increases when water flowing in a broader pipe enters a narrow pipe.

BERNOULLI'S THEOREM

The total sum of energy of a fluid during its flow remains constant. A fluid can have potential energy, kinetic energy and pressure energy during its flow. Its potential energy depends upon height, kinetic energy on velocity and pressure on the pressure of the fluid.

Applications of Bernolli's Theorem :

- The size of the needle of a syringe controls flow better than the thumb pressure exerted by a doctor while administering an injection. The velocity of flow is controlled by the size of the needle whereas the pressure is controlled by thumb pressure. In order to keep total sum of pressure energy and kinetic energy of the flow constant, velocity increases more in accordance with the Bernoulli's theorm.
- Two rows of boats moving parallel to each other and nearby, are pulled towards each other. The velocity of water between the two rows increases which results in increase in K.E. of w ater in between. Hence, pressure and pressure energy of water on the outerside of the rows increase. Consequ e n t ly, t h e ro w s of boats are pushed inwards because the total sum of energy of water in between an d

outside the rows have to be constant in accor d ance with the Bernoulli's theorem.

- The roofs of hut or tinned roofs are usually blown off without causing any harm to the huts during cyclones or storms. The wind blows speedly above the roof during the storm whereas air inside the hut remains at rest. It gives higher kinetic energy and small pressure energy above the roof whereas below the roof K.E. is small and pressure energy is high. Due to high pressure and hence, higher pressure below the roof, the roof experiences an upward force and is blown off with stormy wind.

- The wings of the aeroplanes are designed such that it experiences an upward pressure and hence, an upward force. It is based on Bernoulli's theorem. The upper surface of the wing is more curved than its lower surface and its leading edge is thicker than its trailing edge. Hence, the velocity of air above the wings becomes more than that below them i.e. kinetic energy of air above the wings becomes greater than that of air below the wings. Consequently, the pressure energy and hence, pressure of air below the wings become greater than those of the air above the wings. It gives an upwards push on the wings and prevents the planes from falling down.

- When a spinning ball is thrown, it deviates from its usual straight line path and its path becomes curved. This effect is based on Bernoulli's theorem and is known as Magnus effect. When a spinning ball is thrown, air moves backward above and below the ball. The speed of air below the ball becomes more because the spinning ball throws lower air in a backward direction. Hence, kinetic energy of lower air becomes more and consequently, in order to have equal energy, the pressure energy of upper air gets to increase. It results in increase in pressure above the ball. This pressure provides a centripetal force acting at a right angle to the linear velocity of the ball. Consequently, the ball follows a curved path.

TRIVIA

- Molecular forces donot obey the inverse square law of distance.
- The molecular forces are of electrical origin.
- Work done in forming a soap bubble of raidus R is $8\pi R^2 \sigma$, where σ = surface tension.
- Work done in breaking a drop of radius R into n drops of equal size = $4\pi R^2 \sigma (n^{1/3} - 1)$.

  Same amount of energy is liberated in combining n drops into a single drop.
- Angle of contact increases with rise in temperature. It decreases on addition of soluble impurities.
- Angle of contact is independent of the angle of inclination of the walls.
- The materials used for water proofing increase the angle of contact as well as surface tension.
- Detergents decrease both the angle of contact as well as surface tension.
- Surfaces tension does not depend on the area of the surface.
- Viscosity of liquids decreases with the rise in temperature.

- Viscosity of gases increases with the rise in temperature.
- The rate of flow of liquid in a tube of radius r length l whose ends are maintained at a pressure difference p is :

  $V = \frac{\pi p r^4}{8\eta l} = \frac{P}{R}$. Here η = coefficient of viscosity where $R = 8\eta\, l / \pi r^4$ is called fluid resitance.
- Viscosity is independent of pressure.
- When a liquid is in equilibrium, the force / forces acting on its surface are perpendicular everywhere.
- In a liquid the pressure is same at the same horizontal level.
- The pressure at any point in the liquid depends on depth (h) below the surface, density of liquid and acceleration due to gravity.

  It is independent of the shape of the containing vessel, or total mass of the liquid.
- Bernoulli's equation is in accordance with the law of conservation of energy.

  It assumes that in the flowing liquid, every particle going across the cross- section possesses the same velocity.

  Bernoulli's theorem doesn't take the viscosity into account. When the fluid flows along a covered path the energy of centripetal force must also be taken into account.
- If a vessel contains liquids upto a height H and it has a hole in the side at a height h, then the velocity of efflux is $v = \sqrt{2gh}$. The time taken by the liquid to reach the ground level is $t = \sqrt{2h/g}$. Horizontal range of the liquid $R = 2[h(H - h)]^{1/2}$. The range is the same for the hole at a height h above the bottom or at the depth h below the surface of the liquid.
- The range is maximum for h = H / 2. It is given by

$$R_{max} = 2\left[\left(\frac{H}{2}\right)\left(H - \frac{H}{2}\right)\right]^{1/2} = H$$

- Interatomic or intermolecular forces are zero when the separation between them is infinite.
- At a certain distance $r = r_0$, the interatomic or inter molecular force is zero. The value of r_0 is different for the different atoms and molecules.
- For $r > r_0$, the interatomic / intermolecular forces are attractive.
- For $r < r_0$, the interatomic / intermolecular forces are repulsive.
- At $r = r_0$, the interatomic / intermolecular potential energy is minimum and negative. It is the equilibrium position of the atoms / molecules.
- Both the interatmoic as well as intermolecular force vary inversely as the sixth power of distance ($F \propto 1/r^6$).
- Differences between interatomic and inter molecular forces:

(i) Interatomic forces depend only on the interatomic separation but the inter molecular force depends on the intermolecular separation as well as the orientation of the molecules.

(ii) Interatomic force are 50 to 100 times larger than the intermolecular forces.

(iii) Value of r_0 for atoms is less than that for molecules.

(iv) The intermolecular forces may extend beyond their immediate neighbours. This is not true for the interatomic forces.

■ ■ ■

SPACE EXPLORATION

Space is a vast and endless area or region outside the earth's atmosphere where the stars, planets and other celestial bodies exist.

Sp ace exploration is the stud y of collecting and analysing the information and data about the various heavenly or celestial bodies in the outer space.

With the advancement in technology, a complete branch of science known as Space Science has been developed to explore the o u ter sp ace. At p resent, the sp ace exploration is done by using artificial and space probes.

A small body revolving around a planet in an orbit is known as a satellite.

TYPES OF SATELLITES

Satellites are of two types :

(i) **Natural Satellite :** A celestial body revolving around a planet is known as the natural satellite. For example, the moon is the natural satellite of the earth.

All planets except Mercury and Venus have natural satellites.

(ii) **Artificial Satellite :** A man made satellite that revolves around the earth is known as an artificial satellite.

ORBIT OF SATELLITE

The closed elliptical path followed by an artificial satellite around the earth is known as the orbit of the satellite.

Characteristics of the Orbit of the Satellite:

(a) **Apogee :** The farthest point on the orbit of a satellite from the surface of the earth is known as apogee.

(b) **Perigee :** The nearest point on the orbit of the satellite from the surface of the earth is known as perigee.

(c) **Inclination :** The angle between the plane of the equator of the earth and the plane of the orbit of the satellite is known as inclination.

A satellite is bou n d to the earth's gravitational pull as a planet is bound to the Sun's gravitational pull.

DIFFERENT TYPES OF ARTIFICIAL SATELLITES

Geo-stationary Satellite : A satellite which is at rest with respect to the earth is called a geo-stationary satellite. The orbit of such a satellite aroun d the earth is known as a geo-synchronous orbit.

Geo-stationary satellite plays an important role in communication technology. In other words, a communication satellite is a geo-stationary satellite.

Polar Satellite : Geo-stationary satellites, orbiting about 36000 km above

Specialised Establishments Operating Under DRDO

- **Vikram Sarabhai Space Centre (VSSC):** Specialised in the development of satellite launch vehicles and sounding rockets.
- **ISRO Satellite Centre (ISAC):** The lead centre for satellite development, covering structures, thermal systems, spacecraft mechanisms, power systems and satellite integration.
- **Satish Dhawan Space Centre (SDSC)-SHAR - Sriharikota Space Centre:**India's prime launching pad facility, providing the launch infrastructure as well as solid propellant processing and their testing. A second launch pad has been recently built at SDSC-SHAR.
- **Liquid Propulsion Systems Centre (LPSC) :** The lead centre in the area of liquid and cryogenic propulsion for launch vehicles and satellites.
- **Space Applications Centre (SAC):** Specialised in the development of payloads for communication, meterological and remote sensing satellites; it conducts space applications research and development.
- **ISRO Telemetry, Tracking and Command Network (ISTRAC):** It provides mission support to Low-Earth orbit satellites and to launch vehicle missions.
- **Master Control Facility (MCF) :** The monitoring and control centre for the geostationary satellites.
- **ISRO Inertial Systems Unit (IISU):** Carries out research and development in inertial sensors and systems and allied satellite elements.
- **National Remote Sensing Agency (NRSA) :** An autonomous institution supported by DOS, it is responsible for acquisition, processing and distribution of data from remote sensing satellites, based in Hyderabad.

the equatorial plane, are used for communication purposes.

On the other hand, low to medium altitude satellites are known as polar satellites. These satellites move over the orbit passing through the north and south poles of the earth above the polar plane. The orbit in which the polar satellite moves is known as the polar orbit.

Polar satellites are not used for communication purposes. They are used for remote sensing and hence are known as remote sensing satellites.

The orbit in which a polar satellite or remote sensing satellite moves is such that the satellite always passes over a particular area of the earth at the same local time. Such orbit of the satellite is known as sun-synchronous orbit (or polar orbit).

BASIC REQUIREMENTS FOR SELF-SUFFICIENCY IN SPACE TECHNOLOGY

Any country which intends to be self-sufficient in the space technology has to fulfill the following requirements:

1. Fabrication of Satellite or Spacecraft : Satellites play an important role in the field of space research. Therefore, an expertise is required for planning, designing and fabricating the different types of satellites or space crafts.

2. Designing and Fabrication of Launch Vehicles : Launch vehicles are required to put satellite in the orbit around earth and to launch the space probe.

Therefore, these vehicles have to be developed for the successful launching of satellites.

3. Earth Control Station : When satellite is put into orbit, its all operations have to be controlled and guided by sending proper command from surface of the earth. Such commands are sent from the station established on the earth.

4. Ground Facilities : The arrangements are to be made in order to get the benefit of the information an d d ata sent by the satellite throughout the country. The signals re-transmitted from the satellite are received by the receiving antennas installed across the length and breadth of the country.

The Indian Space Rearcher Organisation has set up a large number of organisations and research centres across the country to carry out research an d developmental activities in the field of space research and technology.

Setting up of Rocket Launching Facility : The India's space exploration programme began with the setting up of a rocket launching facility at Thumba, near Thiruvananthapuram (Trivandrum). India launched its first rocket RH-75 in 1967 fro m the Th um ba Eq u atorial Rocket Launching Station (TERLS). Although this rocket was very small (diameter = 75 mm), yet it had all the basic features of a rocket. Since then India never looked back and today it has the honour to be the sixth nation in the world in the field of space technology.

■■■

SIMPLE HARMONIC MOTION

PERIODIC MOTION

The motion of a body which is repeated identically after a fixed interval of time is known as periodic motion and the fixed interval of time is known as time period of the motion.

The motion of the hands of a clock is in a periodic motion. The time period of the hour's hand is 12 hours, of the minute's hand is 1 hour and of the second's hand is 1 minute.

The rotation of the earth about its axis with a time period of 24 hours and the revolution of earth around the sun with a time period of 1 year are other examples of the periodic motion.

SIMPLE HARMONIC MOTION

It is a special type of oscillation in which the particle oscillates in a straight line, the acceleration of the particle is always directed towards a fixed point on the line & the magnitude of acceleration is proportional to the displacement of the particle from this point. This fixed point is called the centre or mean position of oscillation. The simple harmonic motion is an oscillatory motion which in turn is a periodic motion. However, a periodic may or may not be an oscillatory motion.

The motion of a freely suspended bar magnet in the earth's magnetic - field, of the pendulum of a wall clock, of the bob of a simple pendulum etc. are simple harmonic motions.

Application of SHM are discussed as below :

- When the load attached to a spring is pulled once a little from its mean position & left free, it oscillates in simple harmonic motion.
- The motion of liquid contained in U-tube when it is compressed once in one of the two limbs & left to itself, is simple harmonic motion.
- If a tunnel is dug along the diameter of earth & a body is dropped in it, the body will oscillate in simple harmonic motion between the ends of the earth's diameter.
- When the oscillation of a body in simple harmonic motion is free from frictional forces, its oscillations are undamped. The amplitude and energy do not change with time in an undamped oscillation. The oscillation of a simple pendulum in vacuum is an undamped oscillation.
- When the oscillation of a body in simple harmonic motion involves frictional forces, its oscillations are damped. The amplitude and energy of the body in a damped oscillation decrease with time.
- Most of the oscillations in air or in a medium are damped oscillations like oscillation of the bob of a simple

pendulum in air, of the stretched string in air etc.

- When a body oscillates with its own natural frequency without involving an external periodic force, its oscillations are called free-oscillations. The oscillations of the string of a sitar when plucked once and let free, of the bob of a simple pendulum when once displaced from its mean position and let free and of the prongs of a tuning fork when one of its prong is struck once on a rubber and let free are examples of free oscillations.
- When a body oscillates with the help of an external periodic force other than it own natural frequency, its oscillations are called forced oscillations.
- All musical instruments consisting of strings like sitar, violen Reasonant Oscillations etc. produce forced oscillations.

RESONANT OSCILLATIONS

When a system oscillates with its own natural frequency, with the help of an external periodic force whose frequency is the same as that of the natural frequency of the oscillating system, then the oscillations of the system are called resonant oscillations. The resonant oscillations have very large amplitude. At resonance, the oscillating system continuously absorbs energy from the agent applying external periodic force.

If the rhythm of pushing against the ground is synchromized with the natural frequency of the swing, it gives greater heights due to resonance effect.

All mechanical structures have one or more natural frequencies. When a mechanical structure is subjected to a strong driving force that matches one of its natural frequencies, the amplitude of oscillations of the structure becomes very large. Consequently, the structure may collapse. It is for the same reason the marching soldiers break steps while crossing a bridge. In order to avoid effect of resonance the aircraft designers make sure that none of the natural frequencies at which a wing can oscillate match the frequency of the engines during flight.

In an earthquake, the structures, whose natural frequency matches the frequency of the seismic waves, collapse. During an earthquake sometimes, short and tall structures remain uneffected while the medium height structures fall down. This happens because the natural frequencies of the short structures happen to be higher and those of taller structure lower than the frequency of the seismic waves.

WAVES

Wave is some sort of disturbance in which, information and energy, in the form of signals, propagate from one point to another without the actual journey of the medium. All our communications depend on the transmission of signals through waves. All radiations are waves.

Wave motion is a kind of disturbance which travels through a medium on account of repeated periodic vibrations of the medium particles about their mean position without any net transport of the medium.

Types of Waves : On the basis of medium requirement waves are of two types viz. **(i)** ***Mechanical or Elastic waves :*** They require a medium for propagation.

eg sound, waves on the liquid surface, vibration of string, etc. **(ii)** ***Electromagnetic waves :*** They do not require a medium for propagation e.g light, X-rays, microwaves, infra-red, ultra-violet rays, etc.

On the basis of the mode of vibration the waves are of two types viz.

(i) Transverse wave and (ii) Longitudinal waves

Transverse Wave Motion : It is the type of wave motion in which the particles of the medium vibrate about their positions in a direction per pen dicular to the propagation of the wave. A transverse wave is represented in the form of crest and trough.

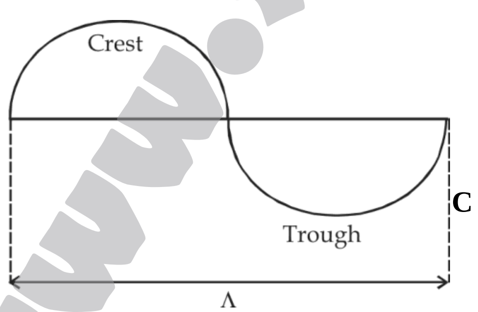
When a stone is thrown in a pond, transverse waves are formed. The vibrations of the membrane a of drum, of the string of a sitar, violin etc. produce transverse waves.

Longitudinal Wave Motion : It is the type of wave motion in which the particles of the medium vibrate about their mean positions in the same direction in which the wave is propagated.

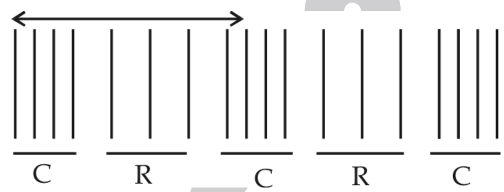
Sound produced from a source is a longitudinal wave like vibrations of a tuning fork, ringing of a bell, etc.

A longitudinal wave is represented in the form of compression and rarefaction.

Transverse Wave



Longitudinal waves



C = Compression

R = Refraction

l (Wave Length) : For the transverse wave the wave Length is equal to the distance between the two successive crests or troughs. It is also equal to the sum of the width of a crest and a neighbouring trough. For the longitudinal wave, the wave length is equal to the distance between the two successive compressions or rarefactions. It is also equal to the sum of the width of a co mp ression an d a neighbo u ring rarefaction.

Time Period (T) : It is equal to time interval taken to complete one vibration.

Frequency (n) : It is the no. of vibrations produced per second. It is equal to the reciprocal of time period i.e.

$$\text{Frequency} = \frac{1}{\text{Time period}} \text{ or } \boxed{V = \frac{1}{T}}$$

Speed of a wave is given as

Speed = Frequency × Wavelength

$$\boxed{V = v\lambda}$$

$$\therefore V = \frac{\lambda}{T}$$

$$\therefore V = \frac{\lambda}{T}$$

A mechanical transverse wave that requires a medium can propagate through solids and at the surface of liquids, but not inside liq uids an d gases. H o wever, a longitudinal wave can pass through solids, liquids and gases.

TRIVIA

- A pendulum clock slows down in summer and goes faster in winter.
- Sound waves are mechanical waves which cannot travel in vaccum.
- Sound waves do not propagate in sawdust because it is not a continous medium.
- Mechanical waves propagate energy and momentum, but they do not propagate matter.
- The sound waves are not dispersed in air.
- The weakest audible sound has intensity 10^{-12} W / m^2. Its loudness is equal to 1 dB.
- If the intensity of sound increases by a factor of 10 then the loudness increase by 10 dB or 1B.
- If the loud ness of sou n d is changed by 1dB, then the intensity of sou n d changes by 26%.
- The prongs of a tuning fork vibrate transversely and the stem vibrates longitudinally with the same frequency.
- The point of contact of the stem and prongs of the tuning fork is an antinode.

Sounds

Sound is produced in a material medium by a vibrating source. These vibrations are carried by air, as a medium and strike our ear drum. The ear drum vibrates and the message is conveyed to our brain and we hear the sound. A sound heard persists for 0.1 second in brain. It is called as persistence of hearing.

Depending upon the frequency range, sound has three categories viz. (i) Infrasonic (ii) Sonic and (iii) Ultrasonic or supersonic sounds.

Infrasonic sound has a frequency less than 20Hz. Sonic sound is between 20 Hz to 20,000 Hz. It is the audible range for human ears. Ultrasonic sound has a frequency greater than 20000 Hz. Both the infrasonic and ultrasonic sounds are not audible to human ear. However, a dog can hear sound of frequency upto 50000 Hz and a bat up to 10^5 Hz. Dolphins can produce and detect sounds of frequency upto 10^5 Hz.

Sound is a longitudinal wave. Its speed in dry air is 332 m / s. The speed of an object greater than the speed of sound is known as supersonic speed. The speed of sound depends upon elasticity, density, temperature and motion of particles of the medium of propagation. Higher the elasticity of a medium, greater is the speed of sound in it e.g. speed of sound in air is 332 m / s and in steel 5000 m / s. If one end of a long steel rod is struck, two distinct sounds are heard at the other end. The first sound heard is propagated through steel and the second one is propagated through air.

An increase in the density of the medium reduces the speed of sound. Moist air has lower density than dry air and hence speed of sound is more than that moist air.

The speed of sound increases with rise in the temperature of the medium. The speed of sound in air increase by 0.61 m / second for every one degree rise in temperature above 0°C.

The speed of sound increases along the direction of wind velocity and decreases against the wind velocity.

The speed of light is much greater than that of sound. Hence, thunder is heard much after the flash of lightning is seen. Due to the same reason, spectators hear the sound of ball on bat a little after they see the batsman actually striking the ball in a cricket match.

Sonic Boom : Sound produced by a supersonic aircraft is heard as a loud explosion on the earth. It is known as sonic boom. However, a person inside the supersonic aircraft cannot hear its sound.

Reflection of Sound : Sound waves are reflected from the obstacles of size of wavelength of sound and follow laws of reflection similar to those of light. The reflecting obstacles can be walls, mountains, clouds, ground, etc. Sound waves can be focused after reflecting from a curved surface in the same way as light waves.

ECHO

Reflected sound is called echo. An echo occurs when the reflected sound wave comes back to the listener within a time interval of not less than 0.1 second after the original sound wave reaches the listener so that a distinct repetition of the original sound is perceived. It is so because the persistence of hearing of sound is 0.1 sec. A sound can be perceived only if stays back at least for 0.1 second or more on our ears.

An echo is used to determine the speed of soun d in a medium. Exploration of underwater petroleum deposits is done by detecting echo of shock waves produced by explosions on the water surface.

The wave phenomena like total internal reflection, refraction and interference are also given by sound waves similar to those of the light wave.

SUPERSONIC OR ULTRASONIC WAVES

These waves are used :

(i) to determine the elastic symmetries of crystals of solids and to detect flaws in metals.

(ii) to fin d the velocity of sound in liquids that also informs several physical and chemical properties of the liquids.

(iii) for fin ding the depth of sea an d to d etect the su b m erge d rocks, submarines and icebergs.

(iv) to form stable emulsions of immiscible like water and oil.

(v) to accelerate crystallisation of substances and to produce oxidation.

(vi) to coagulate aerosols i.e. displaced fine particles of a solid or a liquid in a gas, e.g. dust, smoke, mist, etc.

(vii) to liquify gels in the same manner as they are liquefied by shaking.

(viii) in getting alloys of uniform composition.

(ix) for washing silken fabrics.

ULTRASONOGRAPHY

It is a technique used to form an image or picture of a matter by using ultrasonic waves. This technique is used in medical science treatment. The medical sonography is commonly known as ultrasound. In this technique, ultrasound wave passes through the organs to be diagnosed. The velocity of wave depen ds upon the elasticity an d density of the tissues in the organ and an echo is detected by a specific microphone. The echo obtained from the tissues of the organ is converted into electric signals on the screen of ultrasonograph and the images are recovered. The pattern of images helps in diagnosis of the organs like heart, liver, kidney, pancreas, etc.

Sound navigation and ranging : It is device that transmits ultransonic waves through water and records the vibrations reflected i.e. echo from an objects. Sonar is used in fin ding submarines, depth of sea, rocks and mineral deposits, etc.

Biological Effects of Ultrasonic Waves : Ultrasonic waves can kill or injure small

Difference between Intensity and Loudness

	Intensity		Loudness
1.	It is a physical quantity. which can be accurately measured.	1.	It is not an entirely physical quantity.
2.	It does not depend upon the sensitivity of the ear.	2.	It depends upon (i) sensitivity of the ear and (ii) intensity of\ sound.
3.	It has an objective existence i.e., it exists whether there is some listener or not.	3.	It has got a subjective existence i.e, it exists only when some listener is acually present.
4.	Unit of intensity is Wm^{-2}.	4.	Unit of loudness is bel.

In a tape recorder of T.V. bass refers to low pitch and treble refers to high pitch. So when bass is on, low pitch sounds of tabla and dholak become loud. When treble is on, high pitch sounds become predominant.

animals like frog, fish, etc. These waves can destroy micro organisms like bacteria and yeast.

In dental science, ultrasonic waves are used for extracting the broken teeth, to detect cracks or other defects in homogeneity noticeable by reflection or absorption.

Vibration of a Source of Sound : When a source is sounded, it generally vibrates in more than one mode. When it is sounded gently, the source vibrates in a simple manner and produces tones of lower frequencies, but when the source is sounded rapidly, the vibration becomes complex and it gives rise to tones of higher frequencies. The tones of the lowest frequency are called the fundamental note and the tones of higher frequencies are called over tones. The notes of frequencies which are integral multiples of the fundamental frequency are called as harmonics.

DOPPLER'S EFFECT

When a source of sound and a listener are at rest, the listener receives an unchanged frequency produced by the source. If there is a relative motion between them, then, the number of waves receive d per second or the apparent frequency of the source changes and is not the same as that of the source. The pitch of the note heard appears to rise if they approach each other and appears to fall if they recede away from each other. The apparent change in frequency of a sound wave due to a relative motion between the source of sound and the listener is known as Doppler's Effect. It is equally observed for light too.

If a railway engine travelling with a high speed with its whistle blowing is approaching a listener, the frequency appears to rise. The frequency appears to fall just as the engine passes the listener.

Doppler's effect is used to detect a star, a galaxy etc. It can be used to find out whether a star / galaxy is approaching us or receding away from us. It favours the hypothesis of an expanding universe.

Dopplers effect is used in 'speed guns' used by police to measure the speed of vehicles. This effect can be used to detect a moving object as well.

MUSICAL SOUND

Sounds produced by oscillating strings (sitar, piano, violin etc.), vibrating membranes (drum), air columns (flute, organ pipes), wooden blocks or steel bars (marimba, xylophone) etc. produce a pleasant effect on our minds and hence, are known as musical sounds.

Intensity, loudness, pitch, quality, etc. are characteristics of musical sounds.

Intensity : Intensity of sound is a purely physical quantity, It is equal to the amount of sound energy passing per unit time per unit area around a point in a direction normal to the area. Intensity is measured in watt / m^2 or watt / $(cm)^2$.

Threshold of Hearing or Zero Level of Intensity : it is equal to 10^{-16} watt / cm ^{2} for a normal human ear which can just hear a note of frequency of 1000 Hz.

Loudness : The sensation produced in the ear that enables us to distinguish between a loud sound and a faint sound is called loudness.

Two sounds of equal intensity but different frequencies may not appear to be equally loud even to the same listener because sensitivity of the ear is different for different frequencies.

Loudness is measured in **bel**. one bel = 10 decibel (db). Both the intensity of sound and loudness increase with increase in amplitude of the sound wave, frequency of the wave, density of the medium and velocity of sound in a medium. They decrease with increase in distance from the source of sound.

Pitch : It is the characteristic of musical sound which distinguishes a sharp sound from a dull sound. Thus, it represents the degree of shrillness of a musical note. Pitch depends on the frequency of sound and Doppler's effect.

The buzzing of bee or humming of a mosquito has high pitch, but low intensity, while the roar of a lion has a low pitch, but high intensity. Frequency of ladies, voice is generally higher than that of gents and hence, a lady' voice is always sharper than a gent's voice.

Quality : It is the characteristic of musical sound that enables us to distinguish between the sounds of same intensity and same pitch produced by two different sources. Its cause is the difference in the frequency and relative intensities of overtones produced by two sources of sound.

Voices of two singers singing a duet, voices of our friends, voices of family members etc. can be distinguished from each other on the basis of difference in quality of the sound produced by them.

REVERBERATION

The persistene of sound after the source has actually stopped producing sound is called reverberation of sound and the time for which the sound persists is called the time of reverberation.

When a loud sound is produced by a source in a hall it is partially absorbed, reflected and transmitted by the walls, ceiling and floor. If the source of sound stops producing sound, the intensity of sound decreases due to absorption of sound. However, the sound continues to be heard because of the persistence of the reflected sound waves which go on traversing the hall a number of times before they reach an intensity below the threshold of hearing i.e. the multiple reflection of sound results in reverberation.

A room with zero reverberation time is called a dead room. An ordinary syllable takes about 0.2 seconds to decay. For a musical sou n d, the optimum value of reverberation time may be between 1 to 2 seconds. The reverberation time in the halls like theatres, auditoria, etc. is adjusted suitably by a specific design so that sound heard is distinct and pleasant.

For obtaining good acoustic property the hall should have sufficient sou n d absorbing features, like:

(i) A few open windows.

(ii) Sound absorbing soft materials like cloth, asbestos, etc. or heavy curtains put up in the hall at various places.

(iii) A good audience, because one listener is equal to 5 square feet of an open window.

(iv) Curved walls or corners should be avoided so that sound is not unduly concentrated and there are no regions of silence.

The tim e of reverberation can be d ecrease d by increasing absor p tion of sound. Reverberation should be small but not absolutely zero because then the hall gives a dead effect.

Diatonic Musical Scale : This scale consists of 8 notes. From the note (1) to (8) pitch increases due to increase in the relative frequencies.

▪▪▪

OPTICS

Ray Optics : It is base d on "the rectilinear propagation of light" i.e., light follows a straight line motion through a given transparent medium. It involves reflection, refraction & dispersion of light.

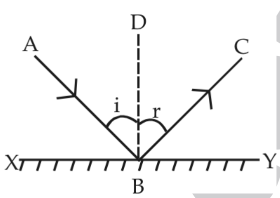
REFLECTION OF LIGHT

"When a light ray is incident on a surface, it returns back into the same medium."

Laws of Reflection :

(i) The incident ray, normal drawn at the incident point and the reflected ray lie in the same plane.

(ii) The angle of incidence is equal to the angle of reflection. In the given figure



XY = reflecting surface,

AB = incident ray,

BC = reflected ray,

DB = normal drawn at the incident point.

Angle of incidence

i = ∠ABD and angle of reflection

r = DBC

∴ i = r or, ∠ABD = ∠DBC

Reflection on a Plane Mirror : The image formed by a plane mirror is virtual & erect. The image distance is equal to the object distance from the mirror. The image is laterally inverted i.e., the right side of the object appears as the left side of its image & vice-versa. Lateral inversion is due to the fact that the image of an object is as far behind the plane mirror as the object is in front of the mirror.

For a given incident ray, if the plane mirror is rotated through an angle 'q' then the reflected ray rotates through an angle of '2q'.

The length of a plane mirror in which a person can see his / her full image is half the height of the person.

If two plane mirrors facing each other are inclined at an angle q with each other, then number of images of an object lying between them are given by—

$$n = \frac{360}{\theta}$$

(a) if n = an odd whole no. then 'n' images are formed

(b) if n = an even whole no., then (n – 1) images are formed.

e.g. (i) if angle between the two plane mirrors is 60°, then

no. of images formed by them

$$n = \left(\frac{360}{60}\right) = 6 - 1 = 5.$$

Image Formation in a Concave Mirror		
Position of object	**Position of image**	**Nature of image**
1. At infinity	At the focus	Real, Inverted & diminished.
2. Beyond the centre of curvative	Between the centre of curvature & focus	Real, Inverted & Diminished
3. At the centre of curvature	At the centre of curvature	Real, inverted & same size as that of the object
4. Between the centre of curvature and focus	Beyond the centre of curvature	Real, inverted & magnified
5. At the focus	At inifinity	Real, Inverted & highly magnified
6. Between pole & focus	Behind the mirror	Virtual, Erect & magnified

(ii) If the two mirrors are parallel, then q = 0°

$$\therefore\ n = \left(\frac{360}{\theta}\right) = \mu = \text{infinity}.$$

i.e., infinte no. of images are formed.

Use of Plane Mirror : Plane mirrors are used as looking glasses, in a solar cooker to reflect the sun-light, in a Kaleidoscope to see colourful images, in a periscope usually used in submarines to see outside the water surface, in a barbar's shop to see the back portion of the head, etc.

Some important facts regarding the image formation by a plane mirror :

- When we see a series of images in a thick plane mirror, out of these the second image is brightest.
- Out of 26 alphabets (e.g., A, B, C etc.) only 11 alphabets show lateral symmetry and the rest 15 alphabets have lateral inversion.
- If the object is displaced by a distance 'x' towards or away from the mirror, then its image will be displaced by a distance 'x' in the same sense.
- If the mirror moves by a distance 'x' towards or away from the object, its image will move by a distance '2x' in the same sense.
- If the object moves with a velocity 'v' towards or away from the mirror, its image appears to move with a velocity '2v' in the same sense. The same is true if the mirror moves.

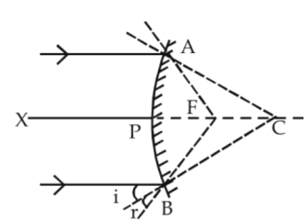
Reflection on Spherical Mirrors :

Types of spherical mirrors

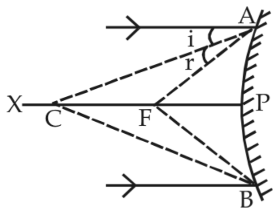
(i) **Convex or Divergent Mirror :** It is a portion of a hollow sphere of glass whose inner surface is silvered. Since rays incident parallel to the principal axis are diverged away the principal axis, hence, it is known as a divergent mirror.

(ii) **Concave or Convergent Mirror :** It is a portion of a hollow sphere of glass whose outer surface is silvered. All rays incident parallel to its principal axis are convergent at its focus.

The centre of a sphere whose certain portion is convex or convave, is called a centre of curvature. The middle point on the spherical mirror is called as its pole. The mid point between the pole and the centre of curvature is the focus. The distance between the pole and the focus is focal-length (f). The distance between the pole and the centre of curvature is radius of curvature (R). The perpendicular drawn at a point where a ray is incident on the spherical mirror must pass through the centre of curvature.



Convex mirror



Concave mirror

P = Pole

Px = Principal axis

C = Centre of Curvature

PC = Radius

F = Focus

PF = Focal Length

A & B : Incident points

AC & BC = Normal drawn at incident points.

Image formation in a convex Mirror.

It always produces virtual and diminished image irrespective of the position of the object.

Real Image : It is always inverted and in front of the concave mirror.

Virtual Image : It is always erect and behind the concave and convex mirror.

Focal length is half of the radius of curvature (f = R / 2).

Mirror Formula : $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}=\frac{2}{R}$

Where u = objects distance from the pole of mirror.

v = image distance from the pole of mirror.

f = focal length of the mirror.

R = radius of curvature of the mirror.

Magnification or Linear Magnification (m) -

$$=\frac{\text{Size of image}}{\text{Size of object}}=\frac{\text{Image distance}}{\text{Object distance}}$$

Spherical Aberration: The inability of a concave mirror of a larger size to converge all rays parallel to the principal axis at the focus, is called spherical aberration.

It can be removed by using a parabolic concave mirror of larger aperture.

Uses of Spherical Mirrors:

- A convex mirror is used as a reflector in street lamps to diverge light over a large area.
- A convex mirror is used as a rear view mirror or driver's mirror in cars, scooters etc. for looking at the traffic at the rear of the vehicle because this mirror produces an erect and diminished image of the traffic behind the vehicle. Since the image is small in size, hence the field view is much wider as compared to a plane mirror or a concave mirror.
- A concave mirror is used as a reflector in search light, head lights of motor vehicles, telescopes, solar cookers, etc. to produce an intense parallel beam of light. A bulb is placed at the focus of the concave mirror. The beam of light from the bulb after reflection from the concave mirror goes as a parallel beam.
- A concave mirror is used by dentists and ENT specialists to focus light on teeth, eye and throat to examine these organs. The device consisting of the concave mirror used to examine eyes is called Ophthalmoscope.
- A concave mirror is used as a shaving mirror or make up mirror as it can form erect and magnified image of the person within its focus.

- A spherical mirror can also be used as a trick- mirror or magic mirror to see different types of images of the same object or person.

Some important facts regarding the reflection of light:

- **Image :** Size of mirror does not affect the nature of the image except that a bigger mirror forms a brighter image. A virtual image cannot be taken on screen. But our eye lens forms a real image of the virtual image (acting as virtual objects) on the retina. A virtual image can be photographed.
- The focal length of a plane mirror is infinity.
- When a spherical mirror (concave or convex) is placed in a liquid e.g. water, its focal length does not change because focal length of a mirror depends upon its construction and not on the external medium.

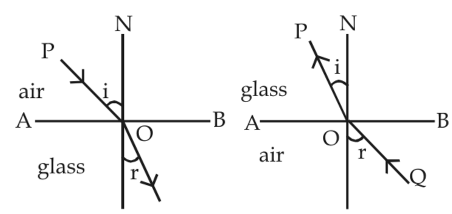
ABC of Photometry

S.No.	Term	Definition	Unit
1.	Luminous flux (f)	visible light energy	lumen
2.	Lumnious intensity or Illuminating power (I)	luminous flux emitted per unit solid angle	Candela or C.P.
3.	Illuminance or Intensity of illumination of surface (E)	luminous flux that passes through unit area in a direction normal to area.	(i) Lux or metre candle (ii) phot or cm candle
4.	Luminance or Brightness (B)	luminous flux reflected from unit area into our eyes.	Lambert

- When we read a book, light is scattered by the paper into our eyes. This is called Diffuse-reflection. A printed paper has a rough surface and hence, it cannot produce a regular reflection. That is why we read a book because of reflection of light but we do not see even a faint image of ours in its printed pages.

REFRACTION OF LIGHT

When light goes from rarer (e.g. air) to a denser (e.g. glass) medium, it bends towards the normal to the interface, separating these two media. On the other hand, when light goes from a denser to rarer medium, it bends away from the normal to the interface separating these two media. This phenomenon is known as refraction of light.



PO = Incident ray, AB = Interface

OQ = Refracted ray, i = Angle of incidence,

r = Angle of refraction.

Distinction between Real Image and Virtual image

Real Image	Virtual image
1. It is can be obtained on a screen.	1. Reflection of light occurs from the side which is bulged out.
2. Rays of light from the object, on reflection/ refraction, actually meet at the image.	2. Rays of light from the object, on reflection/ refraction only appear to meet at the image.
3. It is always inverted.	3. It is always erect.
4. Linear magnification is negative	4. Linear magnification is positive.

Laws of Refraction: (I) The incident ray, the refracted ray and the normal to the surface separating two media all lie in the same plane.

(II) **Snell's Law:** $\mu = \frac{\sin i}{\sin r}$ where μ is a constant. μ is known as the refractive index of the medium in w hich refracted ray travels w.r.t. the medium in which the incident ray travels.

Cause Behind Refraction of Light: Due to change in medium, wavelength of light changes. It results into change in the speed of light in that it causes bending light from straight path of original light.

Relative Refractive Index (μ)

$$1\mu_2 = \frac{c_1}{c_2} = \frac{\lambda_1}{\lambda_2} = \frac{\mu_2}{\mu_1}$$

where $1\mu_2$ = Relative refractive index of medium 2nd w.r.t. 1st medium,

C_1, C_2 = speeds of light of the two media.

l_1, l_2 = wavelengths of light of the two media.

μ_1 & μ_2 = individual refractive indices of the two media

Difference between Concave and Convex Mirrors

Concave mirror	Convex mirror
1. Reflection of light occurs from sunken side of mirror.	1. Reflection of light occurs from the side which is bulged out.
2. Its focus and centre of curvature are on front side of mirror. f and R both are negative	2. Its focus and centre of curvature are at the back of mirror. f and R, both are positive.
3. Image formed may be erect or inverted.	3. Image formed is always erect.
4. Size of image may be smaller, equal or larger than the size of object.	4. Size of image is always smaller than the size of object.
5. Field of view is narrow.	5. Field of view is broad.

Images Formed by Convex and Concave Mirrors

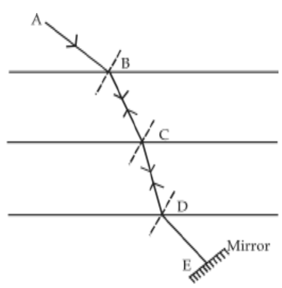
Mirror	Position of Object	Position of Image	Nature of Image	Size of Image
Convex	at ∞	at focus	erect	much smaller
Convex	between ∞ and pole	between pole and focus	erect	smaller than object
Concave	at μ	at focus	real and inverted	smaller than object
Concave	beyond C.	between F and C	real and inverted	smaller than object
Concave	at C	at C	real and inverted	same as size of object
Concave	between F and C	beyond C	real and inverted	larger than the object
Concave	at F	at infinity	real	larger than the object
Concave	between F and P	behind the mirror	virtual and erect	larger than the object

Deviation (d) of a light during refraction in a medium increases with (1) increase in refractive index (μ), (ii) increase in the density (r) of the medium and (iii) decrease in wavelength (l) i.e.

$$\boxed{\delta \infty \mu \infty \delta \infty \frac{1}{\lambda}}$$

Principle of Reversibility :

'If the path of a ray of light is reversed after suffering a number of refractions and reflections, then in the given figure a light ray suffers refraction thrice at point B, C & D. It follows path AB → BC → CD → DE. If the final ray DE is incident at 90° to a plane mirror M, it retraces the original path as ED → DC → CB → BA.



Some Common Effects of Refraction

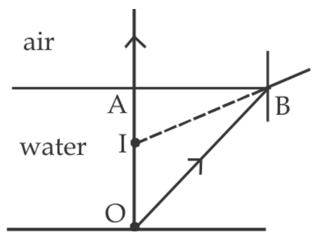
- Stars twinkle due to refraction. The different layers of atmosphere are of different (a) density, (b) temperature (c) speed and their density, temperature speed change continuously. Hence, the apparanet position of the star changes continuously. It leads to the twinkling of a star.
- A rod appears bent in water due to refraction of light.
- The sun is visible to us before actual sunrise & after actual sunset. The atmosphere has higher density than that of outer space. Hence, light coming from the sun enters outerspace to atmosphere i.e., from rarer to denser medium. It results in the bending of light. When the sun is below the horizon before the sunrise and after the sunset, its apparent position is visible above the horizon. Hence, the sun is visible 2 minutes before the actual sunrise and 2 minutes after the actual sun-set. Thus, the day becomes longer by 4 minutes due to effect of refraction.
- Real and apparent depths of an object in water or any transparent medium.

Difference between Reflection and Total Internal Reflection

(Simple) Reflection	Total Internal Reflection
1. Reflection occurs when light is travelling in a rarer medium or in a denser medium.	1. Total internal reflective occurs only when light is travelling in denser medium and tending to go into rarer medium.
2. Reflection takes place at all values of angle of incidence.	2. It is possible only when angle of incidence in denser medium is greater than critical angle for the pair of media in contact.
3. Some energy gets absorbed or refracted while majority of energy is reflected.	3. The entire energy is reflected. There is no absorption/ refraction.

Difference between convex lens and concave lens

Convex lens	Concave lens
1. The lens is thick at the middle and thin at edges.	1. The lens is thin at the middle and thick at edges.
2. Image formed may be real or virtual.	2. The image formed is always virtual.
3. Image formed may be equal in size, smaller or larger than the object.	3. Image formed is always smaller than the object.
4. It converges the rays of light.	4. It diverges the rays of light.
5. On moving sideways, image moves in opposite direction.	5. On moving sideways, image moves in same direction.



An object at O appears at I when it is viewed from air.

AO = Real depth of object in water or a transparent medium.

AI = Apparent depth of object.

If μ = relative refractive index of water w.r.t.air.

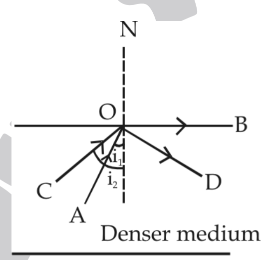
then, $\mu = \frac{AO}{AI}$ or,

Relative Refractive Index $= \frac{\text{Real depth}}{\text{App. depth}}$

Since relative refractive index of water is always greater than that of air (μ } 1), hence, real depth of an object is greater then apparent depth.

TOTAL INTERNAL REFLECTION (T.I.R.)

When light is incident from denser to rarer medium, it bends away from the normal drawn at the incident point.



Let us consider two light - rays viz. AO & CO incident at point O from denser to rarer medium. Ray AO is incident at angle i_1. Its angle of refraction is <NOB = 90°. The refracted ray OB is parallel to the surface of denser medium. This angle is called as Critical angle (i_1 = c). Ray CO is incident at an angle $i_2 > i_1$. Its refracted ray is OD in the denser medium. It means when a light ray is incident at an angle greater than the critical angle, it returns back to the same medium. This phenomenon of returning back of a light ray in the denser medium is known as T.I.R. **Critical angle (c):** The angle of incidence of a light ray in the denser medium corresponding with the angle of refraction in the rarer medium is 90° is called as critical angle.

Conditions for T.I.R. : (i) Light should be incident from denser to rarer medium & (ii) The angle of incidence should be greater than the critical angle (c).

Some common cases of T.I.R. :

- **The Brilliance of Diamonds :** The critical angle for the rays of travelling from diamonds to air is about 24.4°. The diamond is cut suitably such that light entering the diamond from any face falls at an angle greater than 24.4°, suffers multiple total internal reflections at the various faces, & remains within the diamond. The diamond sparkles due to the light trapped in it.
- **Mirage :** It is an optical illusion seen usually in deserts by which an inverted image of a distant object like a tree is observed along with the object itself as if reflected from the water - surface.

  In hot desert, lower atmospheric layers are rarer due to higher temperature than those of upper layers. A ray of light coming from the tree bends away from the normal as it travels from denser upper layer to the rarer lower layer. This process continues till the angle of incidence is less than the critical angle. At a particular layer of air the angle of incidence becomes greater than the critical angle and it gives rise to the T.I.R. It gives the impression of a water pond near the tree i.e. mirage.

- **Air bubbles in water or glass shine :** Water or glass is denser w.r.t. air. When light is incident at an angle greater than the critical angle, on going from water / glass to air bubble, it suffers T.I.R. Hense the air bubble shines brilliantly. This effect is used in manufacturing decorating glass objects.
- **Totally Reflecting Prisms :** These prisms are right angled isosceles prisms which turn the light through 90° or 180°. The critical angle for glass-air interface is 42° & in these prisms the angle of incidence is 45°. Thus, the angle of incidence becomes greater than the critical angle that causes total internal reflection. Such prisms are used in periscopes.

Combination of Colours

(a) Triangle representing primary colours and complementary colours is :

(i) R + G + B = W
(ii) B + Y = W
(iii) R + C = W
(iv) G + M = W

(b) Triangle representing complimentary colours and their combination is :

(i) B + Y = G
(ii) R + B = M
(iii) Y + R = O
(iv) Y + M = B + O = R + G = Black

Seven Colours of Visible Light

Colour	Range of wavelength (λ)	Range of frequnecy ($\times 10^{14}$ Hz)
Violet	3900-4550	7.69-6.49
Indigo	4550-4920	6.59-6.10
Blue	4920-5770	6.10-5.20
Green	5770-5970	5.20-5.03
Yellow	5970-6220	5.03-4.82
Orange	6220-7800	4.82-3.84
Red		

Refraction Through Lenses

Lens is a transparent medium bounded by two refracting surfaces. Out of these two refracting surfaces at least one is spherical.

A lens can be regarded as combination of a larger no. of small prisms. When a beam of light is incident on a lens, the rays of light get refraction through these prisms.

Structure of a lens:

(i) **Principal Axis :** It joins the two centres of curvature of the two spherical surfaces of a lens.

(ii) **Optical Centre :** The central point inside the lens where the passing ray remains undeviated is called optical centre.

(iii) **Principal Focus :** It is a point on the principal axis where the rays of a parallel beam of light meet or appear to meet after being refracted through the lens.

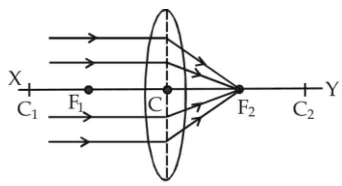
(iv) **Focal Length :** It is the distance between the principal focus & the optical centre.

Difference between Primary and Secondary Rainbow

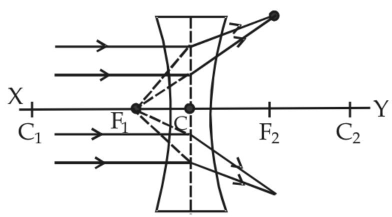
Primary Rainbow	Secondary Rainbow
1. It is much brighter.	1. It is fainter.
2. Outer arc is red and inner arc is violet.	2. Outer arc is violet and inner arc is red.
3. Incident ray of light undergoes one total internal reflection.	3. Incident ray of light undergoes two total internal reflections.

A biconvex or a biconcave lens has two centres of curvature and two foci.

Convex Lens



Concave lens



XY = principal axis, C = optical centre,

C_1 & C_2 = Centres of curvaturess

F_1 & F_2 = foci of lens.

Image formation by a lens :

(1) A convex lens can form both the real as well as the virtual images depending upon the position of the object.

(2) A concave lens forms always a virtual image.

Power of a Lens (P) $= \dfrac{1}{\text{focal length}} = \dfrac{1}{f}$.

Its S.I. unit is Dioptre (D). ID = $1m^{-1}$. Smaller the focal length of a lens higher is its power.

Common Defects of Vision

- **Long sightedness (Hypermetropia):** A person suffering from this defect can see objects far away but cannot see the nearer object. In this defect eye forms the image of an object behind the retina. For correct vision image should be formed at the retina only. This defect is corrected by using a convex (converging) lens of suitable focal length.
- **Short-sightedness (Myopia) :** A person suffering from this defect can see the nearer objects clearly but is unable to see objects far away. In this defect the image is formed in front of retina. This defect is corrected by using a concave lens of suitable focal length.

Some facts regarding the Lenses :

(1) If a convex and a concave lens of the same focal length are put in contact the combination acts as a glass slab.

Defects of Human Eye

Defect	What it is	Cause	Remedy
Myopia or Short sightedness	(i) Eye can see distinctly only the near objects, (ii) Far point of eye comes closer than infinity.	Focal length of eye lens decreases. Rays from µ focus at a point in front of the retina.	Using a concave lens of focal length = distance of far point from defective eye.
Hypermetropia or Long sightedness	(i) Eye can see distinctly only the far off objects, (ii) Near point of eye shifts away from the eye.	Focal length of eye lens increases. Rays from near point focus at a point at the back of ratina.	Using a convex lens of focal length (f) where $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ Here, u = distance of object from eye lens v = distance of near point of defective eye.

(2) If a convex and a concave lens of the same focal length are placed co-axially with a small separation between them, the combination acts as a convex lens.

(3) If a lens is cut into two equal halves with a plane perpendicular to the principal axis, the focal length of each part doubles.

(4) If a lens is cut into two equal halves with a plane along the principal axis, the focal length of each part remains unchanged.

(5) An air bubble in water behaves as a concave lens.

(6) When a lens is placed in a medium of higher density (higher refractive index), the nature of the lens reverses i.e. a converging lens behaves as a diverging lens & vice-versa.

(7) When a lens is placed in a medium of equal density, it acts as a glass slab. Its focal length becomes infinity and power becomes zero.

OPTICAL INSTRUMENTS

- **Microscope :** It is used to magnify minute objects close to us.

(i) **Simple Microscope (Magnifying glass)** : It is a biconvex lens. When an object is placed within its focus, a magnified, virtual and erect image is formed.

(ii) **Compound Microscope :** It consists of two convex lenses of unequal size placed co-axially. The larger lens is eye-lens to see the final image and the smaller lens is object lens in front of which the object is placed. The object lens forms a real inverted image

Difference between Astronomical and Galilean Telescope

Astronomical Telescope	Galilean Telescope
1. Used for observing far off objects in the sky.	1. Used for observing far off objects on the ground.
2. Final image is inverted w.r.t. the object.	2. Final image is erect w.r.t. the object.
3. Eye piece is a convex lens.	3. Eye piece is a concave lens.
4. $M = \frac{f_0}{-f_e}\left(1+\frac{f_e}{d}\right)$	4. $M = \frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right)$
5. Length of telescope tube is greater, $L = f_0 + f_e$	5. Length of telescope tube is smaller, $L = f_o - f_e$

of the object. This image is formed within the focus of the eye-lens and acts an object for the eye-lens. The eye-lens forms a highly magnified virtual image of the object.

- **Telescope :** It is used to see far off objects.

(i) Astronomical Telescope : It is used to see stars, planets etc.

It consists of two convex lenses. The larger one is the object lens and the smaller one is the eye lens. The real image formed by the object lens within the focus of the eye-lens, acts as an object for the eye-lens which gives the final, virtual and highly magnified image.

DISPERSION OF LIGHT

When white light passes through a glass prism, we get seven colours on a white screen. This phenomenon is known as dispersion of light. These seven colours obtained are viz. violet, indigo, blue, green, yellow, orange and red. They can be remembered as 'VIBGYOR'. Dispersion of light occurs due to refraction of light of different wavelengths contained by white light. Smaller the wavelength of light, more is its deviation. Since wavelength increases from violet to red light, hence, the deviation decreases from violet to red light. A band of seven colours of white light obtained by dispersion is known as a spectrum.

Spectroscope (or Spectrometer) : A device used to disperse light and to observe the spectra obtained is called spectroscope.

COLOUR OF OBJECTS

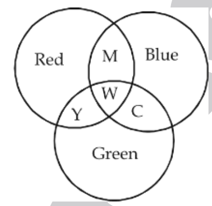
Colour of any object is the same as is reflected by the object and received by our eyes. e.g. when white light falls on a red- rose, it reflects only wavelength of red colour and absorbs all other colours of white light. Hence, it appears red.

Pigment : It imparts colour to the objects. A pigment absorbs most of the colours of white light and reflects one or more colours e.g. (i) A red rose appears black in green light. A red pigment in rose absorbs the green light and reflects nothing. So red rose appears black. (ii) A yellow flower appears red in red light. This is because yellow pigment in the yellow flower cannot absorb red light and hence, reflects the red light.

Primary Colours : They cannot be obtained by mixing two or more colours. They are viz. Red, Blue and Green. When they are mixed together, the result is white
i.e. Red + Blue + Green = White

Secondary Colours : When two primary colours are mixed, the new colour is a secondary colour.

They are :



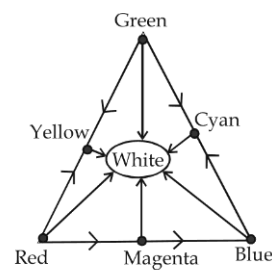
(1) Magenta (M) = Red + Blue

(2) Yellow (Y) = Red + Green

(3) Cyan (C) = Green + Blue

(4) White (W) = Red + Green + Blue.

Complimentary Colours : Any two colours are said to be a pair of complimentary colours if these colours produce white, when mixed together e.g.



(i) **Yellow + Blue =** White

∴ Red + Green + Blue = White & Red + Green = Yellow.

(ii) **Magenta + Green =** White

∴ Red + Blue + Green = White & Red + Blue = Magenta.

(iii) Cyan + Red = White

∴ Green + Blue + Red = White & Green + Blue = Cyan.

Thus, the complimentary pairs are (i) Yellow + Blue, (ii) Magenta + Green & (iii) Cyan + Red.

Primary Pigments : They are Yellow, Cyan & Magenta. When these three primary pigments are mixed in equal proportion a black pigment is obtained.

Yellow pigment + Cyan pigment + Magenta pigment = Black pigment.

Because, this mixture of pigments absorbs all colours of white light and reflects nothing, so it appears black.

Secondary Pigments : When a pair of primary pigments are mixed together, a new pigment is obtained called secondary pigment. They are:

	Primary Pigments	Secondary Pigments
(i)	Cyan pigment + Yellow pigment	Green Pigment
(ii)	Cyan pigment + Magenta pigment	Blue Pigment
(iii)	Yellow pigment + Magenta pigment	Red pigment

Thus, the secondary pigments are Green, Blue and Red pigments.

The primary pigments are same as that of secondary colours whereas the secondary pigments are same as that of primary colours.

SCATTERING OF LIGHT

When light passes through a medium and falls on the particles of the medium, it gets scattered in all directions. The intensity of scattered light decreases with increase in the wave length of light i.e., smaller the wavelength of light, more is the intensity of its scattering. e.g.

(i) **Blue colour of Sky :** Most of the blue colour of white light coming from the sun gets scattered by atmospheric particles because blue colour has smaller wavelength.

(ii) **The sun looks red at the sunrise and sunset:** The red colour is scattered least due to its longest wavelength and hence, the red-light is able to travel maximum distance in atmosphere. At the time of the sunrise and sunset, the position of sun is lower in sky and hence, it looks orange-red.

(iii) **Due to least scattering of red-colour,** it is used as a sign of danger-signals.

Rainbow : It is a spectrum of sun's light in nature. It occurs in the form of arcs of concentric coloured circles in the sky, when the sun's light falls on rain drops. Rain-drops act as tiny prisms that cause dispersion of light. The essential condition for observing a rainbow is that the observer must stand with his back towards the sun. Rainbow is formed due to the total internal reflections and refractions caused by rain drops.

Wave-Optics : Light is a transverse wave lying under the electromagnetic wave spectrum. Its speed in vacuum is 3×10^{8}m / s. It can undergo different wave phenomena like reflection, refraction, dispersion, interference, diffraction, polarisation, superposition, etc.

INTERFERENCE OF LIGHT

It involves superposition of two light waves at a point in the medium of propagation of light. When these light waves superpose crest to crest or trough to trough, the result is constructive interference whereas crest to trough superposition results in destructive interference. Coloured soap bubbles and oil film on water surface are observed due to interference of w hite light. For this thickness of wall of the bubble and oil film should be of the order of wavelength of visible light (4000A° to 8000A°). The phenomenon of interference is used in holography (three dimensional virtual image formation) by using a laser beam.

POLARISATION OF LIGHT

It involves restricting all vibrations of a light wave in a single plane.

Polaroids : Materials that polarise light. Most of them are artificial. Tourmaline is a natural polaroid.

Uses of Polaroids :

- In Sun glasses to protect the eyes from glare.
- In head light of motor-car to reduce glare.
- In wind shields of automobiles.
- In holograhy (3D Motion pictures)
- In old oil paintings to improve colour contrast.
- In optical stress analysis.
- In calculators and watches, letters and numbers are formed by LCD (liquid crystal display through polarisation of light.
- Polarisation of scattered sunlight is used for navigation in solar compass in polar regions of earth, where magnetic compass becomes non-functional.
- In CD Players, polarized laser beam acts as needle for producing sound from compact disc, which is in encoded digital format.
- Polarisation is used to study asymmetries in crystals and molecules using the phenomenon of optical activity. The ability of a crystal or molecule to rotate the plane of polarised light, either clockwise or anticlockwise is called optical activity.

■■■

HEAT

Heat is the form of energy that flows from a body at higher temperature to another body at lower temperature, when the two bodies are in contact with each other. Every body is composed of a large no. of particles which possess certain kinetic energy. The total sum of kinetic-energy of all constituent particles of a body is equal to heat contained by the body.

TEMPERATURE

It is the degree of hotness or coldness of the body. It is just a scale that measures the thermal state of a body. All bodies in thermal equilibrium are assigned equal temperature. A hotter body is assigned higher temperture than a colder body. The temperatures iof the two bodies are said to be in thermal equilibrium if no transfer of heat occurs when they are placed in contact.

Scales of Temperature : Common scales for the measurement of temperature are (i) degree centigrade or degree celsius (°C) (ii) Kelvin (K) and (iii) degree Fahrenheit (°F) scales. They are related to each other as follows :

$$\frac{t°C}{100} = \frac{TK - 273}{100} = \frac{t°F - 32}{180}$$

$$\text{or, } \frac{t°C}{5} = \frac{TK - 273}{5} = \frac{t°F - 32}{9}$$

$\therefore$ TK = t°C + 273, $t°C = \frac{5}{2}(t°F - 32)$ & so on.

The temperature of a body is measured by a

Thermometer: There is no upper limit of temperature but there is a fixed lower limit. The lowest value of temperature is called as 'Absolute Zero'. The absolute zero is equal to zero kelvin (O°K) or (–)273.15°C.

Clinical Thermometer : It is a mercury in glass type thermometer. The thermometer scale is marked from 95°F to 110°F or 35°C to 43°C within the range of human body temperature. Advantages of mercury in the thermometer-

(i) it is opaque and shining and hence, temperature can be read easily.

(ii) it is a good conductor of heat & hence, measures temperature quickly.

(iii) it does not stick to the wall of glass tube & also does not vaporize much & hence, gives correct readings.

A clinicial thermometer should not be sterilized in hot water otherwise mercury will expand too much and break the glass. Instead of mercury, water cannot be used inside the clinical thermometer because it freezes at 0°C whereas mercury freezes at (–) 39°C. Hence, in the cold countries where temperature in winter is usually less than 0°C, alcohol thermometers are useful. The temperatures recorded in the weather forecasting are carried out by using a special type of thermometer called the six's maximum and minimum thermometer.

THERMAL EXPANSION

The increase in length, area or volume of an object due to rise in its temperature is called as thermal expansion. The object shows contraction due to decrease in its temperature. The expansion / contraction of an object depends upon the change in temperature & its nature i.e. expansivitiy.

Practical applications of thermal expansion:

- A small gap is always left in between two iron-rails in a railway line.
- An iron rim to be fitted on a wooden cart wheel is always slightly small in diameter. The rim on heating expands and upon cooling gives a strong grip on the wheel due to contraction.
- Some suitable space is left between the girders used for supporting bridges.
- A glass stopper jammed in the neck of a glass bottle can be removed by warming the neck of the bottle.
- The clock pendulums are usually made of invar (an alloy), which has very low expansivity. This enables the clock to keep correct time in different seasons.

Bimetallic Strip : It consists of a brass layer & an invar layer riveted together. The expansivity of brass is more than that of invar. Hence, due to rise in temperature the strip expan ds into a curved shape having brass on the convex side. When temperature decreases, the strip retains original shape. Bimetallic strips are used as switches in thermostats which are used for regulating temperatures of electrically heated rooms, ovens, toasters, etc.

Unusual Expansion of Water : The volume of w ater decreases & density increases with increase in temperature from 0°C to 4°C. But its volume increases and d ensity d ecreases with increase in temperature above 4°C. Thus, the density of water is maximum at 4°C. This unusual expansion of water has a favourable effect for aquatic animals. Since the density of water is maximum at 4°C, water at the bottom of lakes, ponds etc. remains at 4°C in winter even if at the surface it freezes. This allows marine animals to remain alive and move near the bottom.

SPECIFIC HEAT

The specific heat of a substance is equal to the amount of heat absorbed by its unit mass to raise its temperature through one degree. Thus, larger the value of specific heat of a substance, smaller is rise in its temperature inspite of absorbing a large amount of heat. The specific heat of a substance depends upon the nature and its physical state. As specific heat capacity of water is large (4200 J kg $^{-1}$k^{-1}), hence, by absorbing or releasing large amounts of heat, temperature of water changes by small amounts. That is why water is used in hot water battles and also as coolant in radiators.

VAPOURS

A vapour is a gas that can be liquified by increasing the p ressu re witho u t changing the temperature. Gas and vapour are two distinct state of matter. A gas cannot be liquified by the application of p ressu re alone, ho w soever large the pressure may be. However, a gas can be liq uifie d by a pplying high p ressu re lowering the temperature.

When the molecules of a liquid escape the liquid surface slowly, it results in vapour above the surface and this process is known as evaporation. Evaporation lowers the energy of a liquid and hence, causes cooling effect. This effect is used in cooling water in pitchers having porous walls. When a space contains the maximum possible amount of vapour, the vapour is called saturated. If the amount is less than possible maximum amount of vapour, the vapour is called unsaturated. The possible maximum amount of vapour depends on the temperature & can be achieved easily due to rise in temperature of the liquid. The pressure exerted by a saturated vapour is called saturation vapour pressure (SVP). The temperature at which the saturation vapour pressure becomes equal to the present pressure is know as Dew-Point. If the temperature is decreased below the dew point some of the vapour condenses.

HUMIDITY

The amount of water vapour in a unit volume of air is called the Absolute humidity of air. Generally, it is expressed in gm / m^3. The ratio of the amount of water vapour present in a given volume to the amount of water vapour required to saturate the volume at the same temperature is called the relative humidity (R.H.). The R.H. can be given in terms of the following ratios as R.H.

$$= \frac{\text{Amount of water vapour present in a given volume of air at a temperature}}{\text{Amount of water vapour required to saturate the same volume at the same temperature}}$$

$$= \frac{\text{Vapour – pressure in air}}{\text{SVP at the same temp.}}$$

$$= \frac{\text{SVP at the dew point}}{\text{SVP at the air temp.}}$$

Generally, relative humidity (R.H) is expressed in a percentage. If the above ratio is 0.5, the relative humdity is 50%. If the air is already saturated, the R.H. is 100%.

Dew : In winter nights, the atmospheric temperature goes down. The surfaces of window-panes, flowers, grasses etc. become still colder due to radiation. The air near them becomes saturated & condensation begins. The droplets condensed on such surfaces are called as Dew.

Fog : In winter, if temperature goes down even more, the whole atmosphere in that region may become saturated. Small droplets then condense on the dust particles present in the air. These droplets keep floating in the air & form a thick mist which restricts visibility. This thick mist is called Fog.

In winter, glass- walls of a house, window & car-glass get wet on its outer surface. It occurs due to the condensation of water-vapour in the atmosphere on the glass surface as the temperature inside house or car is relatively higher than outer temperature. In summer, body temperature is regulated by the evoporation of sweat. However, at higher humidity in air, the rate of evaporation from the body slows down and sweat starts rolling off in streams. Sitting under a fan then increases the rate of evaporation due to moving air. The increased evaporation produces cooling.

The human body is comfortable at a temperature between 23°C to 25°C at a relative humidity between 60% to 65%. An air conditioner regulates these conditions of temperature and humidity inside a room.

BOILING OF A LIQUID

The energy of a certain mass of a liquid in its vapour state is more than in its liquid state. When heat is supplied to a liquid, its kinetic energy increases and at a certain stage, the molecules anywhere in liquid can form vapour bubbles. These bubbles float to the surface and finally vapour molecules come out of the liquid. This phenomenon is known as boiling and the temperature at which boiling occurs is known as boiling point. At the boiling point, the vapour pressure at the liquid surface becomes equal to the atmospheric pressure. Hence, higher the atmospheric pressure at the liquid surface higher is the boiling point of liquid. Water boils at 100°C when the atmospheric pressure is 1 atmosphere. 1 atmosphere is equal to 760 mm of mercury. If the pressure becomes 2- atmosphere, water boils at 120°C. In pressure cooker water boils at temperatures higher than 100°C due to highly increased pressure. The increased boiling point allows water to hold more heat which cooks food-faster. At higher altitudes, atmospheric pressure is reduced. It lowers the boiling point of water and food takes longer time to cook. Hence, a pressure cooker is more useful for cooking on hill-stations.

HEAT ENGINES

A heat engine converts heat into mechanical work. It takes heat from a body at higher temperature, converts a part of heat into the mechanical work & delivers the rest to bodies at lower temperature. The working substance inside the heat engine comes back to the original state. Thus, a heat engine works in cyclic process. The efficiency of a heat engine is equal to the ratio of the mechanical work done by the engine to heat supplied to it i.e.,

$$\text{Efficiency} = \frac{\text{work done by the engine}}{\text{heat supplied to it}}$$

Efficiency of a heat engine is always less than 1 or 100% because a heat engine cannot convert total heat supplied to it into mechanical work.

A heat engine consists of three components viz.

(i) **Source of heat :** It is at higher temperature from which the engine gets heat.

(ii) **Working Substance :** It converts the heat obtained partly into mechanical work & supplies the remaining heat to the sink.

(iii) **Sink :** It is at lower temperature to absorb unused heat.

Types of Heat Engine :

(i) **External Combustion Engine :** In an external combustion engine, heat is produced by the burning fuel in a chamber outside the body of the engine e.g. steam-engine. Super heated steam at 250°C & 20 atmosphere is its working substance. Practically, its efficiency is about 12% to 16%.

(ii) **Internal Combustion Engine :** In this engine, heat is produced by burning of fuel inside the body of engine e.g. Petrol & diesel engine. Its working substance is a mixture of air (98%) and fuel (2%). Petrol engine with a practical efficiency of 26% is used in light vehicles while diesel engine with a practical efficiency 40% is used in heavy vehicles.

(iii) **Refrigerator or Heat Pump :** It is a heat engine working in reverse direction.

Its working substance takes an amount of heat from a cold body, converts it partly into work & supplies the heat left to the hot body. Food stuffs, water, etc. inside the refrigerator act as a source of heat. A highly volatitle liquid, Freon (dichlorodifluoro methane) is its working substance. The outer surrounding at higher temperature acts as sink.

The freezer is surrounded by a copper coil in which freon evaporates that causes cooling effect. The vapour is removed and condensed to form liquid in the condenser coil, fitted at the back of the cabinet, by a compression-pump or compressor. The condenser coil becomes warm due to the liquification of vapour. Again, the liquid begines to evaporate & this cyclic process continues. A thermostat switch regulates the temperature inside the refrigerator by switching the compressor on and off at intervals. When the refrigerator is defrosted, the temperature inside it increases. Hence inner ice content melts. Defrosting is necessary for better working of the refrigertor.

HEAT TRANSFER

Conduction, convection and radiation are the three methods to transfer heat from one point to another. Usually, conduction takes place in solids, convection in liquids & gases and radiation does not require a medium.

A. Conduction : It involves heat-transfer from the hot end of a body to its cold end due to molecular collision to minimise the temperature difference. However, the conduction does not involve the actual movement of the molecules of the medium.

In general, solids are better conductors than liquids & liquids are better conductors than gases. Metals are much better conductors than non-metals. Metals have free moving electrons which carry heat from one point to the other in a metal.

For a given body, the rate of flow of heat by the con duction is directly proportional to the cross-sectional area, proportional to the temperature difference between the ends & inversely proportional to the distance between the ends. Hence, a thick & short metallic rod conducts more heat in a given time across its two ends than a thin & longer metal-rod.

Applications of Thermal Conduction:

- Cooking utensils are made of metals whereas their handles are made of plastic or wood because metals are better conductor and plastic & wood are poor conductors. Hence, hot utensils can be easily held by their insulating handles.
- In winter, metallic handle of a wooden door appear colder because it is a good conductor. Heat flows from our body to the handle which gives the sense of cold.
- Eskimos live in double walled snow huts called igloos. Air enclosed between the walls of ice is a bad conductor and ice is also a bad conductor. It prevents the heat they produce from escaping and keeps them warm.
- Saw dust is a poorer conductor of heat than the wood from which it is made because of air trapped in the saw dust.
- In winter, birds often swell their feathers. Air enclosed between their body and feathers does not allow flow of heat from the body of the birds to the cold surroundings.

- Ice is packed in gunny bags or saw-dust. Air trapped in the saw dust blocks the transfer of heat between the cold ice and the surroundings. It prevents the melting of ice.
- A new quilt is warmer than an old one. The new quilt encloses more air than the old one. This air, being bad conductor of heat, does not allow heat of our body to flow to the surroundings.
- Two thin blankets together are warmer than one blanket of their combined thickness. The air contained in between the two blankets is a bad conductor and it prevents heat from escaping and keeps the body warm.
- In airconditioned rooms, double layered windows are preferred than the single layered windows because a thin layer of air is contained between the two layer of glass panes in the window.
- In winter, a stone floor feels cold to the bare feet, but a carpet on the same floor feels warm even though they, are at the same temperature. Since the stone is a better conductor of heat than the carpet, hence the feet feel cold on the stone but not on the carpet.
- Due to the continuous working of a refrigerator, a thick layer of ice deposits on the outside and the inside of the freezer and hence, it has to be switched off for defrosting. The cooling action of the freezer slows down because ice is a bad conductor of heat. Hence, defrosting improves the functioning a refrigerator.

B.Convection : It involves the transfer of heat due to the movement of molecules. The hot molecules have higher kinetic energy and hence, they move towards the cold region and in order to occupy their position the cold molecules come from the cold region. It results convection currents and consequently the entire system gets heated. Convection is common in liquids and gases.

Applications of Thermal Convection:

- Function of ventilation in houses is based on the convection. During winter, air comes out from houses because the inside temperature is high whereas in summer air comes in because the outer temperature is high. It involves the movement of air from high in temperature to lower temperature by convection currents.
- In refrigerators, freezer is set at the top. Temperature of air at the bottom is higher than that inside the freezer. The warm bottom air moves up and cold freezer air moves down. It results convection current of air in the refrigerators that cools the entire inner space.
- In geysers and waters heater, the heating elements are fitted at the bottom. It causes hot-bottom water to move up and cold top-water to move down and thereby setting up a convection current. Consequently entire water content gets heated.
- In electric ovens, the heating elements are fitted near the bottom to heat the entire enclosed air by convection.
- Monsoons, trade wind in sea, water streams in sea, winds, etc. are due to the convection.
- The main mechanism for heat transfer inside a human body is forced convection through blood which is circulating by the pumping action of heart.

C. Radiation : Heat transfer by conduction and convection requires a material medium whereas heat transfer by radiation does not require a medium. All bodies radiate thermal radiations at all temperatures. The amount of heat radiation radiated per unit time depends on the nature of the radiating surface, surface area and temperature of the body. Similarly, all bodies absorb a part of thermal radiation incident on them. When an amount of thermal radiation is incident on a body, it is partly absorbed, partly reflected and partly transmitted. The amount of absorbed, reflected and transmitted thermal radiation depends on the nature & temperature of the body.

When a body absorbs more and emits less radiation, its temperature goes up; when a body emits more and absorbs less radiation, its temperature goes down and when a body absorbs and emits equal amount of radiations, its temperature remains constant. A good absorber is a good emitter and a poor absorber is a poor emitter. A body that absorbs all the radiations falling on it is called a black body.

Applications of Black Body: Such a body will emit radiation at the fastest rate on heating. Lamp black is close to a blackbody. Bolometer and thermopile are close to a blackbody. Bolometer and thermopile are instruments used to measure thermal radiation.

- A rough black surface is a good emitter as well as a good absorber of heat-radiation while a bright polished surface is a bad emitter as well as a bad absorber. Hence, a bright polished cup keeps tea or coffee warm for a longer time in comparison a rough black cup. The base of an electric iron is highly polished so that it does not lose heat by radiation. White or light colours of houses keep cooler in summer because light coloured surface do not absorb much solar radiation.
- **Thermos Flask :** It is a double walled glass bottle having a vacuum between the walls. The inner wall is silvered whose mouth is closed by a plastic stopper. The vacuum does not allow the loss of heat by convection and the stopper being insulator does not allow conduction of heat. The silvered wall prevents radiation as it is a poor emitter and a poor absorber of radiation. Thus, in a thermos flask transfer of heat by conduction, convection and radiation is minimised. Hence, a hot liquid in it remains hot and a cold liquid or ice in it remains cold for a longer time.
- At a point in front of fire, heat is received due to radiation only, while at a point above the fire, heat is received both due to radiation and convection. Hence, it is hotter at the same distance over the top of a fire than in front of it.
- When animals feel cold, they curl their bodies in a ball so as to decrease the surface area of their bodies. As total energy radiated by a body is proportional to the surface area of the body, the loss of heat due to radiation would be reduced.
- A box or a house with glass walls or glass windows, acts as a green-house because it traps heat radiations entering it through glass. The glass allows the heat radiation inside but blocks the hot-air from comeing out. Hence, a car parked in the sun with its windows closed gets terribly warm in comparison to the outer atmosphere.

- Cloudy nights are warmer than clear nights because clouds reflect the radiations emitted by the earth at night and keep it warm. Thus, clouds act as a blanket.
- Glass, which is ordinarily used as the base in photographic plates, is transparent to light while opaque to thermal infra-red radiation. But certain special kinds of glass have been prepared which are transparent only to thermal infra-red. Such glasses, used in the preparation of photographic plates, have made it possible to obtain long distance photographs, even under misty conditions using infra-red radiations.
- The fact that good reflectors are bad absorbers and bad radiators is utilised in making firemen's helmets and metallic tea-pots highly polished on the outside.

  Water can absorb 90% of heat radiation, which shows the importance of the existence of water vapour in the atmosphere. The water vapours in the atmosphere protect the earth from the more intense heat rays of the sun during the days and from the extreme cold during the nights. In very dry regions, where there is little water vapour in the air, the days are intensely hot and the nights are extremely cold.
- Gases are poor radiators of heat, hence in the construction of furnaces, the gases are made to fall on fire-bricks, which radiate heat freely.
- Because black bodies are the best absorbers of heat radiations, a black dress is uncomfortable during the hot summer, while a white one is cool.

NEWTON'S LAW OF COOLING

It states that the rate of loss of heat from a hot body is directly proportional to temperature difference between the body and its surroundings.

A hot water during cooling from 100°C to 90°C takes less time than that in cooling from 50°C to 40°C. Hence, when hot water and fresh tap-water are placed inside a refrigerator, the rate of cooling of hot water is found to be faster than that of fresh-tap water.

If hot coffee is served with cream in a cup and without cream in another cup, the creamed coffee remains hot for a longer time.

LAWS OF THERMODYNAMICS

First Law : The first law of thermodynamics is a particular and more rigorous statement of the principle of conservation of energy. When a substance absorbs an amount of heat at a constant pressure, then part of this heat is used up to raise the temperature which results in the increase of internal energy. The rest of the heat is used in doing work in allowing the external pressure.

Second Law : It is impossible to construct a device working in a cyclic process whose sole effect is the transfer of heat from a body at a lower temperature to a body at a higher temperature 'OR' it is impossible to construct an engine working on a cyclic process whose sole effect is the conversion of all heat supplied to it in an equivalent amount of work.

Entropy : It is a measure of randomness or disorderness of a system. It is a thermal property of a body which remains constant during an adiabatic process.

Third Law : At absolute zero (zero Kelvin) temperature the total sum of absolute entropy of a crystalline solid is equal to zero.

THERMODYNAMIC PROCESS

Isobaric Process : It involves constant pressure

Isochoric Process : It involves constant volume.

Isothermal Process : It involves constant temperature. However, heat changes.

Adiabatic Process : It involves constant heat. However, temperature changes.

Melting process and boiling process are common examples of an isothermal process because they occur at constant temperatures. Practically, a perfect adiabatic process is impossible. However, its approximate examples are (i) Sudden bursting of the tube of a bicycle tyre (ii) Propagation of sound in air. (iii) Expansion of gas or vapour in a heat engine.

LAWS OF GASES

- **Boyle's Law :** For a given mass of a gas, the volume is inversely proportional to its pressure at a constant temperature.

If P = pressure and V = volume of a given mass of a gas at a constant

temperature then, $V \propto \frac{1}{P}$ or VP = constant

constant

or, $P_1V_1 = P_2V_2$

Where P_1 and P_2 are initial and final pressures and V_1 and V_2 are initial and final volumes of a given mass of a gas at a constant temperature.

- **Charle's Law :** The pressure remaining constant, the volume of a given mass of a gas is directly proportional to its temperature in Kelvin scale i.e. V a T or $\frac{V}{T}$ = constant; where V is volume & T is temperature in Kelvin.

$$\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

- **Gay Lussac's Law :** The volume remaining constant, the pressure of a given mass of a gas is directly proportional to its temperature in Kelvin i.e.

P a T or $\frac{P}{T}$ = constant, where P is pressure and T is temperature in Kelvin of a given mass of gas at constant volume.

$$\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

- **Ideal Gas Equation :** It is also known as standard or the perfect gas equation which is given as

PV = nRT

where P = pressure, V = Volume, T = temperature in Kelvin, n = number of moles and R = universal gas constant.

KINETIC THEORY OF GASES

The Kinetic Theory of gases explains the behaviour of gases. Basic features are:

(i) All gases are composed of molecules. The molecules of a gas are alike and differ from the molecules of other gases.

(ii) The molecules are extremely small point masses, their dimensions being negligible as compared to the distance between them.

(iii) The molecules are continuously in motion. They have different velocities in different directions. The velocity of gas m olecules increases with temperature.

(iv) The gas m olecules collid e continuously against each other and against the wall of container.

(v) The pressure of the gas is equal to the pressure exerted by the gas molecules on the wall of container.

(vi) The gas-molecules are perfectly elastic spheres and exert negligible force of attraction or repulsion on each other or on the wall of container.

The kinetic theory of gases explains most of the gas laws like Boyle's law, Charle's law, ideal gas equation, etc.

TRIVIA

- The net change in the intermolecular kinetic energy is determined by the temperature. This is in accordance with the kinetic theory of gas. That is average kinetic energy associated with intermolecular forces is directly proportional to the temperature of the system.
- The heat capacity or thermal capacity depends on nature of the substance (specific heat capacity) and mass or quantity of matter of the body.
- Thermodynamics deals with the conversion of heat into other forms of energy as well as the change in state (solid, liquid, gas) of a system.
- Random motion of the constituents of the system involving exchange of energy due to mutual collisions is called thermal motion.
- Total kinetic energy, or internal energy or total energy does not determine the direction of flow of heat. It is determined by the temperature alone.
- When heat is absorbed by a body but its temperature does not change, only the intermolecular potential energy of the system changes. This is the case with melting and boiling.
- Systems are in thermal equilibrium when their temperature are same or average kinetic energy per molecule is same.
- Internal energy consists of energy of translational, rotational as well as vibrational motion of the molecules.
- The ratio of molar specific heat capacity depends on the molecular weight of the substance. Because it depends on mass of one mole which is turn depends on molecular weight.
- The temperature, volume or pressure of a system may remain constant when it absorbs heat.
- The temperature of the system may increase when heat is supplied to it or work is done on the system.
- Whole of the heat supplied can never be converted into mechanical work. This implies that the efficiency of heat engine can never be equal to 100%.
- Ther mod yna mics deals with the interconversion of heat energy, internal energy and mechanical energy or work.
- The physics of heat engine is similar to that of refrigerator.
- Hydrogen cannot be used as a thermometric substance above 500°C, because it starts diffusing.

- Pure and dry gas should be used as thermometric substance.
- Below -200°C, the hydrogen and nitrogen cannot be used because they start liquifying. Therefore, helium gas is used for temperature below - 200°C.
- The platinum thermometer can measure temperature accurately upto 0.1°C.
- The thermoelectric thermometers are very sensitive and can be used to measure the temperature of insects.
- **Radiation Pyrometer :** These are the devices to measure the temperature by measuring the intensity of radiations received from the body. They are based on the fact that the amount of radiations emitted from a body per unit area per second is directly proportional to the fourth power of temperature (Stefan's law). These can be used to measure temperatures ranging from 800°C to 4000°C. They cannot measure temperatures below 800°C, because the amount of radiations emitted from the bodies is too small to be measured.
- **Vapour Pressure Thermometer :** The vapour pressure depends on the temperature alone and it is independent of the nature of the vapours. This fact can be used to measure the temperature. It can be used to measure temperat ues near absolute zero by using different gases as the thermometric substances.
- **Magnetic Thermometer :** The magnetic thermometer is a device that uses adiabatic demagnetisation for measuring the temperature. They can be used to measure temperature very near to the absolute zero.
- The mercury thermometer with cylindrical bulb are more sensitive than those with spherical bulb.
- Alcohol thermometer is preferred to the mercury thermometer due to the larger value of the coefficient of cubical expansion.
- Following properties make mercury the ideal thermometric substance.
  (i) Does not stick to the glass walls.
  (ii) It shines.
  (iii) Coefficient of expansion is uniform.
  (iv) Vapour pressure is low.
  (v) Low thermal conductivity and specific heat.
  (vi) Available in pure form.
- Gas thermometers have higher sensitivity than the mercury thermometers because their coefficient of cubical expansion is much larger and same is for all gases:
  (i) Celsius & Fahrenheit at - 40°C = - 40°F.
  (ii) Fahrenheit and Kelvin at 574.25°F = 574.25 K.
  (iii) Fahrenheit and Reaumur at - 25.6°F = - 25.6°R
  (iv) Reaumur and Celsius at 0°R = 0°C
  (v) At no temperature the Celsius scale can have the same reading as the Kelvin scale.
- Six's thermometer measures minimum and maximum temperature during a day. It uses mercury as well as alcohol as the thermometric substance.
- Let the reading on the faulty thermometer be f and the true treading be t, then

Normal human temperature is 37°C = 98.4°F

- The clinical therometers read from 96°F to 110ºF.
- Thermo electric therometers can be used to measure rapidly changing temperature.
- Clinical thermometer are much shorter than the laboratory thermometers because they are used to measure a limited range (96°F to 110°F) of temperature.
- Platinum resistance therometer can be used to measure temperature inside a motor engine.
- The radiation therometers can measure temperature from a distance.
- Adiabatic demagnetisation can be used to meausre temperatures very near to the absolute zero.
- The degree Fahrenheit is the smallest temperature range among all the scales of temperature.
- **Heat :** It is a form of energy. The SI unit of heat is joule.

  (i) **Calorie :** It is the amount of heat required to raise the temperature of 1g of water through 1°C. For international use the calorie is defined as the amount of heat required to raise the temperature of 1g of water from 14.5°C to 15.5°C. [This definition is based on the average value of heat required to raise the temperature of 1g of water from 0°C to 100°C per °C rise in temperature]

  (ii) **Kilocalorie (k.cal)** = 1000 cal = amount of heat required to raise the temperature of 1 kg of water by 1°C.

  (iii) **British Thermal Unit (BTU)** : It is the fps u nit of heat = 252 cal = amount of heat required to raise the temperature of 1 lb of water through 1°F.

- 4.2 J = 1 cal
- **Specific Heat :** It is the amount of heat required to raise the temperature of unit mass of substance through 1 degree. Its dimensional formula is $ML^{2}T^{-2}q^{-1}$. It may be expressed in cal / g°C, kcal / kg°C. BTU / lb°F. J / kgk
- Cal / g°C = kcal / kg°C = 4.2×10^{3} j / kgK.
- **Molar Specific Heat :** The amount of heat required to raise the temperature of 1 mole of substance through 1 kg is called molar specific heat. It is denoted by C. Its unit is J / mol K. It is generally used for gases.
- For the gases, molar specific heat is defined at constant volume (C_v) and at constant pressure (C_p). It is found that $C_p - C_v = R$. Where R is molar gas constant.
- **Thermal Capacity :** It is the amount of heat required to raise the temperature of substance through 1°C or 1K. Thermal capacity = mass × specific heat. The dimensional formula for thermal capacity is $ML^2T^2q^{-1}$. Its unit is cal / °C, kcal / °C, J /K.
- **Water Equivalent :** It is the mass of water that requires the same amount of heat to raise its temperature through 1°C as the substance requires to raise its temperature through 1°C. Its unit is kilogram or gram. If m be the mass of the body and c be its specific heat, then water equivalent is given by W = mc.

- **Principle of Calorimetry :** The amount of heat gained or lost when its temperature rises or falls by Dq is given by : Q = mc Dq, where m is the mass of the substance.
- According to the principle of calorimetry, when two bodies exchange heat : the heat lost = the heat gained. It is in accordance with the law of conservation of energy.
- **Latent Heat :** Heat required to change the state (from solid to liquid or from liquid to gaseous, of one gram / kilogram of substance at constant temperature is called latent heat (symbol L). Its unit is cal / g, kcal / kg or J / kg.
- The amount heat absorbed or given out during the change of state is given by : Q = ML, where M is the mass of the substance.
- Latent heat is of two types : (i) Latent heat of fusion for change from solid to liquid at the melting point and (ii) Latent heat of vaporisation - for change of sate from liquid to gaseous state.
- Latent heat of fusion of ice is 80 cal / g.
- Latent heat of vaporisation for water is 535 cal /g
- Latent heat is used for doing work in increasing the distance between the molecules during the change of state. That is the latent heat increases the potential energy of molecules and their kinetic energy remains constant, therefore, the temperature also remains constant.
- **Sublimation :** Direct conversion of solid to vapours is called sublimation.
- **HoarFrost :** Direct conversion of vapours to solid is called hoarfrost.
- **Melting :** It is the process in which solid is converted into lqiuid. The reverse is called freezing or solidifcation.
- **Boiling :** It is the process of conversion of liquid to gaseous state. The reverse is called condensation or liquefaction.
- Melting and boiling occur at definite temperatures called melting point and boiling or liquefaction.
- The liquids boils at a temperature, at which its vapour pressure is equal to the atmospheric pressure.
- **Evaporation :** Conversion of liquid into gaseous state at all temperatures is called evaporation. It is a phenomenon that occurs at the surface of the liquid.
- The rate of evaporation increases with the rise in temperature.

■■■

ELECTROMAGNETIC RADIATION

An Electromagnetic radiation is an electro magnetic wave (E.M.W.) that consists of oscillating electric and magnetic fields. An accelerated charge (e.g. oscillating charge) produces an oscillating electric as well as magnetic field in its neighbourhood. These oscillating fields act as sources for each other and thereby produce each other. It results an E.M.W. The accelerated charge reduces its energy that appears as energy of E.M.W. The electric-field, magnetic field and speed of the E.M.W. are mutually perpendicular. It gives transverse nature of the E.M.W. An E.M.W. is associated with energy & momentum. Hence, it exerts a pressure on the surface of incidence.

BASIC FEATURES OF E.M.W.

(1) They are produced by accelerated or oscillating charges.

(2) They do not require any material medium for propagation.

(3) They travel in a freespace (vacuum or air) with the speed of light i.e. $3X10^8$ m / s because light is also an E.M.W. When they travel through a medium, their velocity depends entirely on the electric and magnetic properties of the medium.

(4) They are themselves uncharged and hence, do not get deflected by external applied electric and magnetic fields.

(5) They are composed of energy particles called Photons. Every photon has a fixed frequency which does not change when a photon travels through different media. The velocity of the photon changes in different media due to change in its wavelength. Photon is electrically neutral does not have mass at rest. In fact, a photon does not exist at rest because a photon is an energy particle of the E.M.W. which in turn is a dynamic state of energy.

(6) The E.M.W. shows all wave phenomena like light.

ELECTROMAGNETIC SPECTRUM

The orderly distribution of electromagnetic radiations according to their wavelength or frequency is called the electromagnetic spectrum.

Only a small part of this spectrum is visible to human eyes because the radiations of this part produces sensations on the retina of the eye.

(1) **Gamma Rays:** They are emitted by radioactive nuclei. They have the shortest wavelength and the highest frequency and hence, the highest energy. The study of γ- rays provides us with valuable information about the structure of the atomic nuclei.

(2) **X-Rays**: They are produced most commonly when fast-moving electrons

Electromagnatic Spectrum				
S.No.	Name	Wavelength (in m.)	Frequency Range (in Hz)	Source
1.	Gamma rays	6×10^{-14} to 1×10^{-11}	5×10^{22} to 3×10^{19}	Nuclear origin
2.	X-rays	1×10^{-11} to 3×10^{-8}	3×10^{19} to 1×10^{16}	Sudden deceleration of high energy electrons
3.	Ultra-violet	6×10^{-10} to 4×10^{-7}	5×10^{17} to 8×10^{14}	Excitation of electrons, spark and arc lamp.
4.	Visible Light	4×10^{-7} to 8×10^{-7}	8×10^{14} to 4×10^{14}	Excitation of valence electrons.
5.	Infra-Red	8×10^{-7} to 3×10^{-5}	4×10^{14} to 1×10^{13}	Excitation of atoms & molecules
6.	Heat-Radiation	10^{-5} to 10^{-1}	3×10^{13} to 3×10^{9}	Hot bodies
7.	Microwaves	10^{-3} to 0.3	3×10^{11} to 1×10^{9}	Oscillating currents in special vacuum tube.
8.	Ultra-high frequency (UHF)	1×10^{-1} to 1	3×10^{9} to 3×10^{8}	Oscillating circuit
9.	Very High Frequency (VHF)	1 to 10	3×10^{8} to 3×10^{7}	Oscillating circuit
10.	Radio-Frequencies	10 to 10^{4}	3×10^{7} to 3×10^{4}	Oscillating circuit
11.	Power frequencies	5×10^{6} to 6×10^{6}	60 to 50	Weak Radiations from a.c. circuit.
The overlapping in certain parts of above E.M. Spectrums shows that the correponding radiations can be produced by two methods.				

decelerate inside a metal target. They are used -

- **for detecting explosives:** o pium, jewelleries, etc. in the body of smugglers.
- **In Medical Diagnosis:** e.g. for the detection of fractures, foreign bodies, like bullets, diseased, organs and stones in the human body.
- **for detecting pearls** in oysters and defects in rubber tyres, gold and tennis balls.
- **in engineering** e.g. (a) for detecting faults, cracks, flaws and holes in final metal products (b) for the testing of weldings, castings and moulds.
- **in radiotherapy** to cure untraceable skin diseases and malignant growths. The photographic film containing the photographs of the body parts is as known a Radiograph.

(3) **Ultraviolet Rays:** They are produced by the excitation of atoms, a spark and arc lamp. The sunlight consists of ultraviolet rays as a part. Ultraviolet rays are very harmful to the living organisms. A long and constant exposure of our body to these radiations causes blindness and cancer. The ozone layer in the upper at mosphere absorbs most of the ultraviolet rays emitted by the sun. Only a small fraction of these rays reach t he su rface of t he eart h. Therefore, the ozone layer protects the organisms from the ultraviolet rays. A welder wears coloured glasses to protect his eyes, from the ultraviolet rays emitted by the welding spark. During the solar eclipse, the sun is completely covered by the shadow of the moon. But the ultraviolet rays emitted by it reach the earth. Hence, the direct vision of the solar eclipse through the naked eyes is avoided.

They are used: (i) to preserve food stuff & making drinking water free from bacteria as these rays kill bacteria & germs.

- to detect the invisible writings, forged documents and finger- prints in forensic laboratory.
- to study the structure of solids and molecules.
- for sterilizing the surgical instruments.
- for checking the mineral sa mples through the property of ultraviolet rays causing **flourescence.**
- in burglar alarm.

(4) **Visible Light:** White-light emitted by the sun is visible light. It is composed of seven colours. Except the visible light, all the remaining electromagnetic radiations are invisible. Besides the solar-radiations, there are a number of sources giving visible light e.g. candle, electric-bulbs etc.

(5) **Infra-red rays:** Infra-red rays are emitted by the atoms and molecules of hot-body. Infra-red rays are absorbed by the body on w hich they fall. So the body becomes hot. Hence, infra-red rays are also known as heat-radiations.

They are used:

- to heat the interior of a car and house,
- to cook food using a solar cooker,
- to heat water using a solar water heater,
- to treat muscular strains,
- for drying wet clothes and grains after harvesting,
- in night vision devices during warfare because infra-red rays can pass through haze fog, smoke and mist,
- to provide electrical energy to satellite by using solar cells,
- for producing dehydrated fruits,
- for taking photographs during the conditions of fog, smoke, etc.
- in green houses to keep the plants warm,
- in weather forecasting through infra-red photography, and
- in checking the purity of chemicals and in the study of molecular structure by taking infra-red absorption spectra,

(6) **Heat Radiations:** They are produced by any hot bodies. They are used for heating purposes.

(7) **Microwaves:** They are produced by oscillating electrical circuits. They are used:-

- in micro wave ovens.
- in RADAR systems and in satellite communication.

(8) **UHF, VHF and Radiowaves :** They are produced by the oscillating circuits. They are used as carrier waves during the transmission of Radio-signals, TV-signals, FM-Radios, etc.

(9) **Po w er- frequencies or Po w er Waves :** They are pro duced from a.c. circuits. They are used for lightning.

RADIATION IN ATMOSPHERE

The main source of radiations in the atmosphere is the sun. Visible light is weakly absorbed whereas most of the infra-re d ra ditations are absorbe d by t he atmosphere and is used to heat it. The ozone layer of atmosphere absorbs most of the ultraviolet-rays and thus protects us from their harmful effects. The ozone layer converts the ultraviolet radiations to infra-red which is used to heat the atmosphere and the earth's surface. It is suspected that ozone layer is slowly being depleted and this is causing great concern to scientists and environmentalists.

The earth gets heated by absorbing heat from the sun & radiated energy mostly in the infra-red region. Low lying clouds and the atmosphere prevent these infra-red radiations of earth from passing through them and thus serve to keep earth's surface warm at night. This phenomenon is called as "Green House Effect".

The upper part of the atmosphere of the earth receives about 1.36 kilo joule of energy per second per unit area from the sun. The earth's surface receives 47% of this energy emitted from the sun. The energy crisis can be overcome by harnessing this energy. A large number of devices have been developed to harness the solar energy directly. The commonly used devices are: Solar cookers, solar furnaces, solar water heaters, solar power plants, solar-cells etc.

All of the above devices are pollution- free and most of them are economical.

Limitations in harnessing solar energy are---

(i) Solar energy reaching the earth is highly diffused and scattered. Hence, it is not able to perform much useful work.

(ii) It is not available at all places and at all times.

ELECTRIC DISCHARGE THROUGH GASES

At normal pressure gases are insulators but at very low pressure they can allow the flow of electric current due to an applied potential difference. The electric-discharge through a gas is carried out in discharge tube. The discharge tube involves the ionisation of gas which gives rise to different coloured discharges and finally, the cathode rays are produced depending upon the value of pressure inside the tube.

The discharge tube phenomenon is used in making sodium lamps, mercury vapour lamps, fluorescent tubes, neon signs, flood light, etc.

Cathode rays consisting of electrons, are produced in the discharge tube at a pressure of 0.01 mm of mercury.

ELECTRONIC EMISSION

The pheno menon of emission of electrons from the surface of a metal is called electronic emission.

(a) **Thermionic Emission:** It involves emission of electrons due to appropriate heating of the metal surface. The devices like diode valve and triode valve are based on the thermionic emission of electrons. The diode valve is used as rectifier and triode valve is used as transistor an d amplifier in electrical circuits.

(b) **Photoelectric Emission:** It involves emission of electrons from the metal surface due to incidence of light of a suitable frequency. It is also known as photoelectric effect.

PHOTOELECTRIC CELLS OR PHOTO CELLS

They convert light energy into electrical energy. They are based on the phenomenon of photoelectric-emission. They are also kno w n as Electric-eyes. A ph oto-cell converts a change in intensity of illumination into a change in the photo current obtained. This current is used to o perate control syste m s an d in light measuring devices.

Applications of Photo-cells:

- in TV camera for telecasting scenes and in photo-telegraphy.

- to switch on and off the street lightning system at dusk and dawn, without any manual attention.
- in photometry to compare the illuminating powers of two sources.
- in industries for locating small flaws or holes in metallic sheets.
- as photoelectric sorters; to sort out the materials of different shades.
- to determine the opacity of solids and liquids.
- to control the temperature and chemical reactions.

METALS SHOWING THE PHOTOELECTRIC EMISSION

Alkali Metals: Lithium, so dium, p otassium, cesium, etc. sho w the photoelectric effect with visible light.

In the photoelectric effect, one photon incident on the metal-surface causes the emission of one electron called photo electron. Higher the intensity of light, more is the no. of photons incident and hence, more is the no. of photoelectrons emitted. Higher the frequency of the photon incident, higher is the kinetic energy of the photo electron emitted. The photoelectric effect shows the particle nature of light i.e. light is composed of energy-particles called photons.

The particle nature is given as

$E = mc^2$ where E = energy, m = mass & c= speed of photons.

The wave-nature is given as

$E = hv$, w here E = energy an d v= frequency of photon h = Planck's constant

Photons are electrically neutral and have zero rest mass.

Dual Nature of Matter: Microscopic particles like electrons have mass character as well as wave character. The nature of a particle to behave as a mass as well as a wave is known as dual nature of matter. Electron-microscope is the device that exploits the wave-nature of electrons to provide high resolving power.It has successfully been employed to investigate structural details of bacteria, viruses, etc. It has proved to be a powerful tool of investigation for research in science, technology, metallurgy, industry, medicine, etc.

X-RAYS

When highly energetic electrons are made to strike a metal target of high atomic number like Tungsten and Platinum, the x- rays are emitted.

The device used to produce x-rays is known as an x-rays tube or Coolidge tube.

X-rays are electromagnetic waves. They can affect a photographic plate more strongly than visible light. They cause fluorescence w hen incident on certain materials as barium platinocyanide. X-rays can ionise the gas.

They can pass through small thicknesses of aluminium, woods, plastics, human-flesh etc. They are stopped by materials of high density and high atomic number. Hence, x-rays machines are used to inspect luggages at the custom, security gates, airports, etc. The frequent and excess exposure of x-rays may cause diseases like genetic-disorders; cancer, etc. The screen of Computer, TV, oscilloscopes, etc. are using a cathode-ray tube in which a highly accelerated electrons strike the screen. It results in a small amount of x-rays. Hence, their screens are designed to absorb the x-rays.

■■■

ATOMIC PHYSICS

Every atom is composed of three kinds of fundamental particles viz. Electrons, Protons and Neutrons. Protons and Neutrons are in the atomic nucleus while electrons revolve around the nucleus in definite circular path called orbits. Electrons are negative and have a definite energy in a definite orbit. Protons are positive while neutrons are neutral.

When an electron changes its orbit, an amount of energy is exchanged (lost or gained) in the form of radiations (infra-red, visible, ultraviolet and even x-rays). Every atom has an equal no. of electrons and protons and hence, an atom is neutral. The no. of protons in an atom is equal to its atomic number. The sum of the no. of protons and neutrons is equal to the mass number.

The size of the nucleus is much smaller than that of the atom. The concept of nucleus, nuclear and atomic size were given by Rutherford. The concept of orbits and energy of an electron in its orbit were given by Neil Bohr. The motion of an electron in its orbit is similar to that of a planet moving round the sun.

The electron in the orbit closest to the nucleus has least energy and as the orbit number increases away from the nucleus, energy of the electrons also increases.

Every nucleus of the atom has neutrons and protons. The volume of the nucleus is directly proportional to its mass number. Hence, the size of the nucleus increases with increase in the mass number.

NUCLEAR STABILITY

It depends upon the nuclear size and neutron: proton ratio. As the nuclear radius increases, nuclear stability decreases. Higher the n / p ratio of a nucleus lower is its stability. From Hydrogen (Atomic No=1) to Bismuth ($^{209}_{83}Bi$ - At .No. 83 & Mass No. = 209) all nuclei are quite stable except Technetium ($_{43}Tc$) and Promethium ($_{61}Pm$).

However, from atomic number 84 (Polonium -Po) to 92 (Uranium -U) are natural radioactive nuclei. Due to radioactivity, their nuclei disintegrate spontaneously. The nuclei of the elements Neptunium ($_{93}Np$) onwards are artificial and do not exist in free state in nature.

The force of attraction responsible for binding the nucleons (protons, neutrons etc.) in the nucleus is nuclear force. As the nuclear size increases the nuclear force of attraction decreases. The nuclear force is the strongest force in nature.

MASS DEFECT

The total sum of masses of individual nuclear particles (Nucleons) in a nucleus is greater than the rest of the actual rest mass of the nucleus. Their difference is known as mass defect. This mass defect gets converted into energy which is called Nuclear-binding energy.

Nuclear species called Nuclides are symbolised as ${}^{A}_{Z}X$ where X= chemical symbol of the species, Z= Atomic number= Number of proton = Number of electrons, A = Mass number = Sum of number of protons and neutrons, A-Z= Number of neutrons (N).

e.g. ${}^{209}_{83}Bi$. Bi = Bismuth, 83 = Atomic no. = No. of proton

209 = Mass No. = Z+N = A

209 - 83 = 126 = No. of neutrons.

- **Isotopes** : They are a group of nuclides having equal no. of protons.
- **Isobars**: They are a group of nuclides having equal mass no.
- **Isotones:** They are a group of nuclides having equal no. of neutrons.

RADIOACTIVITY

The property by virtue of which a heavy n ucleus of element disintegrates itself without being forced by any external agent to do so, is termed as radioactivity. The pheno menon of ra dioactivity is q uite natural and can not be stopped. It was discovered by Henry Becquerel in 1896.

The ra dioactivity results in the conversion of an unstable larger nucleus into smaller stable nucleus along with the emission of certain radioactive decays. These radioactive decays are alpha rays, beta rays & gamma rays. During every radioactive decay an amount of energy is released.

When a nucleus emits an alpha-particle, the daughter nucleus has atomic number lesser by 2 units and mass number lesser by 4- units.

When a nucleus emits a beta-particle, the mass number of the daughter nucleus remains unchanged but its atomic number increases by one unit. There is no effect on the atomic and mass number due to gama-emission.

Units of Radioactivity:

1 Becquerel (Bq) =1 decay / second

1 Curie (Ci) = 3.7×10^{10} decays / second

1 Rutherford (Rd) = 10^{6} decays / second

HALF- LIFE TIME (T)

The time period during which half of the total initial number of radioactive atoms decays, is called as half-life time.

e.g. for ${}^{14}_{6}C$ = T= 5770 years.

for Polonium, T= 3×10^{-7} sec.

Half-life time (T) is given as: $T = \frac{0.6931}{\lambda}$ (where l = decay constant)

Average life time of a ra dioactive substance is given as $\tau = 1.44 \times T$, where T = half life.

The full-life time of a ra dioactive substance is infinity i.e. the taken initial sample of a radioactive sample decreases in amount with time but never becomes zero.

Besides α -, β - &, γ - particles, some other subnuclear particles like positrons, neutrinos, antineutrino etc. are also emitted during the radioactive decays. Positron is an antiparticle of electron i.e. it has mass equal to electron but is equally positively charged. It is also known as positive β - p article. Sy m bols use d for p osition, neutrino an d anti-neutrino are $+^{e}_{1}, \nu \& \bar{\nu}$ respectively. Nuclear changes during the radioactive decays:

(1) a decay $\rightarrow {}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He^{++} + Energy$

Uranium $\rightarrow$ Thorium + α-particle + Energy

(2) β decay $\rightarrow {}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e + Energy$

Thorium $\rightarrow$ Protactinium + b-particle + Energy

(3) γ decay $\rightarrow {}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e + \gamma$

Sodium $\rightarrow$ Magnesium + β- particle + gamma-particle.

ARTIFICIAL & INDUCED RADIOACTIVITY

The phenomenon of disintegration of otherwise stable nuclei by bombarding them with suitable projectiles is called artificial radioactivity.

Generally, such disintegration stops as soon as the bombardment is over. However, if the bo m bar d e d n ucleus keeps on disintegrating even after the bombardment is stopped, the phenomenon is called induced radioactivity.

e.g. Boron, when bombarded by α - particle, continue to disintegrate further even after the bombardment is stopped, as follows :

$${}^{10}_{7}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{0}N$$

Boron + a particle $\rightarrow$ Nitrogen - 14 $\rightarrow$ Nitrogen -13 + Neutron. ${}^{13}_{7}N$ Produced is a radioactive nucleus produced by artificial radioactivity. Its half-life is 11 minutes.

$${}^{13}_{7}N \rightarrow {}^{13}_{6}C + {}^{0}_{+1}e$$

Nitrogen $\rightarrow$ Carbon - 13 + positron.

ABC OF RADIATION

Properties	α-rays	β-rays	γ-rays
1. Similar to	Helium nuclei	Electrons	E.M. Waves like X-rays
2. Symbols	${}^{4}_{2}He^{++}$	${}^{0}_{-1}e^{-}$	${}^{0}_{0}r^{0}$
3. Atomic No.	2	–1	0
4. Mass No.	4	0	0
5. Speed	1.4×10^{7} m/s to 2.1×10^{7}m/s	33% to 99% of the light	Equal to the speed of light
6. Penetrating power	Least and can be stopped by 0.02 mm thick aluminium sheet.	Higher and can pass through a few mm thick alumium sheet	Highest & can pass through several cms thicks iron & lead slabs.
7. Ionising power	Maximum due to maximum charge (+)2 unit & maximum mass	Intermediate that of between a– & g rays	Minium due to zero charge
8. Range in air	Depends upon the radio active source and varies from 3 to 8 cm.	Several meters	Very long
9. Effect on photographic plate	Produce smaller effect	More effect	Maximum effect
10. Flourescence effect	Produce flouresence in in some substance like barium-plantinocyanide and zinc sulphide	Also produce flouresence in barium plantinocyanide and zinc suplide	Produce flouresence in some substances like willimite
11. Effect of electric and magnetic field	Show deflection	Show deflection	do not show deflection
12. Effect on human body	Cause burning effect	Can cause a shock on longer exposure.	Can cause cancer

NUCLEAR REACTION

It involves the transformation of a stable nucleus into another nucleus by bombarding the former with suitable particles. These particles are called projectiles e.g. neutron, proton, electron, alpha-particle, γ-ray etc. Neutron due to mass and Zero charge is the best projectile.

Representation of a nuclear reaction.

Target Nucleus +Projectile $\rightarrow$ Daughter Nucleus + Emitted - Particle

e.g. ${}^{14}_{7}N \rightarrow {}^{4}_{2}He \rightarrow {}^{17}_{8}O + {}^{1}_{1}H$

Nitrogen - 14 + - particle $\rightarrow$ Oxygen - 17 + Proton

Above reaction is the 1st artificial nuclear transmutation discovered by Rutherford in 1919.

A nuclear reaction may be of two types viz. Nuclear Fission and Nuclear Fusion.

I. Nuclear Fission

The process of splitting a heavy nucleus (usually of atomic mass >230) into two comparatively small nuclei of middle weight along with the release of very large amount of energy is called nuclear fission.

In this process, a fraction of mass disappears that appears in the form of energy released.

Otto Hahn & Strassman discovered that when Uranium -235 isotope (${}^{235}_{92}U$) is bombarded with thermal neutron, it splits up into two smaller nuclei with the emission of 3 neutrons along with 200.4 Mev of energy per fission.The neutrons produced after fission are called secondary neutrons.

Such a huge amount (200.4 Mev) of energy is released only in about 10^{-9} seconds. This released energy appears in the form of γ-rays, kinetic energy of nuclei of Barium (Ba), Krypton (Kr) & neutrons (n).

$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + 200.4MeV$$

- **Nuclear Chain Reaction :** In a nuclear fission of Uranium three secondary neutrons are released along with a huge amount of energy. These three neutrons ca use the fission of other three Uranium-235 nuclei & produce 9-neutrons which in turn, can bring about the fission of 9-Uranium -235 nuclei & so on. This process multiplies so quickly (i.e. a few micro-seconds) that a tremendous energy is released in a fraction of time. Such a continuous process is known as Chain Reaction. If the chain reaction is controlled the energy released is used for peaceful purposes like in Nuclear Reactor or Nuclear-pile. If the chain-reaction is uncontrolled, the tremendous energy released brings about a disastrous effect like Atom-Bomb.

- **Controlled Chain Reaction:** If only one neutron, out of 3- neutrons released in every fission of Uranium, is used to cause further nuclear fission, the constant amount of energy is released. Such a nuclear fission is known as controlled nuclear fission or controlled chain reaction. The secondary neutrons released are fast moving neutrons whereas to have a controlled chain reaction the slow moving neutrons called Thermal neutrons are required. Hence to achieve a controlled chain reaction the fast moving neutrons have to be slowed down and the surplus neutrons have to be absorbed. The fast moving neutrons are slowed down by a substance called a Mo derator e.g. graphite, deutrium or heavy water. The number of neutrons released is reduced by Control Rods e.g. Boron - rods or Cadmium rods.

- **Nuclear Reactor :** It converts nuclear energy into heat. It is base d on controlled nuclear fission.

Fuel: A fissionable material is used as a fu el. e.g. $^{235}_{92}U, ^{239}_{94}U$ (Plu tonium), etc. Commonly is used as a fuel.

Coolant: It is used to absorb the heat produced in the reactor core. e.g. water and heavy water are used as Coolants at or dinary te mp arat u re b u t at high temperature, generally liquid sodium is used as a coolant.

Shield: The whole reactor is protected with a concrete wall; so that radiations emitted can be stopped.

Moderators & Control-rods: Moderators are around the core of the reactor. Control - rods are inserted inside the core of the reactor.

Fast Breeder Reactors: Out of the total Uranium available in nature only 2% part is fissionable ^{235}U & 98% part is non-fissionable ^{238}U. In the fast breeder nuclear reactor, ^{238}U is first converte d into fissionable ^{235}U which is further broken dow n an d the n uclear fission reaction proceeds as follows:

$$^{238}_{92}U + ^{1}_{0}\gamma \xrightarrow[-\beta]{} ^{239}_{93}N_P$$

$$\xrightarrow[-\beta]{} ^{239}_{94}Pu \xrightarrow[-\infty]{} ^{235}_{92}U$$

Use of Nuclear Reactors:

(a) in electrical power production

(b) for the propulsion of ships, submarines and air crafts.

(c) to produce radioactive isotopes. These isotopes are used in medical science, industry and agricultural research.

(d) to produce neutron beam of high intensity which is used in the treatment of cancer and nuclear research.

Indian Nuclear Reactors

Our country has adopted a three- stage strategy of nuclear power generation :

(a) The first stage aims in the use of natural uranium as a fuel, with heavy water as moderator.

(b) The second stage involves the development of the fast breeder reactors. For this, the discharged fuel from the reactors is reprocessed to obtain plutonium-239, which is further used for the fast breeder reactors.

(c) The third stage involves using fast breeder reactors to produce missile U-233 from Th -232 & to build power reactors based on them. India is currently, well into the second stage of the programme and considerable work has also been done on the third stage (i.e. the utilization of Th-232).

Earlier reactors developed in India were Apsara (first) and CIRUS (Canada India Reactor). They used natural uranium as fuel and heavy water as moderator. Besides these research reactors, EERLIN A, PURNIMA (I, II & III), DHRUVA an d KAMINI have been su bseq uently co mmissione d as research reactors. KAMINI is the country's first large research reactor that uses U-233 as fuel.

India gets most of its Uranium from the Jadugura mines in Jharkhand. The Uranium obtained from these mines is taken to the

Nuclear Fuel complex situated at Hyderabad for processing. At this complex, the fuel elements are formed after enriching the Uranium. These processed fuel elements are then supplied to different nuclear plants as situated, at Kota in Rajasthan, Narora in U.P., Tarapur in Maharastra and Kalpakkam in Tamil Nadu.

Nuclear Hazards

The nuclear radiations cause pollution at three stages:

(a) When nuclear fuel is mined, processed and enriched, it constantly emits nuclear radiations.

(b) Accident can be caused due to leakage of nuclear reactions from reactors. Sometimes the nuclear reactor core may get faults resulting in vast radiations. Such accidents have already been occurred, one in USA at Three Mill Island and other at Chernobyl in Ukraine.

(c) Disposal of nuclear waste - It is a big problem and it can not be thrown anywhere. These waste materials contain radioactive substance which radiate radioactive rays. At presently, the nuclear waste is sealed in the thick stainless steel vessels and is dumped deep into the earth.

Harmful effects of the nuclear radiations:

(a) They can change or damage the structure of cells in the human body.

(b) They cause diseases like cancer, leukemia and blindness.

(c) They cause genetic disorder in a human body.

(d) They can cause sterility in the young generation.

The Nuclear radiations incident on the organisms cause the ionisation of atoms and molecules resulting in the decomposition of the complex organic molecules in the body of the organisms. Consequently the normal functioning of the biological system becomes disrupted. The damaging effect of the nuclear radiations would depend upon - (i) dose of radiations, (ii) rate of dose given, and (iii) nature of the organism exposed.

The dose of radioactive (nuclear) radiations is measured in a unit called Roentgen(R). The quantity of radiations that produces 1.61×10^{12} pairs of ions in 1 gm of air is equal to one Roentgen(R). In practice, milliroentgen is used as the exposure unit or dosage unit. The radiation absorbed per second is called dose rate or exposure rate or radiation absorbed dose.

The safe limit of exposure to radiation over the entire body is 250 milliroentgen (mR) per week. This is known as Permissible dose. Cancer may be caused at a dose rate of 100R. Death of an organism is possible if this dose exceeds 600R.

II. Nuclear Fusion

The phenomenon of combining two or more lighter nuclei to form a single heavy nucleus is called nuclear fusion. It results in the release of tremendous amount of energy. It requires very hight temperature (10^7K) & pressure which are not possible on earth. Such conditions are available in stars & hence, the nuclear fusion is a stellar phenomenon. It is the cause behind the stellar energy. In the biggest star i.e. sun, the nuclei of hydrogen fuse together to produce helium nucleus and a tremendous amount of energy.

$$4\,{}_1^1\mathrm{H} \rightarrow {}_2^4\mathrm{He} + 2\,{}_{+1}^{0}e + 26.7\,\mathrm{Mev}$$

APPLICATION OF RADIOACTIVE ISOTOPES

- In discovery of new sub-nuclear particles.
- In discovery of new radioactive and non-radioactive isotopes of elements.
- In the radio-active and nuclear research.
- **In agriculture-** by using the tracer-technique the fertilizer consumption of plants can be measured by the help of Geiger-Muller Counter (GM Counter). G M Counter can detect the presence of a radioactive isotope and can measure its activity.
- **In industry-** The tracer technique can be applied by using a radioactive isotope to study the wear of auto mobile-engines.
- **In medical science-** by using the radioactive isotope of Iodine by the help of tracer technique, the position of goitre can be detected.
- **In carbon dating-** It invoLes the determination of age of fossils by measuring the radioactive isotope of Carbon - 14.
- **In Radio dating -** The age of old rocks is determined by measuring the radioactive materials e.g. Uranium present in the rocks.

The last two applications given above are based on the half-life period of C-14 an d Uranium. The half-life of C-14 is approx. 5770 years.

ATOMIC BOMB

It involves uncontrolled nuclear chain reaction (fission). In an atom bomb two subcritical masses of U-235 or Pu - 239 are bro u ght together in less than a microsecond. It results in a violent explosion causing destruction because the combined mass becomes super critical. At the critical mass of a radioactive sample, a controlled chain reaction occurs.

TRIVIA

- In photoelectrical effect, the electron is assumed to be bound. That is, the energy of the incident photon is of the order of the binding energy of the electron.
- In Compton effect, the electron is assumed to be free. That is, the energy of the incident photon is much larger than the binding energy of the electron.
- Einstein was awarded Nobel Prize for explaining the photoelectric effect.
- Photoelectric effect was discovered by Hallwach.
- The kinetic energy of photelectrons varies from zero to $h(v - v_0)$.
- Einstein's photoelectric equation is in accordance with the law of conservation of energy.
- Cesium is the best photosensitive metal.
- The hardness of the X-rays depends on the accelerating potential of the electrons incident on the target.
- Voltage applied across the X-ray tube is of the order of 10000 V.
- The atomic number of the target determines the hardness of X-rays.
- Mosley related the frequency of characteristic X-rays to the atomic number of the target.

- Production of X-rays is an atomic phenomenon and the production of γ-rays is a nuclear phenomenon.
- Frequency of γ-rays is greater than that of X-rays.
- Efficiency of production fo X-rays is less than 1%.
- The target in the X-ray tube should have high atomic weight and high melting point.
- Absorption coefficient of X-rays is highest for lead.
- Hydrogen atom cannot emit X-rays.
- Compton effect is observed with X-rays and γ-rays.
- Electron microscope works on the wave nature of moving electrons.
- Wavelength of the matter waves does not depend on the charge of the particle.
- Bohr's theory is applicable to both the hydrogen as well as hydrogen like atoms.
- Observation of faint spectral line very near to blue line of hydrogen spectrum lead to the discovery of deutrium.
- As the quantum number increase the difference of energies between the consecutive energy levels decreases.
- In the Bohr model of the atom, an electron can revolve around the nucleus in a stable orbit without emitting radiations of its orbit has whole number of de Broglie waves.
- Iron, nickle, cobalt, etc. has ferromagnetic properties due to partially filled inner subshells.
- Total energy of the orbital electron is negative.
- Lead is the heaviest atom which is radioactively stable.
- All naturally occuring radioactive substances are finally converted into lead.
- For radioactive nuclei : $\frac{n}{p} > 1$.

  where n = number of neutrons and p = number of protons.
- The quantisation of the enegy states of an atom was demonstrated by Frank Hertz experiment. The experiment demonstrated the existence of discrete energy levels in the atom.
- The binding energy of the electron in the ground state of hydrogen is called rydberg, 1 rydberg = 13.6 eV.
- The isotope ${}_1H^3$ of hydrogen is unstable and decays to ${}_2He^3$.
- Radium was isolated by Pierre Curie and Madma Curie.
- Out of electron, proton and neutron, only neutron is unstable in free space. It decays into a proton and an electron.
- When β-particle is emitted the parent and daughter products are isobar.
- Half life period of lead is infinite.
- Artificial radioactivity was discovered by Henry Becquerel.
- Natural radioactivity was discovered by Henry Becquerel.
- In free space, the neutron decays as :

  ${}_0n^1 \longrightarrow {}_1p^2 + {}^0_{-1}e + \bar{v}$(antineutrion)
- Probability of a radioactive atom to survive n times longer than the half life is : 2^{-n}.

- The radioactive decay rate is not affected by temperature or pressure.
- The first nuclear transmutation was achieved by Rutherford.
- In the nuclear reactions, mass + energy is conserved.
- The decay constant as well as half life period are independent of the age of the radioactive sample.
- The radioactive substances are stored in lead containers, because lead absorbs the radioactive radiations.
- The moderator of the nuclear reactor should slow the neutrons without absorbing them.
- In the sun an d stars, the energy is released thro ugh natu ral fusion of hy d rogen into helium with carbon serving as nuclear catalyst.
- To photograph the brain tumour, Hg^{197} radio isotope is generally used.
- The neutrino has no charge and negligible mass.
- Both photon and neutrino are chargeless and have negligible mass. But the spin of photon is 1 and that of neutrino is $\frac{1}{2}$.
- ${}_{92}U^{238}$ can be fissioned by fast neutrons and ${}_{92}U^{235}$ is fissioned by slow neutrons.
- Nuclear fission was discovered by Hahn and Strasman.
- Positron was discovered by Anderson.
- Proton was discovered through artifical disintegeration of nitrogen by $\propto$=particles as follows :

$${}_2He^4 + {}_7N^{14} \longrightarrow {}_8O^{17} + {}_1H^1$$

- Critical mass of fissionable uranium – 235 can be reduced by surrounding it with neutron reflecting substances.
- The decay of artificial radioactive isotopes is accompanied by positron decay.
- In the fission of ${}_{92}U^{235}$ energy released is 200 MeV.
- Enriched uranium is better fuel for the reactor because it has greater proportion of U-235.
- The percentage of mass which changes into energy during fusion is of the order of 0.7%.
- In the fission of uranium, the percentage of mass converted into energy is about 0.1%.
- Protons attract each other when they are separated by a distance of 10^{-14}m.
- A neutron can be added to or taken out of the n ucleus of an atom without changing its chemical properties.
- Nuclear fusion requires very high temperature.
- Energy released in nuclear fission mostly appears as kinetic energy of the fission fragments.
- The mass of the sun is decreasing at the rate of 4×10^9 kg per second.
- Mass number of nuclei is either equal or more than the atomic number.
- First atomic bomb was designed by E. Teller.
- Man made element produced in the first nuclear reactor was plutonium.

- Plutonium - 239 is the best nuclear fuel.
- First atomic reactor was designed by Enrico Fermi.
- Artificial transmutation of elements was discovered by Rutherford.
- Enriched uranium is that in which the percentage of U-235 is more than 0.7%.
- The fissionable material used in the atom bomb dropped on Nagasaki in 1945 was Plutonium.
- Thermal neutrons have kinetic energy of the order of other gas molecules in their surrounding.
- The density of nucleus is of the order of 10^{17} kg / m ^{3}.
- The thickness of pn junction is of the order of 10^{-6} cm.
- Sound waves after being converted into electrical waves are not transmitted as such because they are heavily absorbed by the atmosphere.
- For full wave rectifier, the minimum number of diodes required is two.
- Both n as well as p type semicon ductors are neutral.
- The output of rectifier is DC mixed with AC.
- The resistance of intrinsic semicon ductor decreases with the increase in temperature.
- Diode was discovered by Fleming.
- The p ro duction of electro m agnetic waves by an oscillating charge was predicted by Maxwell.
- Thermionic emission was discovered by Thomas Alva Edison.

■■■

ASTRONOMY

The branch of science which deals with the study of position, composition, motion and other related facts of the heavenly bodies, is called astronomy. The source of information about the heavenly bodies is electro magnetic waves ra diated from them. It includes the two windows of the astronomy viz.

(i) Optical Window of Astronomy: It involves the study of the heavenly bodies through visible radiations by the help of optical telescope.

(ii) Radio Window of Astronomy: It involves the study of the heavenly bodies through radiowaves by the help of radio-telescope.

ASTRONOMICAL UNITS OF DISTANCE

(i) **Light Year (ly):-** It is eq u al to t he distance travelled by light in vacuum in one year. 1ly = 9.46×10^{15}m

(ii) **Parsec (Parallactic Seconds):-**

1 parsec = 3.1×10^{16}m

(iii) **Astronomical unit (Au):-** It is equal to the distance between the earth and the sun.

1A.U = 1.5×10^{11}m

The universe is the limitless expanse of space around us consisting of the solar system, stars, galaxies, etc.

SOLAR SYSTEM

The sun has its own family, known as the Solar System. Solar system consists of the sun, its nine planets and other heavenly bodies like asteroids, satellites (Moons), comets, meteors, etc.

The sun is at the centre and all other members of system move around it in elliptical orbits due to the gravitational force of attraction between them.

Sun

It is the nearest star to us. It is heaviest and largest member of the solar-system. Its mass is 1.98×10^{30} kg and diameter is 1.392×10^{9} m. It is about 109 times the diameter of the earth. It rotates about its axis and completes one rotation in 25 days. Our sun is also called Yellow dwarf star. It emits continuously the electromagnetic radiations both in visible and in radiowaves regions.

The sun consists of a bright layer at the centre called Photosphere that emits light. The photosphere is surrounded by a hot- gaseous layers called the chromosphere.

The sun comprises different elements in gaseous state. Hydrogen - 70%, Helium - 28%, other heavier elements Lithium to Uranium - 2%. The temperature, density and pressure increase from the surface to the centre of the sun. Temperature increases from 6000K on the surface to 14×10^{6} k at the centre and density increases from 10^{-4} kg / m^3 at the surface to 10^4 kg / m^2 at the centre.

Source of solar energy is due to energy released during the nuclear fusion. It involves the conversion of a certain mass into energy. The sun has been continously radiating energy at the rate of $46x10^{26}$ Joules per second for the last several billion years without getting cooler. The light emitted from the sun reaches the earth in 8.3 minutes.

Solar Constant(S) : The amount of radiant energy received per second per unit area of a perfectly black body surface at right angles to the direction of the sun-rays at the mean distance of the earth from the sun is known as the solar constant.

Solar constant = 1388 Watt / m^2 = 2 cal / (cm^2 - minute).

Sun-Spots: Certain dark spots are observed in the photographs of the visible light disc of the sun. These dark-spots are called sun-spots. They have relatively lower temperature (4500K) at the sun- surface. Their numbers vary with time. The maximum sun spots activity occur regularly after every eleven years. This period is known as the sun-spot cycle. The sun-spots are also associated with high magnetic fields (2000 to 3000 gause).

Solar Flares: At the time of the maximum sun-spot activity, some portions near the sunspots sometimes suddenly become much brighter than the usual. Such regions are called Solar Flares. These sun-flares emit protons, electrons and α-particles. It results a lot of magnetic and radio disturbances all over the earth. It also affects the plant growth.

Solar Wind: The out flow of materials as charged particles e.g. electrons and protons, etc. from the sun is called as solar wind. It results in emission of one million tonne particles per second from the sun.

Planets

There are eight planets in the solar system. These planets are revolving around the sun in elliptical path. They do not emit their own light but reflect some of the incident light of the sun. These planets in the order of increasing distance from the sun are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Until recently Pluto was recognised as the ninth planet. However, Neptune and Pluto keep on exchanging their distance in their elliptical orbits in such a way that sometimes Neptune is the farthest and sometimes Pluto.

The mass of the earth is about $6x10^{24}$ kg. The planets Venus and Uranus rotate about their axis from the east to the west whereas all the other planets rotate from the west to the east. Venus and Uranus are called retrograde.

(1) Mercury: It is the hottest, the smallest and the nearest to the sun amongst all planets. It is seen just before the sun rise, and after the sun-set. Its atmosphere contains H, He, Ar and Ne-gases. The temperature of its sun-facing side is 427° C and the opposite dark side is at -270° C. It does not have favourable temperature, oxygen and water for the existence of life.

Because it reflects 76% of the sunlight falling on it. Its atmosphere contains 95 to 97% CO_2 and small quantities of N_2, Ar, SO_2, CO & water vapour. Its temperature is 480°C and pressure is very high. Hence, life is not possible on it. It is seen 3 hrs before the sun-rise and 3 hrs after the sunset. Hence, it is known as Morning / Evening star.

(3) Earth: It is one of the unique planets having life. Its atmosphere contains 78% of

N_2, 21% of O_2 and traces of He, Ne, Kr, CO_2 and water vapour. 71% surface of its is covered with water. Moon is its natural satellite.

(4) Mars: Its very thin layer of atmosphere contains 95% CO_2, 2.7% N_2, 1.6% Ar and traces of O_2, CO and other gases. Its surface has craters of different sizes. It is also known as "Red - Planet" because it appears red owing to the present of iron- oxide upto 16% of its soil. Its day-temperature ranges from 21°C to 27°C but at night it becomes (-) 84°C. Phobos (diameter =27 km) and Deimos (diameter = 14 km) are its two satellites.

(5) Jupiter: It is the largest planet. It is a spinning ball of gases and liquids like ammonia, hydrogen (NH_3,H_2) and helium He with no solid surface. Its temparature is about (-) 140°C. No life is possible on it due to ammonia clouds and intense emission of radio wave on it.

(6) Saturn: It is the second largest planet. It consists of H_2 and He with traces of NH_3 and methane (CH_4). It is recognised by a system of revolving rings around it. The rings have dust particles and ice. Its temperature is about (-) 180°C. The largest satellite is Titan (diameter = 5800 km).

(7) Uranus: It is made up of H_2, He, NH_3 and CH_4. It appears green due to the large amount of CH_4 and NH_3 clouds in its atmosphere. Its temperature is about (-) 127°C.

(8) Neptune: It is the 8th planet of the sun. It has six satellites.

Its surface has frozen methane (CH_4). Its orbit crosses the orbit of Neptune. Its single discovered satellite is Charon. It was treated as the coldest and lightest planet of the sun.

Moon: It is the natural satellite of the earth. Its period of revolution around the earth as well as the period of rotation about

Solar System : Profile

S.N.	Name of Planets	Radius (in thousand) km)	Mean distance from the (sum in m. km)	Mass compared to earth	Time period of revolution (around the sun)	Time Period around own axis (of rotation)	Number of satellites
1.	Mercury (Buddha)	2.4	57.9	0.055	88 days	59 days	0
2.	Venus (Shukra)	6.1	108.2	0.815	225 days	243 days	0
3.	Earth (Prithvi)	6.3	149.6	1	1 year	23 hrs. 56 min	1
4.	Mars (Mangal)	3.4	227.9	0.108	1.9 year	24 hrs.27 min	2
5.	Jupiter (Brihaspati)	71.4	778.3	317.9	11.8 years	9 hrs. 50 min.	16
6.	Saturn (Shani)	60	1427	95.2	29.5 years	10 hrs. 14 min.	22 + Ring
7.	Uranus (Indra)	23.4	2870	14.6	85 years	10 hrs. 49 min.	12 + ring
8.	Neptune (Varuna)	22.3	4594	17.2	165 years	15 hrs.	6
9.	Pluto (Yama)*	3.2	5900	0.002	248 years	6.39 days	1

The mass of the earth is about 6×10^{24} kg.

The planets Venus & Uranus rotate about their axis from the east to the west whereas all other planets rotate from the west to the east. Venus & Uranus are called retrograde. * Now demoted its own axis is 27.33 days. So the same face is pointed towards the earth. Its diameter is 3476 km and the distance from the earth is 3.54×10^5 km. Its mass is 0.0123 times the mass of the earth. Its surface is rocky and rough. There are deep depressions or holes and high mountains on the surface of the moon. It does not have atmosphere and water. Its gravitational pull is 1 / 6th that on the earth. Latest measurements showed that the maximum temperature on the moon at day is 117°C and minimum temperature at the night is - 171°C. Moon does not emit light by itself. It simply reflects light of the sun falling on it. The reflected light on the Moon reaches the earth in 1.28 seconds. Due to its rotation around the earth, it looks different depending on its position with respect to the sun and the earth. The age of the moon is the same as that of the earth i.e. about 4 billion years.

Asteroids: The groups of small solid objects made of rocks and minerals which move in the gap between the orbits of Mars and Jupiter are called Asteroids. They are also known as Minor-planets. They are more than 5×10^5 in number. They move around the sun in the form of rings. They are about 320 to 490 million km away the sun. Their orbits are highly elliptical which enable them to approach the Earth, Venus and Mercury after regular intervals of time. Their size varies from 50 m to 350 km in radius. They are believed to be the pieces of a much larger planet which broke up due to the gravitational pull of Jupiter. Ceres is the largest known asteroid. Their composition is similar to that of Moon.

Comets: Comet is a heavenly body which is made of gases, ice and dust particles and moves around the Sun in a long spindle shaped orbit. When a comet passes close to the sun it has a bright head and a long tail. Near the sun, some of the materials of the comet gets evaporated due to solar heat. The light of the sun exerts a pressure on these vapours and forces them away from the comet in the form of tail. When a comet is far away from the sun, it shows no tail. A comet appears after regular intervals of time in the sky e.g. Halley's comet has a time period of 76 years. It was last seen in 1986 and is expected to be seen again in 2062.

Meteors: They are smaller pieces of stones and metals which are produced due to breaking of comets while approaching the sun. When they enter the earth's atmosphere, they burn due to friction of the atmosphere and burn completely before they fall on the earth's surface. They appear bright due to burning. Hence, they are called Fire balls or shooting stars.

Meteorites: They are unburnt meteors reaching to the earth's surface. They produce craters on the earth's surface.

Terrestrial Planets: They are closer to the Sun e.g. Mercury, Venus, Earth and Mars.

Giant or Jovian or Superior Planets: They are far away from the Sun e.g. Jupiter, Saturn, Uranus, Neptune & Pluto.

Albedo: The ratio of the sun's energy reflected by a planet to that incident on it is called as albedo. It is also known as the reflecting power of a planet. The clouds and atmosphere are good reflectors of light. Higher the value of albedo of a planet, more is the possibility of atmosphere on the planet. e.g. For Venus, albedo = 0.85 & for Mercury, albedo =0.06 & for Moon, albedo = 0.07. Hence, Venus has denser clouds and atmosphere but Mercury and

Moon do not have any clouds and atmosphere.

Existence of Atmosphere on a Planet: The possibility of existence of atmosphere on a planet depends upon the escape velocity of that planet. Higher the value of escape velocity, more is the possibility of atmosphere on the planet. The escape velocity depends upon the acceleration due to gravity (g) and temperature of the planet. If the value of 'g' is more, the escape velocity is more. If the temperature of the planet is high, the average velocity of the gas molecules may achieve the escape velocity and consequently, the gas molecules escape out from the surface of the planet.

Thus, to have atmosphere on a planet, the planet must have lower surface temperature, higher value of 'g' and higher escape velocity.

FORMATION OF SOLAR SYSTEM

Formation of Sun: The Sun was formed about 5 billion years ago. The clouds of H_2, He and dust formed Nebulae. At the beginning, these clouds were at very low temperature. These clouds collapsed slowly due to their mutual gravitational force of attraction to form a Protostar. As these clouds collapsed, the atoms of H_2 and He collided with each other and hence, temperature accelerated. At a very high temperature, the atoms of H_2 ionised into ions which further fused together to form He- nuclei along with the release of tremendous energy. Thus, sun was formed. At present, the sun is a middle aged star and is expected to live for another 5 - billion years.

Formation of Planets & Satellites : When a protostar was converted into a star (Sun), then the remaining mass (H_2, He & dust) formed disc shaped clouds around the sun. These clouds were at very low temperature vis-a-vis the sun and hence contracted due to gravitational pull and condensed to form a small chunk of matter known as planetesimal. There were larger number of planetesimals around the sun, which attracted each other to form biger chunks of matters. These big chunks of matters continued to grow by attracting smaller pieces of matters by gravitational pull. The matter was scattered in space in all directions. They gave rise to planets and satellites. The matters which could not participate in formation of planets and natural satellites collided with these formed planets and satellites. It led to form deep craters on the surface of planets and satellites. These craters are visible on the surface of moon and Mars.

Evolution of Earth : The Earth was formed by the collection of large number of cold planetesimals. These planetesimals came from two regions (i) from the inner planets like Mercury and Venus and they were rich in iron, silicon, magnesium and traces of other elements (ii) from the outer planets like Jupiter, Saturn and Uranus and they were rich in H_2, CO_2, CH_4 and water. A larger amount of heat was produced when these cold planetesimals collided with each other. Heat was also produced due to (i) the contraction of planetesimals under the force of their gravitational pull (ii) the disintegration of some radioactive elements like uranium and thorium. Hence, due to large amount of heat the initial earth was in a molten state. The melted earth then began to reorganise itself under the gravitational pull as follows :

- The heaviest materials like iron & nickel sank towards the centre of the earth which formed the core of the earth.

- The lightest materials began to float on the surface and formed the crust of the primitive earth.
- The intermediate dense materials arranged itself in between the core and the crust of the earth and formed the mantle of earth.

The process of reorganisation of molten matter of the primitive earth into various layers of different densities is called differentiation. At the time of differentration, the water vapours and the gases in the various minerals were released. Later on, these water vapours were condensed to give rain. The rain water filled the craters on the earth and thus, oceans were formed. The various gases released formed the atmosphere of the earth. The changes occuring on the earth were fast in the begining now they are slowing down. At present, these changes are responsible for the occurence of earthquakes, eruption of volcanoes and making and raising of mountain ranges.

STARS

A star is a luminous heavenly body emitting its own heat and light continuously. Stars twinkle because of refraction of light through different layers of the atmosphere. Stars appear to move from east to west because our earth rotates about its own axis from the west to east, otherwise stars are stationary with respect to the earth. The pole star (Dhruv Tara) lies above the earths north pole i.e. on the axis of rotation of the earth. The points on the axis of rotation of the earth appear stationary to the observer on the earth. Hence, pole star appears stationary to the people on the earth.

Evolution of a Star : The vast space between the stars is filled with dust particles and gases like H_2 and He. This material is called Interstellar matter, from which a star is formed. The interstellar matters are in the form of clouds. When the clouds of gas-particles are illuminated by nearby stars, the clouds appear as bright nebulae whereas the clouds rich in dust appear as dark nebulae because they absorb the radiation of the stars. The process of the formation of star begins only if the original clouds have a mass of at least 1000 solar mass.

Formation of Protostar (First Stage) : Initially, the interstellar matter is at very low temperature (–173°C). Due to the gravitational attraction the interstellar matter contracts and is compressed to such an extent that a huge ball of gases is formed. This gaseous ball is known as a protostar. A protostar contains highly condensed gases mainly H_2 & He. A cloud of intersteller matter takes about 10^5 years to become a protostar. Protostar does not emit light and heat.

Formation of a Star from Protostar (Second Stage) : In the protostar the gas molecules collide with each other. Gradually these collisions become fast and numerous due to continuous increase in the contraction inside the protostar. It gives rise to a temperature of 10^7°C that is enough to begin nuclear fusion. These nuclear fusions result in huge amounts of heat and radiations. Consequently, a protostar is converted into a star. This process is very slow and takes about 10^5 years. Thus, a huge interstellar matter in the form of clouds of gases and dust, is first converted into a cluster of protostars and then into a cluster of stars i.e. a galaxy.

Inspite of a large attractive force of gravitation inside the star, it does not collapse because there is a high temperature that provides a high-pressure to counter balance the attractive force. This balance continues for billions of years.

Formation of Red-giant (Third Stage) : Due to continuous nuclear fusion of hydrogen nuclei to form He-nuclei, the number of H-atoms decrease. It results in the decrease in pressure in the core of a star. Hence, the inward force of attraction increases in the core and the core contracts rapidly but the outer layer expands outward. Thus the volume of a star becomes very large. The outer layer gradually cools and appears red. This stage of a star is known as giant, super gaint or red-giant. This stage lasts for several million years and at the end, the rate of production of energy becomes so high that it explodes in the form of a Nova or Super Nova, throwing out the major outer mass into interstellar space. This is the death of a star. Depending upon the mass of left core of a star the following heavenly bodies are formed:

(a) White Dwarf : If the original mass of a star is less than two times the mass of the sun, the gravitational compression leaves the core of the star, composed of protons with electrons flying around in the form of electron clouds. When this electron-cloud with stands the inward gravitational force, then a stable equilibrium is achieved. At this stage, the star is called a white dwarf. It gradually cools finally ceasing to emit radiations. Then it becomes a black-dwarf. The most famous white dwarf is Sirius-B close to the brightest star Sirius.

(b) Neutron Stars : If the original mass of a star is between 2 to 5 times the mass of the sun, the recoil of supernova explosion is set up in the core. Now, the electrons are forced into the nuclei and the result is combination between electrons and protons to form neutrons. Hence, the core contains neutrons only. It gives the birth of a neutron star.

(c) Black Hole : If the original mass of a star is more than 5 times the mass of the sun, the recoil of supernova is extremely violent. Hence, the core collapses to have an object which has a very high density and gravity. As a result any radiation or

Theories of Origin and Evolution of the Universe

The Big Bang Theory : This theory was proposed by Le Maitre and Gammow. According to this theory, at the beginning of the universe, the entire matter of the universe was once concentrated in an extremely dense and hot (10^{12}k) fire ball. Then about 20 billion years ago a vast explosion (big-bang) occurred. The matter was broken into pieces which were thrown out with high speed in all directions forming stars and galaxies; which are still moving away from one another. The Hubble's law agrees with this theory.

Steady State Theory : It was given by Bondi, Gold and Fred Hoyle. According to this theory, the no. of galaxies is constant and new galaxies are continously created to occupy the position of those galaxies which have the crossed the boundary of the universe. Thus, the size and mass of the universe are constant.

Pulsating Theory : According to this theory the expansion and contraction of the universe occur alternately i.e. the universe is pulsating. At present, the universe is expanding and after a certain amount of expansion, it will begin contraction due to the gravitational pull. The alternate expansion and contraction of the universe gives rise to a pulsating universe.

material particle that enters this object never comes out. This object is called a Black Hole. As the black hole is invisible, so what is happening inside it and what had happened to the matter of the core of the star is unknown. The recent experiments have shown that one of the components of Cygnus XI is a black hole.

GALAXY

A Galaxy consists of very large group of stars, their families (i.e. planets etc.), du st an d gases held together by the attractive force of gravitation. A galaxy is a building block of the universe. Total galaxies are about 100 billions and each galaxy has about 100 billion stars. Thus, there are about 10^{22} stars in the universe. Our solar system belongs to the galaxy kno w n as Milky Way galaxy (Akash Ganga). Another kno w n galaxy is Andromeda which is about 2.2 million light years away from us.

Types of Galaxies :

(i) N ormal Galaxies : They e mit comparatively small amou nts of radio ra diation vis-a-vis the total ra diations emitted. They are bright from the centre and gradually get dim towards the edges. Milky Way and Andromeda are normal galaxies. De pen ding up on their appearance, the normal galaxies can be eliptical, spiral or irregular.

(ii) Radio Galaxies : They emit million times more ra dio w aves than norm al galaxies. They contain stars called Quasars which are known as quasi-stellar-radio-sources.

Milky Way Galaxy : It is so called because the light from the various stars together gives the impression of a stream of milk flowing across the sky. In the front view it appears spiral. From the side view, it hasa thick central part (Nucleus) which gradually becomes thin towards the edge. Its diameter is about 10^{5} light years. The sun is at 3×10^4 light years away it centre. The sun completes one revolution around the galactic centre in 220 millions years with a speed of 250 km / second.

Pulsars : They are neutron stars which emit radio signals at extremely regular intervals of time. Their pulsating radio signals are due to their high rotation and a very large magnetic field.

CONSTELLATION (NAKSHATRAS)

A constellation is a collection or group of a few stars. It forms a pattern which resembles the shape of an animal, object or a h um an being. There are 88 kno w n constellations. They are visible in a definite part of the sky.

Some of the important constellations are :

(i) Ursa Major or Big Bear (Saptarishi) : The word Ursa has been derived from the Latin word Ursus which means a bear. Ursa is the feminine of Ursus. Ursa major consists of seven bright stars. The shape of the pattern of these stars resembles the of a great bear. This constellation is seen clearly in the summer season fro m A p ril to September, in the northern part of the sky.

(ii) Ursa Minor (Little Bear) or Dhruva Matysa : It consists of seven stars which are closer to each other and less bright than the star in Ursa Major. It's most important star is at its tail. This star is known as Polestar (Dhruv Tara) which is nearer to the North Pole. The pole star helps in determining the direction of sailors and travellers. The Indian name of this constellation is Dhruva Matysa or Laghu Saptarishi. This constellation can be seen clearly in July in the northern part of the sky.

(3) **Scorpio or Vrischika :** It consists of seven stars whose arrangement resembles a scorpio. It can be seen clearly from February to August in the Southern part of the sky.

(4) **Orion, The Hunter (Vyadha or Mirga) :** Its shape is like that a hunter. The two stars at the top row makes the right and left shoulder of the hunter. Three stars in the middle row form his belt and the two stars in the bottom row form his feet. The faint stars below the belt are arranged in the shape of a sword of the hunter. This constellation can be seen clearly from October to April in the southern part of the sky.

(5) **Cassiopeia (Sarmistha) :** It consists of five dominated stars. The pattern of the stars is like the letter W. This is clearly seen in October in the Northern part of the sky.

(6) **Pleides (Krutika) :** It does not have a specific pattern of stars. It is just like a cluster of twinkling gems. The cluster of stars in this constellation are called globular clusters. This is visible from October to January in the northern part of the sky.

RED-SHIFT OF GALAXIES

It is explained on the basis of the Doppler-effect. When the source of wave moves away the observer, the apparent wave-length increases or the apparent frequency decrease. This is known as Red-shift because the region of spectra has large wavelength and smaller frequency. The study of the spectral pattern of the galaxies shows a red-shift. It means that most of the galaxies are moving away from each other with enormous speed and the universe is continuously expanding.

Hubble's Law : Hubble and Milton studied the red-shift of various gallaxies and put forth the law. The Hubbles law states that the recession velocity of a galaxy is proportional to it distance from us i.e.

$V \propto r$ or $\boxed{V = Hr}$

Where V= recession velocity of a galaxy. r

= the distance of the galaxy from us

and H = Hubble's constant = 16 km per second per million light years. It means that any galaxy which at a given moment is situated, one million light years from us, is receding away at a rate of 16 km / sec.

COMMUNICATION SYSTEM

The system of electronic communication involves the faithful transfer of messages in the form of electrical signal from one point to another point. Basic components of a co mmu nication syste m include Transmitter, Transmission Channel & Receiver. The information message is first converted into electrical signal by a device called Transducer. This electrical signal is then trans mitte d by trans mitter. An electronic signal in the Audio frequency range cannot be transmitted over a long distance because of lower value of audio frequency range. Hence, low frequency signals are loaded on a high frequency carrier signal by a p rocess kno w n as Modulation. It involves translating the original low-frequency information signals into high freq uency w ave before transmission such that the translated signal contin ues to p ossess the infor m ation containe d in the original signal. In Modulation, some characteristics of the carrier signal (e.g. amplitude, frequency or ph ase) varies in accor d ance with the message signal. The message signal is called Modulating signal which is loaded onto the high frequency carrier signal to produce the Modulated wave signal. A modulated signal has high frequency and a large band-width. Hence, it can be transmitted over a long distance without much loss in energy.

There are three types of Modulation viz. (i) **Amplitude Modulation :** It results into amplitude modulated wave (AM-wave signals). (ii) **Frequency Modulation:** It results into frequency modulated wave (FM-wave singals). (iii) **Phase modulation:** It results into phase into modulated signal.

AM wave signals are mainly used for commercial broadcast of voice-signals. They can be noisy because at mospheric phenomena like lightning or man made electrical signals affect this. AM-wave carrier frequency ranges from approx. 0.5 to 2 MHz.

FM-signals are noise free and of better quality. They have large bandwidth and are preferred for transmission of music. FM signals include—(i) FM radio (88 to 108 MHz), (ii) Very High Frequency (VHF) TV (47 to 230 MHz) & (iii) Ultra High Frequency (UHF) TV (470 to 960 MHz).

MODE OF TRANSMISSION OF COMMUNICATION

Analog Communication : In analog commu nication, the modulating signal which modulates the carrier signals for transmission is continuous or representative of the original infor m ation to be transmitted.

Digital Communication : In digital communication, the original information signal is first converted into discontinuous amplitude levels & then coded into a corresponding sequence of Binary symbol 0 & 1. This coded information signal is then modulated by a suitable modulation method before the transmission.

The digital communication involves the quantization of the digitial data (0 and 1) by the help of a device called quantizer. Hence, it becomes relatively more error-free and noise-free. It makes the digitial commu nication more reliable than the analog-communication.

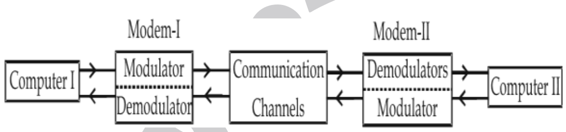
DEMODULATION

It is the reverse processs of modulation that is carried out in a receiver to record the original information signal.

In an electronic communication system, the transmitter modulates the information signals and transmits them by an antenna via transmission channels. The receiver receives the modulated transmission signals an d demodulates them to recover the original information signals. A transmitter performs data transmission and a receiver perfor ms d ata retrieval. In electronic communication, data to be transmitted means information signals.

MODEM

It connects one computer to another across ordinary telephone lines. It can fu nction as m o dulator as w ell as De m o dulator an d hence, its na m e is Modem (Mo ® Modulation and dem ® demodulation). In the transmitting mode, it acts as a modulator while in the receiver-mode, it acts as a demodulator.



When the information data are supplied from computer-I to computer-II, modem-I acts as a modulator and modem-II acts as a demodulator. When data are supplied from computer II to computer-I, Modem-II acts as a modulator & modem-I acts as a demodulator.

Modems that support a voice / data switch have an inbuilt microphone and speaker for voice communication. In voice m o d e, the m o d e m acts as a reg ular telephone while in data mode, the modem acts as a regular modem.

The rate at which a modem can transmit and receive data (message) is measured as Bits per second (bps). Higher data transfer rate can be achieved by data compression which is performed by some specific modems.

The digital communications, computer & modem use a binary number system to deal with digital signals (data). Binary system involves two volues as 1 and 0 only. 0 ® refers, open-circuit or No or space.

1 ® refers to close circuit or yes or mark.

Both 0 and 1 are called Bits. A group of bits is called a Byte or a binary word. A byte of two bits (0 & 1) can give a four code-combination : 00, 01, 10, & 11. Hence in general, the no. of codes is given as $N = 2^n$.

When N = total no. of co d e- combinations

n = the no. of bits in a byte.

FAX (FACSIMILE TRANSMISSION)

Facsimile means exact reproduction. Fax transmission usually concerns the electronic reproduction of a document (printed words, graphs or photographs) at a distant place through telephone lines.

At the transmitting end, a fax machine digitizes the printed matter on paper and transmits the corresponding data over the telephone lines. At the receiving end, a fax machine receives digital image-information and reconstructs the received image on the paper. This is also known as Facsimile Telegraphy.

COMMUNICATION CHANNELS

The commu nication channel is the physical medium between a transmitting and a receiving stations through which the transmitted signals may propagate.

Ty pes-(i) Sp ace Co mmu nication channel including satellite communication and (ii) line communication channels.

Space Communication : It involves the transmission of the message signals freely in space by a transmitting antenna and receiving the signals by intercepting them with the help of receiving sets or antennas at the other end.

The space communication channel involves:

(i) Ground wave communication (ii) Sky w ave co mmu nication (iii) Sp ace or Tro p os pheric or su rface w ave communication.

(i) Ground Wave Communication : It is the transmission of the signals between the transmitting and receiving antennas close to the earth. It is not suited for very long range commu nication becausee it involves the loss of energy to the earth during the propagation of the wave. It is used for between radio broadcasting at low frequencies ranging from 500 Khz to 1500 Khz. The ground of the wave includes the medium wave (MW) band.

(ii) Sky Wave Communication : In sky wave propagation, the wave signals are first transmitted to the ionosphere and then is received by receiving sets on the earth after being reflecte d back fro m the ionosphere. It is also known as short wave (SW) band in the radio transmission.

(iii) Space or Tropospheric Wave Communication : It involves the transmission of FM-Radio-signals, TV signals an d Microwave signals in the range of VHF & UHF. These signals cannot be transmitted by using ionosphere because the ionsosphere can reflect the frequency upto 40MHz only. Hence, these signals are transmitted from the transmitting antenna to the receiving antenna directly. Its range depends upon the height of the transmitting antenna. Its range can be increased (a) by using a no. of antennas called Repeaters in between the transmitting antenna and receiving antenna.
(b) by increasing the height of the transmitting antenna. This height can be maximised by locating the transmitter on a satellite.

SATELLITE COMMUNICATIONS

It involves those frequency signals which can pass through the ionosphere without being reflected by the ionosphere. The satellite carries an equipment called Radio-Transponder. The function of the transponder includes reception, storage, a mplification an d transmission of the information signals.

The communication satellite is usually a geo-stationary satellite that appears fixed at a position above the earth. Its time-period of revolution is 24 hrs, height 36000 kms and direction of revolution from west to east similar to that of the earth. It is revolving in a circular orbit called Geo-synchronous orbit that is coplanar with the equatorial plane of the earth.

Owing to the curvature of the earth a single satellite cannot cover the entire earth.

For global comunication, three satellites are parked 120° apart from each other in the geo-stationary orbit.

Remote-Sensing : It is a technique which is used to observe and measure the characteristics of the object or phenomenon at a distance without being in physical contact with it. Its working is related with the measurement of some kind of signals emitted, transmitted or reflected from an object in order to determine certain physical properties of the object, like its temperature location, size, colour nature, etc. The remote sensing uses, electromagnetic techniques that covers the entire electromagnetic spectrum. Any photography is a kind of remote sensing. RADAR, SONAR, Satellite with sensors, etc. are other examples of remote sensing.

Satellite remote sensing systems provide the data critical to weather-prediction, agricult u re forecasting, resou rce exploration (archaeology, geological survey, forestry, etc.) an d enviro n m ental monitoring.

Uses of Remote Sensing :

- To know the area of earth's surface covered by forests, types of plants and density of forest at a particular loca-tion.
- To prepare waste land maps.
- To locate the potential fishing zones.
- To locate the d ebris of a crashe d aeroplane or jet plane.
- To identify the extent of pollution and its source.
- To estimate the damage being done by the floods.
- To locate the place where underground nuclear explosion has been carried out.
- For ground water surveys.
- In the field of spying, to lcoate the position and movements of the enemy.

T.V. REMOTE CONTROL

The Remote Control used in TV and music system is an electronic device. It consists of an integrated circuit (I.C.) and other components like a diode, a transistor, a capacitor, etc. When a key on the remote is pressed, it translates it into infrared signals which are received by the electronic circuit of the TV and required operations are performed.

Line Communication : In order to interconnect (i) a transmitter to an antenna, (ii) a transmitter to a receiver (iii) a receiver to an antenna some specific wires are req uire d. These wires are kno w n as transmission-lines. Some of them are as follows:

(i) Parallel Wire Lines : They are commonly used to connect an antenna with the T.V.

(ii) Twisted Pair Wire Lines : They are used as telephone lines.

(iii) Coaxial Wire Lines : They are used by T.V. cable operators.

(iv) Optical Fibre Lines : They are used in optical communication.

The efficiency of the transmission line increases from the parallel wire lines to the optical fibre lines. The optical fibre line is the best because it has maximum efficiency and minimum loss in energy.

Coaxial cable system is better than parallel twisted pair wire-lines because of greater available band-width, lower energy losses and much lower cross-walk.

In the cable system, the deviation in frequency & phase response of the signals passing through a cable are set by using a device called equalizer.

A telephone link can be established using gro u n d w aves, sky- w aves, microwave, co-axial cables and latest, the optical fibre cables. The microwave link is more noisy than the coaxial link. The optical fibre link are free from noise & energy losses.

LASER

(Light Amplification by stimulated emission of radiation): Laser is a process by which a coherent, hightly intense mono chromatic and almost perfectly parallel beam of light is obtained. The term 'Laser' is also used for the beam of light obtained this way.

Use of Lasers : Lasers are used in :

- **Microsurgery :** For delicate organs e.g. retina, cervical tumours, tissues, etc.
- **Engineering :** Tiny welds are made with precision using powerful laser beams.
- **Industry :** To drill holes in diamonds and hard steel.
- **Communication :** In optical communication.
- **Holography :** In three dimensional photography without lenses.
- **Military :** As a powerful war weapon.
- **Weather Forecasting :** A laser based RADAR called Lidar is used for weather forecasting.

Reading bar codes, manufacturing and reading compact discs, cutting cloth in garment industry etc. are also some of the uses of lasers.

MICROWAVE DEVICE

(1) Radar (Radio D etetection & Ranging) : RADAR system detects the objects like aero planes an d ships. Its antenna transmits microwave (frequency greater than 1000 MH $_z$) signals which are reflected from the object. Knowing the time interval between the transmission an d reception of the signals, the distance of the object is measured.

(2) Microwave Oven : It bakes food using microwaves. These microwaves are produced in the oven at a high frequency of abo u t 2450 M H z by m eans of a Magnetron. Since the metals block the microwaves, hence, most microwave ovens are made of glass. Microwaves produced are directly absorbed by the food-material without heating the surroundings. The m olecules of foo d content vibrate on absorbing the microwaves that causes heat. The energy is used by the food only and hence, it takes a small interval of time to cook the food.

■■■

ELECTRO MAGNETISM

ELECTROSTATICS

Electrostatics deals with the study of electric charges at rest. Electric charges at rest are produced either by friction between two insulating bodies which are rubbed against each other or by electrical induction between a charged body and an earthed uncharged body.

When two insulating bodies are rubbed against each other, electrons are transferred from one body to the other. Electrons are negatively charged particles. Hence, the body giving electrons becomes positively charged while the body gaining electrons beco m es negatively charge d. Electric charges are of two types only viz. positive and negative. Like charges repel and unlike charges attract each other.

Bodies gaining two kinds of charges on rubbing

Positive Charge	Negative Charge
Glass Rod	Silk Cloth
Fur or woollen cloth	Rubber rod, Ebonite and Amber.
Woollen Carpet	Rubber Shoe
Nylon or Acetate	Cloth
Dry hair	Comb
Woollen Coat	Plastic Seat.

The minimum amount of charge that can be transferred from one body to the other is the charge on an electron (-1.6×10^{-19}c). Hence the total charge on a charged body is equal to the sum of products of no. of electrons transferred and charge on an electron or a proton. Electric charge is always conserved when some electrons are transferred from one body to the other, the body giving electrons becomes slightly lighter and the body gaining electrons becomes slightly heavier.

COULOMB'S LAW

The electric forces between the two point charges is directly poportional to the p ro duct of the charges an d inversely proportional to the square of distance between the charges. The electric force may be attractive or repulsive depending upon the nat u re of the t w o charges. The coulombic force (electric-force) is much stronger than the force of gravitation. An uncharged body can be charged by placing it near a positively charged body without actual physical contact between them (by induction). The positive charge present on the charged body attracts electrons present inside the atoms at the surface of the uncharged body. Hence, a few electrons come out at the surface resulting in a negative charge at the surface and an equal positive charge appears on its opposite face. Thus it gets polarised because it has equal and opposite charges at the two opposite surfaces. If this body is earthed, the positive charge disappears and the body becomes negatively charged. The uncharged body has no w a net negative charge. The uncharged body can acquire a net positive charge too provided the charged body placed near it was negatively charged.

When a charged glass rod is brought near a piece of paper, it attracts the paper because of force of attraction between the charge on rod and induced charge which has appeared on the paper.

ELECTROSTATIC SHIELDING OR ELECTROSTATIC SCREENING

Protecting a certain region of space from external electric fields is known as electrostatic shielding.

A hollow conductor stores charge only at its surface. Hence, electric field remains outside only, and inside the hollow electric field is zero. Such a space having zero electric field is known as Faraday's Cage. Therefore, to protect delicate instruments from external electric fields, they are kept inside a hollow conductor. In a thunderstorm accompanied by lightning, it is safer to be inside a car or a bus than to be in the open ground or under a tree. The metallic body of a bus or car provides electrostatic shielding from the lightning.

If electric charge is supplied continously to a conductor having certain pointed ends, the electric charge is sprayed out through the pointed ends. A conductor with pointed ends is a good receiver of charge also. A lightning conductor placed at the top of a building has a number of sharp spikes at its two ends. Upper end is free in air to catch electric charge produced due to lightning and the lower end sprays charge into the ground. Thus it provides a safety to the building.

Electroscope : The device is used to detect the presence of electric charge and type of charge on a body. Its most common type is gold leaves electroscope. It can measure potential-difference as well.

Capacitor or Condenser : A device used to store electric charge is known as capacitor.

Van de graaff Generator : It produces highly energised positively charged particles or ions by producing very high electric voltage. It is used in scientific or industrial works.

Atmospheric Electricity : Earth is a good conductor of electricity. Its electric potential is '0' Volt everywhere at the earth's surface. When a positively charged body comes in contact with the earth, electrons flow from earth to the body whereas when a negatively charged body comes in contact with earth, electrons flow from the body to the earth. Lower atmosphere is a poor conductor of electricity but its conductivity increases with increase in height. Ionosphere is a very good conductor. This is primarily due to ionization of particles of air by cosmic ray particles having energies to the order of 10^{14} MeV.

Thunderstorms & Lightning Flashes : In every thunderstorm, the positive and negative ions produced are separated in the cloud. The positive ions are at about 6 km and the negative ions are at about 2-3 km above the earth's surface. It results in a very high potential difference (10^7 to 10^8v) between the lower negatively charged level of cloud and the earth's surface. It causes the electric breakdown of air. Consequently the intervening air gets ionised and conducts charge from the cloud to the earth in the form of a lightning flash. Each flash lasts for 2×10^{-3} seconds and desposits about 20 coulomb charge on earth. All the world over, there occur about 40000 thunderstorms per day.

In recent years, many important industrial applications of electrostatics have been developed. Some of them are:

(1) In prevention of pollution of atmosphere by electrostatic precipitation of fly ash.

(2) In designing electrostatic generators like Van de Graaff generator.

Metallic Conduction and Electrolytic Conduction

Metallic Conduction	Electrolytic Conduction
The flow of current through a metallic conductor is known as metallic conduction.	The flow of current through electrolyte is called electrolytic conduction.
Metallic conduction is due to the movement of electrons in the metallic conductor.	Electrolytic conduction is due to the movement of positive and negative ions in the electrolyte.
The chemical properties of the metallic conductors do not change due to metallic conduction.	The chemical properties of the electrolyte change due to electrolytic conduction.
The metallic conductor is not decomposed due to metallic conduction but it is only heated up.	The electrolyte decomposes due to electrolytic conduction.

Conductor & Insulator

Conductors	Semi Conductors	Insulators
(1) They are good conductors of electricity.	(1) They are poor conductors of electricity.	(1) They are bad conductors of electricity.
(2) They have higher density of free electrons as carriers of charge.	(2) They have lower density of free electrons & holes as carriers of charge.	(2) They do not have carriers of charge.
(3) They have very high conductivity.	(3) They have relatively lower conductivity.	(3) They have very low conductivity.
(4) Conductivity decreases with rise in temperature.	(4) Conductivity increases with rise in temperature.	(4) Conductivity increases with temperature.

(3) In electrostatic spraying of paints, powders etc.

(4) In understanding volcanic lightning and common lightning strikes from the cloud base to the ground.

(5) In the design of cathode ray tubes for RADAR and TV.

(6) In ink-jet printing, which is high quality and delivers high speed printing.

(7) In electrostatic loud speakers and microphones.

Electroplating with Silver: For electroplating with silver, solution of sodium silver cyanide [Na[Ag (CN) $_2$] is used as an electrolyte.

- Joule's heating effect of current is common to both d.c. and a.c. That is why the instruments or eleectrical appliances such as heater, press, geyser, toaster etc. works both on d.c. and a.c. Joule heating effect is irreversible. It means if the direction of current in a resistor is reversed, the cooling of resistor does not occur whereas heating of the resistor takes place. If the resistances are connected in series, the current I is same through each resistor, then

  P μ R and V μ R (as V = lR)

  It means, in series connections, the potential difference and power consumed will be more in higher resistance.

- If the resistence are connected in parallel, the potential difference V is same across each resistor. Then $P \propto \frac{1}{R}$ and $I \propto \frac{1}{R}$ (as V = lR)

- It means in parallel connections, the current and power consumed will be more in smaller resistances.

- In parallel grouping of bulbs, the bulb of higher wattage will give more bright light an d will pass greater current through it. It will have lesser resistance and same potential difference across it. If one bulb gets fused, other bulbs will work.
- In series grouping of bulbs, the bulb of higher wattage will give less bright light and will have smaller resistance and potential difference across it. If one bulb gets fused the other bulbs will not work.

CURRENT ELECTRICITY

Electric Potential : The amount of work done in bringing unit positive charge at a point is called as potential at that point. Electric potential = work done / charge = Joule / coulomb = volt. Unit of electric potential is volt (v).

Potential difference (p.d.). It is equal to the work done in moving a unit positive charge from one point to another point.

Electric p otential an d p otential difference are physically similar quantities having co mm on u nit of volt. Electric potential determines the direction of flow of charge from one conductor to another conductor or from one point to another point through a conductor. Electrons flow from lower potential to higher potential. Electric potential and potential difference can be positive and negative depending upon the nature of electric charge.

Electric Current : The a m o u n t of electric charge flowing through any cross-section per unit time is known as electric-current.

Electric Current (I) $= \frac{\text{Charge (Q)}}{\text{Time(t)}}$ or $I = \frac{Q}{t}$

Unit of electric current is Ampere (A).

$1 \text{ Ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$. Conventionally, the electric current flows from higher to lower potential against the flow of electrons.

Ohm's Law

The cu rrent flo wing th ro u gh a conductor is directly proportional to the potential difference across the ends of the conductor provided the temperature and other physical conditions of the conductor remain the same.

Potential difference (V) $\propto$ Electric current (I)

or, pot. diff. (V) = constant (R) × Electric current (I)

or $\boxed{V = IR}$

Where $R = \frac{V}{I} = a$ constant for a conductor known as resistance. Unit of resistance is ohm (W).

Resistance of a conductor is its ability to o pp ose the flo w of cu rrent. For a conductor, the resistance

$\boxed{R = \delta \frac{\ell}{A}}$, where l = length of conductor.

A = area of cross-section of conductor.

r = resistivity of conductor.

Resistivity (r) of a con ductor is a constant. It depends upon the nature of material of the conductor.

$$\text{Conductivity (C)} = \frac{1}{\text{Resistance (R)}}$$

$$= \frac{1}{\text{ohm}} = \text{ohm}^{-1} = \text{mho}.$$

$$\text{Conductivity (K)} = \frac{1}{\text{Resistivity } (\delta)}$$

$$= \frac{1}{\text{ohm} \times \text{metre}} = \text{ohm}^{-1} \times \text{m}^{-1}$$

Combination of Resistances

When two or more resistances are arranged in series i.e. in a common path of flow of current, the net resistance is equal to the sum of individual resistance. Hence, in series, the net resistance becomes larger. For two resistances R_1 & R_2 : $R_s = R_1 + R_2 > R_1$ or R_2.

When two or more resistances are arranged in parallel i.e., between two common points of two different paths of flow of current, the reciprocal of the net resistance is equal to the sum of reciprocals of individual resistances. Hence, in parallel, the net resistance becomes smaller. For two

resistances R_1 & R_2 in parallel, $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

or $R_P = \frac{R_1 R_2}{R_1 + R_2} < R_1$ or R_2

EMF (electromotive force) of a cell or battery: It is equal to the potential difference between the electrodes when current is not drawn out from the cell.

Heating Effect of Current : When an electric current flows through a conductor, an amount of heat is produced.

Joule's Law of Heating Effect :

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

where H = amount of heat produced.

I = amount of current in conductor.

R = resistance of conductor.

V = Potential difference across conductor.

t = time interval for which current is supplied.

Since heat is the form of energy, hence, heat produced due to the flow of current is electrical energy consumed in a given electrical circuit. Thus, the net

$$\text{Electrical energy} = I^2Rt = VIT = \frac{V^2}{R}t$$

$$\text{Electrical power} = \frac{\text{Electrical energy}}{\text{time}}$$

$$= I^2R = VI = \frac{V^2}{R}$$

Unit of electrical energy is Joule (J) and that of power is watt (w). Horse-power is another unit of power. 1 Horse-power (H.P.) = 746 watt. The practical commercial unit of energy is kilowatt hour (KWH).

1 KWH = $1000 \times 60 \times 60 = 3.6 \times 10^6$ Joule.

Electric Bulb : An electric bulb has a tungsten filament enclosed in a glass envelope filled with inert gases like argon. Tungsten filament has a very a high melting point and resistivity. Its resistance is very high. Hence on passing electric current, it produces heat and light.

Electric Iron (Electric press), Heater, Geyser, Toaster & Immersion Rod : These heating appliances have Nichrome (an alloy of nickel, iron and chromium) wire as heating element. Nichrome has high melting point, resitivity and malleability and it does not oxidise in air easily. On passing current, it gets heated up.

Carbon Arc Lamp : It consists of two carbon rods as the electrodes separated by a smaller air gap. When a high potential difference is applied across the rods, a spark jumps across the air-gap due to ionization of air & a very bright light is emitted by the gap. This light is called an arc-light. The carbon arc lamp is used in electric welding, search lights and cinema projectors.

Electric Fuse Wire : Usually it is an alloy of tin (63%) & lead (37%). It has high resistance and low melting point. It is connected in series with the electrical installations. All of a sudden, if strong current flows, the fuse wire melts away, causing the breakage in the circuit, thereby saving the main installations from being damaged. Thus, it is capable of saving costly appliances.

Chemical Effect of Electric Current

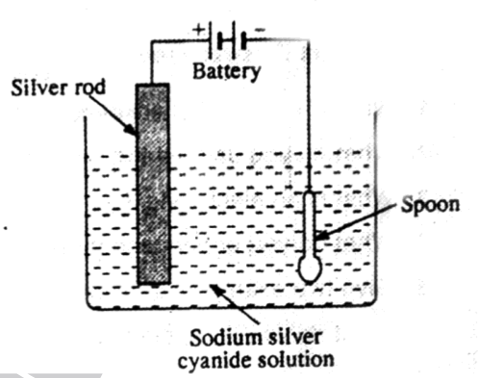
Electrolysis : When an a mou nt of electric current is passed through a solution or melt of an electrolyte, the electrolyte dissociates into positive ions (cations) and negative ion (anions). The cation gets deposited at negative electrode (cathode) and the anion gets deposited at the positive electrode (anode). This phenomenon is kno w n as electrolysis. Electrolysis is explaine d by the Fara d ay's la w s of electrolysis. Faraday constant (F) = 96500 coulomb / gram equivalent = charge on one mole of electrons. Electrolysis involves direct current (d.c.) only and not a.c.

Power Cell Chemsitry

Cell	Electrodes	Electrolyte	Depolariser	EM For Voltage
Voltaic cell	Copper and Zinc rods	Dilute solution of H_2SO_4 (sulphuric acid)	Absent and the cell suffers from polarisation	1.08 Volt
Daniel cell	Copper-container and zin rod	dilute solution of H_2SO_4	Copper-sulphate ($CuSO_4$)	1.1 Volt
Leclanche cell	Carbon and zinc rods	Ammonium chloride (NH_4Cl)	Manganese dioxide (MnO_2)	1.45 volt
Dry cell	Carbon rod and zinc pot	Ammonium chloride (NH_4Cl)	Manganese dioxide (MnO_2). $ZnCl_2$ being hygroscopic absorbs water produced.	1.5 Volt
Lead-Acid Accumulator	A set of perforated lead plates with lead (PbO_2) in holes as positive and a set of lead rods as negative	dilute (20%) H_2SO_4 Solution with specific gravity 1.25. when the specific gravity of H_2SO_4 solution decreases to 1.18 the cell requires recharging	lead oxide (PbO_2)	2.2 volt
Alkali-accul-mulator or NiFe cell Cell or Edison cell	Anode is a perforated steel grid filled with [$Ni(OH)_2$] and cathode is a steel grid filled with [$Fe(OH)_2$] and	20% solution of potassium hydrooxide (LiOH)	($Fe(OH)_2$] & ($Ni(OH)_2$]	1.36 Volt

Applications of Electrolysis :

- **Electroplating :** The process of depositing a layer of precious metal like gold, silver, nickel and chromium over cheap metals like iron and copper by electrolysis is called as electroplating. The precious metal is taken as anode and cheap metal as cathode. The electroplating prevents corrosion (rusting) and makes the cheap metals attractive.
- **Anodising :** It is the process of coating aluminium with its oxide electrochemically to protect it against corrosion. In dilute sulphuric acid as electrolyte, the aluminium article is made the anode. To give the surface of the article beautiful colours, dyes are mixed in the electrolyte.
- **Electrotyping :** It involves the preparation of exact copies of metallic type used in the printing work and the engraved blocks on the metals by the process of electrolysis. A sheet of wax is first pressed against the type set or block. The impression obtained on wax is made conducting by coating it with graphite powder. Then it is copper-plated by the process of electrolysis. The sheet so obtained is a copy of the type of block. This process is also used for the manufacture of gramophone records.



- **Extraction of Metals from the Ores :** Metals like sodium, aluminium, magnesium, calcium, zinc, copper etc. are extracted from their ores by electrolsysis.
- **Purification of Metals :** It is carried out by using impure metal as the anode, pure metal as the cathode and a double salt of the pure metal as electrolytes when a current is passed through the electrolyte solution, pure metal gets deposited at the cathode. This methode is used to purify blister copper.
- **Production of Oxygen and Hydrogen :** Oxygen an d hydrogen are man ufactured commercially by the electrolysis of acidulated water.
- **Manufacture of Chemicals :** By the electrolysis of sodium chloride solution, caustic soda is prepared.
- **Medical Applications :** Electrolysis is used for nerve stimulation especially for polio, for removing unwanted hairs on any part of the body etc.

ELECTROCHEMICAL CELL

It converts chemical energy stored in the electrolyte into electical energy by chemical reaction.

Types of Cells

- Primary Cells
  They can be used only once and cannot be reused by recharging e.g. Voltaic cell, Daniel cell, Leclanche cell, Dry cell.
- Secondary Cells
  They can be re-used again and again by recharging e.g. Lead Acid-Accumulators Alkali accummulator (Edison Cells)
- Fuel Cells
  They do not require even a recharging and continue for ever. But due to high cost production they are used in scientific works only like space research e.g. H_2O_2 cell.

An electro chemical cell consists of two electrodes viz. anode an d cathode; an electrolyte to p rovid e ions an d a depolariser to prevent the formation of hydrogen coating on the surface of cathode.

Button Cells : They are tiny dry cells. They are :

- **Mercury Cells :** EMF or Voltage =1.36 volt

  Life : upto 3 years used in a watches, hearing aids, portable scientific instruments.
- **Silver Oxide Cells :** EMF = 1.62 volt.

  Life and uses similar to that of mercury cells.
- **Lithium Cells :** Life : upto 10 years.

  Used in quartz watches, mobiles, etc.
- **Alkali Cells :** They are very cheap and environmentally safe. Life shorter. Use similar to other button cell EMF = 1.5 V

Battery : An arrangement of a no. of cells in series to provide higher voltage of direct current (d.c.) is called a battery.

Voltameter or Electrolytic Cells : An arrangement consisting of identical electrodes (Anode and Cathode) in an insulating container with an electrolyte-solution to carry out electrolysis is termed as a voltameter or electrolytic cell. It consumes electrical power to cause electrolysis. An electrochemical cell or a common cell produces electric power.

Magnetic Effects of Current : When an amount of electric current flows through a conductor, it develops an amount of magnetic field around itself.

Electromagnet : It consists of a coil of an insulated wire (usually copper) closely wound around a soft iron core. When an electric current passes through the coil, the arrangement acts as an electromagnet.

Electromagnets are used in many devices like electric-bell, electric horn, telephone receiver, electric relay, etc. Electromagnets fitted on cranes can lift heavy iron pieces.

Cyclotron : It is a device used to produce highly accelerated positively charged particles under the effect of a strong magnetic field produced by an electromagnet. Cyclotron is used for nuclear works so as to cause nuclear disintegration, etc.

Galvanometer : It is based on the magnetic effect of current. When a coil having electric current is suspended in a uniform magnetic field, it gets deflected. This forms the basis of galvanometer. A galvanometer connected in any part of an electric circuit indicates the flow of current. It is used to construct devices like Ammeter and Voltmeter.

Ammeter : It measures the amount of electric current in any part of circuit in series.

Voltmeter : It measures potential difference across a circuit in parallel.

- We can produce high voltage on the human body without getting a shock. For this the person must stand on a highly insulated platform. Hence with high voltage on the body, no charge will flow to the ground through the body and the person will not get any shock. There is an impression among many people that a person touching a high power line gets stuck with the line. This is not a correct notion because there is no special attractive force that keeps a person stuck with a high power line. The actual reason is that a current of the order of 0.05 ampere or even less is enough to bring about a disorder in our nervous system. As a result of it, the affected person may temporarily lose his ability to exercise his nervous control to get himself free from the high power line.

- For a given electrical installation, when an electrical appliance of high wattage is switched on it draws more current. Consequently, the voltage across the nearby appliance of lower wattage is lowered for a moment until it is established by the transmission grid. e.g (i) When a car-engine starts, the car light gets dimmer for a moment (ii) Light from a bathroon bulb gets dimmer for a moment when the geyser is switched on.
- When a metallic wire is carrying an electeric current, it is not charged because the total no. of electrons and that of protons in any section of the wire remains the same. Hence net charge on the wire is zero.

Potentiometer : It is an electrical device use d to co mp are e mfs an d internal resistence of the two cells.

Wheatstone Bridge : It measures an unknown resistance with accuracy.

Meter Bridge or Slide Wire Bridge : It is the practical form of wheatstone bridge.

Shunt : It is a low resistance connected in parallel to a device or an electrical circuit to provide a subway for the surplus current. Thus, it provides a safety to the device or the ciruit.

Electromagnetic Induction : Whenever the magnetic flux linked with a closed metallic-loop changes, an amount of emf is in duced in the loop. The in duced emf causes flow of induced current in the loop. This pheno menon is kno w n as electromagnetic induction. It can be carried out by (i) moving a magnet towards or away from the loop (ii) moving a loop towards or away from the magnet (iii) rotating a loop in front of a magnet. This effect forms the basis of serveral devices and is used to produce alternating current by an a.c. generator.

Electric Motor : It converts electrical energy into mechanical energy. It is based on the fact when a current carrying coil is placed in a magnetic field, it experiences a torque that causes rotation of the coils. Electric motors are used to operate many a ppliances like fans, coolers, mixers, geysers, refrigerators washing machines etc.

Motor Starter : When a large electric motor is switched on, its initial current is very high and that can damage its circuit. Hence, the initial higher current should be reduced. A motor starter has a large variable resistance. When an electric motor starts, the motor starter automatically goes in to reduce high current and comes out after switching off the motor. Thus it regulates an electric motor at start and stop.

Choke-Coil : It regulates alternating current in a given circuit. Its resistance value is zero and hence, it does not consume p o w er. A ca p acitor can d o a similar function.

Generator (D ynamo) : It converts mechanical energy into electrical energy. It is of two types:

(i) Direct Cu rrent (D.C.) generator : it produces D.C.

(ii) Alternating current (A.C.) generator : it produce A.C.

Both the generators work on a common principle. When a metallic coil rotates in a magnetic field, an induced em.f. is produced in the coil. However, their constructions are a bit different.

Transformer : It converts higher alternating current at lower alternating voltage into lower alternating current at higher alternating voltage and vice-versa.

It is of two types viz (i) **Step-up transformer :** It converts higher a.c. at lower a.c. voltage into lower a.c. at higher a.c. voltage. It is used at the power station (ii) **step-down transformer :** It converts lower a.c. at higher a.c. voltage supplied by power station into higher a.c. at lower a.c. voltage to be used for domestic purposes. It is used at the colonies. Transformer works on the principle of mutual induction, a form of electromagnetic induction.

Inverter : It converts D.C. into A.C. For domestic purposes it is specially designed to convert D.C. from a battery to A.C. & to charge the battery. When the mains supply is available, it charges the battery (converts A.C. into D.C.) whereas in absence of the mains supply, it automotically switches on the A.C., converted from D.C. supplied by the battery. Thus it fulfils electric supply during the power break down.

Loudspeaker : It converts electrical energy first into mechenical energy and then into sound energy. It works on the fact that when a current carrying coil is placed in a magnetic field, the coil experiences force. This force causes vibrations in a cone. Consequently sound is produced. Its most common type is moving coil loudspeaker.

Microphone : It converts sound energy into mechanical energy of a vibrating diaphragm and then finally into electrical energy to be supplied to the loudspeaker. Its most common type is the moving coil microphone.

GENERATION AND TRANSMISSION OF POWER

Electric power generation occurs in two forms viz. Hydroelectricity and thermal electricity. Both of them involve an electric generator whose armature is connected with a turbine. In case of a hydroelectricity plant, the potential energy of water stored in a dam is converted into kinetic energy of the falling water which in turn is converted into the kinetic energy of the armature of the generator. This kinetic energy finally appears as electrical energy known as hydro electricity. At a thermo-electric plant, the function of the falling water is done by hot-steam coming from boiling water. It requires heat energy produced by burning the fuel like coal & petroleum or heat produced by nuclear reactor.

DOMESTIC ELECTRIC CIRCUITS

The electric power is supplied to the houses or factories through undergound cables or overhead wires on poles. A single phase electric line system comprises three wires, namely phase wire or line wire, neutral- wire and earth-wire. These wires coming from power substation are connected to an electric meter in a house or a factory. An electric fuse is placed in the path of the phase wire before it is connected to the electric-meter. This fuse is known as pole-fuse and has a definite current rating. If current exceeds this rating value, the fuse wire will melt.

Systems of power distribution in a house: The output electric power of the main switch can be distributed in a house by two systems. They are:

(i) **Tree System :** This system of power distribution is like the distribution of the branches of a tree. The power supply of different circuits originates from different fuses. So if a particular fuse melts, then the other circuit remain unaffected. Different appliances in a given circuit are connected in parallel so that they can be switched on or switched off independently. The parallel connection gives equal potential difference across each appliance in a circuit. This system is complex and expensive.

(ii) **Ring System:** In this system the three wires namely live, neutral & earth, start from the main fuse and return to the main fuse ofter connecting various appliances. Each appliance has a fuse. So if a fuse melts due to short circuiting, then only that appliances is switched off. Other appliance remain unaffected and continue to work. This system is easy to install and cheaper.

Earthing: It is usually a copper wire whose one end is connected with metal casing of an electric appliance. The other end of the wire is connected to the copper plate which is buried deep inside the earth. When the live wire touches the metal casing of an electric-appliance, it can cause electric shock on touching the appliance. But in the presence of earthing current flows from the metallic casing to the earth through the earthing-wire. It produces heat in the circuit that in turn causes the melting of fuse in the circuit. The circuit is switched off automatically. It saves the appliance from burning and a person touching the appliances does not get an electric shock.

Whenever there is lightning in the sky, the electric circuits should be switched off to save the electric appliances connected in these circuits from burning.

Flexible Cables: An electric-appliance is connected with three-core flexible cables. The insulations on the three wires are coloured (i) Red or brown for live wire (ii) black or light blue for neutralwire and (iii) green or yellow for earth wire.

Plugs: A three-pin plug consists of one longer and thicker pin and two identical thin pins. The thick pin is for earthing and hence it is connected with the green or yellow wire. The remaining two pins are connected with red or brown (live) wire and black or blue (neutral) wire. The earth pin being thicker cannot be inserted in the live of the socket even by mistake.

Sockets: A socket has three holes. The top bigger hole is for the earth, the lower right hole is for the live wire and the left hole is for the neutral wire.

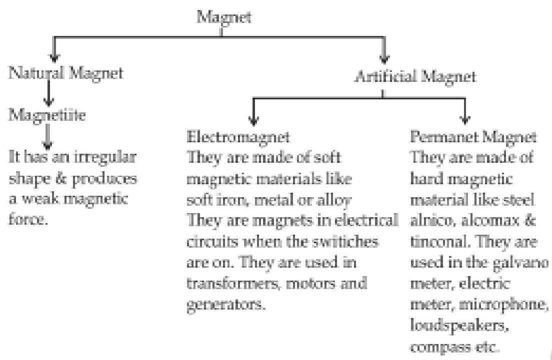
Switches: An electric switch, is always connected across the live wire. If a switch is connected in the neutral wire, the socket remains live even when the switch is in the off position. It can cause a shock from the element of a heater or other appliance even when the appliance is not in use.

The insulation on the wire should be of high strength so that it may not melt easily when wires are heated due to a large current flowing through them. Wires carrying current electricity should not be touched bare footed. The live wire is at higher potential and the earth is at zero potential. If we touch the live wire bare footed, a large current will pass through our body. So we will receive a severe shock. This shock affects our nervous system and may cause even death. Hence, while using electricity, we must wear gloves made of insulated material and shoes of rubber sole so that current may not flow through our body.

MAGNETISM

An iron ore piece having the structural formula Fe_3O_4 (ferrous-ferric oxide) can attract small pieces of iron. Such ore pieces were first of all found in the district of Magnesia in Asia Minor in Greece. These ore pieces were called Natural Magnets. A Greek Philosopher, Thales of Miletus had observed these ore pieces in 600 B.C. This iron ore is called Magnetite. Magnetite was also called 'lode-stone' in the sense of leading stone to show geographic directions (North-South).

A magnet is made of iron or its alloys. Each magnet has two equal and opposite magnetic poles viz. North pole and South- pole lying at its ends.



It we cut a magnet, we get smaller magnets again, instead of an isolated north or south pole of the magnet. Hence the magnetic poles always exist in pairs and not as a single magnetic monopole. Like poles repel each other and unlike poles attract each other. Each magnetic pole can attract small pieces of iron, nickel, cobalt. When a magnet is suspended at mid-point by a thread, its north pole points the geographic north and south-pole points geogra phic south. It is its directional property. On heating, the magnets lose their magnetism.

Magnetism in a magnet is due to the proper alignment of electron spins.

MAGNETIC SCREENING OR SHIELDING

A space can be shielded from magnetic field by surrounding the space with a soft iron ring. As magnetic field lines will be drawn into the ring, the enclosed region will become free of magnetic field. Super conductor also provides perfect magnetic shielding as no magnetic lines pass through the super conductor.

Magnetic shielding is used to protect costly w rist w atches fro m exter nal magnetic fields by enclosing them in a soft iron core.

When an iron bar is magnetised, the spins are aligned parallel to the field. Hence, the length of the bar in the direction of magnetisation increases. This effect is known as mangetostriction effect. This effect is used for producing ultrasonic waves.

CLASSIFICATION OF MAGNETIC MATERIALS

(1) Diamagnetic Substances : They are weakly repelled by an external magnetic field, e.g. Bismuth, antimony, copper, gold, quartz, mercury, water, alcohol, hydrogen.

(2) Paramagnetic Substances : They are w eakly attracte d by a n exter n al m agnetic field e.g. aluminium, platin um, ch ro mium, m anganese, copper sulphate, crown glass, oxygen etc.

(3) Ferro Magnetic Substances : They are stro n gly attracte d by a n exter n al magnetic field e.g. iron, cobalt, nickel an d their alloys like Al Ni, alnico, tinconol vicalloy, steel, perm alloys, mu-metal, radio-metal, etc.

Ferromagnetic substances are used for m aking per m anent m agnets an d electromagnets.

The ferromagnetic materials used for coating magnetic tapes in a cassette player or for building memory stores in a computer are **ferrites** . Most common ferrites used are MFe_2O_4 where M= Mn, Fe, Co and Ni.

EARTH'S MAGNETISM

Earth acts as a huge magnet. Its magnetic south pole is at its geographic north and is located in North-Canada , longitude 96° west and latitude 70.5° North. Its magnetic north pole is at the geographic south and is located in Antarctica, longitude 84° east and latitude 70.5° south.

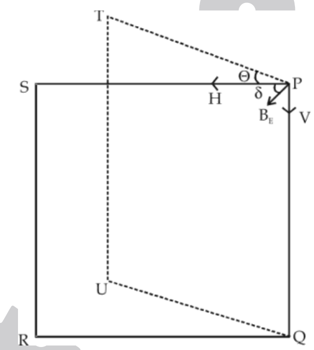
Geographic Meridian : An imaginary vertical plane passing along the axis of rotation of the earth at a place is known as geographic meridian at that place.

Magnetic Meridian : An imaginary vertical plane passing along the axis of a freely suspeneded magnet at a place is known as magnetic meridian at the place.

Magnetic Declination (q) : The angle between the geographic and magnetic meridians at a place is known as magnetic declination at that place. It is in the order of 20°.

Magnetic Inclination or Magnetic Dip (d) : The angle between the direction of the earth magnetic field and the horizontal direction in the magnetic meridian is known as dip-angle or magnetic dip. Its value is maximum 90° at the poles and minimum 0° at the equator.

Horizontal Component : It is the component of total magnetic field of the earth horizontally in the magnetic meridian. In the given diagram : Plane PQRS = Magnetic meridian. Plane = PQUT = Geographic Meridian q = Magnetic declination.



d = Magnetic dip.

H = Horizontal component of the earth's magnetic field (B_E).

V = Vertical component of B_E.

When a compass is used by mariners and others at a place, the magnetic needle of the compass sets itself along the horizontal component of the earth's magnetic field in the magnetic meridian. By knowing the angle of dip and magnetic declination, the location of the place can be determined.

If d = 0° the place is at the equator,

if d = 90° the place is at the poles.

At the geographic north pole, the magnetic north pole of the magnetic needle will be vertically down while at the geographic south pole, the south pole of the needle will be vertically down.

If d is more than 0° and less than 90°, the place is between the pole and the equator.

Evidences behind the earth's magnetism :

(i) A fresh suspended bar magnet always aligns itself along the geographic north-south. It means the north pole of the magnet is attracted by the magnetic south pole of the earth that lies in the geographic north and vice-versa.

(ii) When a soft iron piece is buried below the earths surface along the north-south direction, it acq uires m agnetic properties after some time.

(iii) When we draw field lines of a magnet, we get neutral points. At these points the net magnetic field due to the magnet is co mpletely neu tralize d by the horizontal component of the earth's magnetic field.

TRIVIA

- In the gases, the charge carriers are electrons and + VE ions.
- Filament of 100 W lamp is thinner than that of 200 W lamp.
- When two lamps of different wattage are connected in series, the lamp of lower wattage glows more brightly.
- The power of a heater when connected across a power supply of negligible internal resistance is P. If the length of the coil is halved, the power of the remaining wire is less than 2P.
- Substances which lose their resistivity at low temperature are called superconductors.
- The material of the heating element of an electric heater should have high resistivity and high melting point.
- The heat generated in a wire is doubled when both the radius and length of the wire are doubled.
- If a heater boils 1 kg water in time T_1 and another heater boils the same water in time T_2, then both connected together in series will boil the same water time $T_1 + T_2$.
- The quantity in electricity that is analogues to temperature in heat is potential.
- The current capacity increases, when the cells are connected in series.
- The internal resistance of an ideal cell is zero.
- The resistance of an ideal voltmeter should be infinity.
- The resistance of an ideal ammeter should be zero.
- Energy is dissipated inside a cell due to internal resistance.
- The potential across a cell in closed circuit is less than the emf due to its internal resistance.
- Larger the current drawn from a cell, smaller is the potential difference across it.
- Energy dissipated by the cell = EIt, where E = emf, I = current, t = time.
- Energy dissipated in the external circuit of a cell = VIt, where V = potential drop across the cell.
- The emf of voltaic cell is 1.08 V, that of Daniel cell is 1.12 V and that of Leclanche cell is 1.45 V.
- Acid accumulator is most likely to be damaged due to short circuiting.
- Fast charging does not cause sulphation of acid accumulator, but fast discharging does it.
- Thermocouple should not be used to measure temperature above the neutral temperature.
- And if they are connected in parallel, the time taken to boil the same amount of water will be $T_1T_2 / (T_1 + T_2)$.

- The fuse wire is made of an alloy of lead and tin.
- The resistance in electricity is analogous to friction in mechanics.
- The change in the dimensions of a conductor has no effect on its conductivity, although conductance may change.
- The quantity in electricity that is analogues to temperature in heat is potential.
- The current capacity increases, when the cells are connected in series.
- The internal resistance of an ideal cell is zero.
- The resistance of an ideal voltmeter should be infinity.
- The resistance of an ideal ammeter should be zero.
- Energy is dissipated inside a cell due to internal resistance.
- The potential across a cell in closed circuit is less than the emf due to its internal resistance.
- Larger the current drawn from a cell, smaller is the potential difference across it.
- Energy dissipated by the cell = Elt, where E = emf, I = current, t = time.
- Energy dissipated in the external circuit of a cell = VIt, where V = potential drop across the cell.
- The emf of voilaic cell is 1.08 V, that of Daniel cell is 1.12 V and that of Leclanche cell is 1.45 V.
- Acid accumulator is most likely to be damaged due to short circuiting.
- Fast charging does not cause sulphation of acid accumulator, but fast discharging does it.
- Thermocouple should not be used to measure temperature above the neutral temperature.

■■■

PHYSICS AT A GLANCE

LAWS OF MOTION

- **Newton's three laws of motion form the basis of mechanics:** According to 1st law, a body continues to be in its state of rest or of uniform motion along a straight line, unless it is acted upon by some external force to change the state. The law defines force and is also called law of inertia.
- According to 2nd law, 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 in the direction of the applied force. This law gives us a measure of force.
- According to third law, to every action, there is always an equal and opposite reaction. This law gives us the nature of force.
- Inertia is inability of a body to change by itself, its state of rest or its state of uniform motion along a straight line. Inertia is obviously of three types :

  (i) Inertia of rest (ii) Inertia of motion, (iii) Inertia of direction.
- From Newton's 2nd law, we obtain $\vec{F} = m\vec{a}$ i.e., external force is the product of mass and acceleration of the body.
- The absolute unit of force on SI is newton (N) and on cgs system, is dyne. The gravitational unit of force on SI is kilogram weight or kilogram force. The gravitational unit of force on cgs system is gram weight or gram force.

  $1N = 10^5$ dyne,

  1g wt. = 980 dyne.
- According to the principle of conservation of linear moment, the vector sum of linear momentum of all the bodies in an isolated system is conserved, and is not affected due to their mutual action and reaction. An isolated system is that on which no external force is acting. Flight of rockets, jet planes, recoiling of a gun etc, are explained on the basis of this principle. Newton's 3rd law of motion can also be derived from this principle and vice-versa.
- Apparent weight of man in an elevator is given by :

  $W' = m (g \pm a)$, where mg is real weight of the man. Acceleration is (+a), when the lift is accelerating upwards and (-a), when the lift is accelerating downwards. When lift is moving uniformly (upwards / downwards), a = 0, W' = mg = real weight.

  In free fall, a = g

  $\therefore \quad W' = m (g - g) = 0$

  ie., apparent weight becomes zero.
- The forces which are acting at a point are called concurrent forces. They are said to be in equilibrium, when their resultant is zero.

- A frame of reference in which Newton's laws of motion hold good is called an inertial frame of references. Such a frame is unaccelerated frame of reference.

Energy Equivalence

S.No.	Particle	Mass	Energy equivalent
1.	Electron or positron	9.1×10^{-31}kg	0.53 MeV
2.	Neutron or proton	1 amu = 1.67×10^{-37}kg	931 MeV
3.	Alpha particle	6.68×10^{-27}kg	3724 MeV

GRAVITATION

- Gravitation is the name given to the force of attraction acting between any two bodies of the universle.
- Newton's Law of Gravitation: It states that the gravitational force of attraction acting between two bodies of the universe is directly proportional to the product of their masses and is inversely proportional to the square of the distance between them i.e, = Gm $_1m_2$ / r_2; where G is the universal gravitational constant.
- Gravitational Constant (G): It is equal to the force of attraction acting between two bodies each of unit mass, whose centres are palced unit distance apart. The value of G is constant throughout the universe. It is a scalar quantity. The dimensional formula of G.

  = $[M^{-1}L^3T^{-2}]$. The value of

  G = 6.67×10^{-11} Nm ^{2}kg^{-2}
- **Gravity:** It is the force of attraction exerted by earth towards its centre on a body lying on or near the surface of earth. Gravity is the measure of weight of the body. The weight of the body of mass m = mass × acceleration due to gravity. The unit of weight of a body will be the same as those of force.
- **Acceleration due to Gravity (g):** It is defined as the acceleration set up in a body while falling freely under the effect of gravity alone. It is vector quantity. The value of g changes with height, depth, rotation of earth. The value of g is zero at the centre of the earth. The value of g on the surface of earth is 9.8 ms^{-2}.
- The acceleration due to gravity (g) is related with gravitational constant (G) by the relation $g = \frac{GM}{R^2}$ where M and R are the mass and radius of the earth.

  becomes zero at the centre of earth.
- **Gravitational Field:** It is the space around a material body in which its gravitational pull can be experienced by other bodies.

  The strength of gravitational field at a point is the measure of gravitational intensity at that point. The intensity of gravitational field of a body at a point in the field is defined as the force experienced by a body of unit mass placed at that point provided the presence of unit mass does not disturb the original gravitational field. The intensity of gravitational field at a point distance r from the centre of the body of mass M is given by

  E = GM / r^2 = acceleration due to gravity.
- **Gravitational Potential:** The gravitational potential at a point in a gravitational field is defined as the amount of work done in bringing a body of unit mass from infinity to that point without acceleration. Gravitational potential at a point,

$$V = \frac{\text{work done}\left(W\right)}{\text{test mass}\left(m_0\right)}$$

States of Equilibrium

Stable	Unstable	Neutral
1. When displaced from equilibrium position, tends to come back	1. When displaced from equilibrium position, particle tends to move away from equilibrium position.	1. Particle always remains in the state of equilibrium irrespective of any displacement.
2. Potential energy = Minimum	2. Potential energy = Maximum	2. Potential energy = Constant

- Gravitational potential energy of a body, at a point in the gravitational field of another body is defined as the amount of work done in bringing the given body from infinity to that point without acceleration.

  Gravitational potential energy = gravitational potential × mass of body.

- Inertial mass of a body is defined as the force required to produce unit acceleration in the body.

- Gravitational mass of a body is defined as the gravitational pull experienced by the body in a gravitational field of unit intensity.

- Inertial mass of a body is identical to the gravitational mass of that body. The main difference is that the gravitational mass of a body is affected by the presence of other bodies near it. Whereas the inertial mass of a body remains unaffected by the presence of other bodies near it.

- **Satellite :** A satellite is a body which is revolving continously in an orbit around a comparatively much large body.

  (i) Orbital velocity of a satellite is the velocity required to put the satellite into given orbit around earth. Orbital velocity of satellite, when it is revolving around earth at height h is given by

  $$v_0 = R\sqrt{\frac{g}{R+h}}$$

  When the satellite is orbiting close to the surface of earth i.e., H < < R, then

  $$v_0 = R\sqrt{\frac{g}{R}} = \sqrt{gR}$$

  (ii) **Time period of Satellite (T) :** It is the time taken by satellite to complete one revolution around the earth.

- **Geostationary Satellite:** A satellite which revolves around the earth with the same angular speed in the same direction as is done by the earth around its axis is called geostationary or geosynchronous satellite.

- The height of geostationary satellite is = 36000 km and its orbital velocity = 3.1kms^{-1}.

- **Polar Satellite:** It is that satellite which revolves in polar orbit around earth i.e., polar satellite passes thro ugh geographical north and south poles of earth one per orbit.

- **Escape Velocity:** The escape velocity on earth is defined as the minimum velocity with which a body has to be projected vertically upwards from the surface of earth (or any other planet) so that it just crosses the gravitational field of earth (or of that planet) and never returns on its own. Escape velocity v_e is given by.

  $$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

For earth, the value of escape velocity is 11.2 kms^{-1}.

- For a point close to the earth's surface, the escape velocity are related as

$v_e = \sqrt{2}v_0$

- **Weightlessness:** It is a situation in which the effective weight of the body becomes zero.

- **Kepler's Law of Planetary Motion:**

  (i) **Kepler's First Law (Law of Orbit):** Every planet revolves around the sun in an elliptical orbit. The sun is situated at one focus of the ellipse.

  (ii) **Kepler's Second Law (Law of Area):** The radius vector draw n from the sun to a planet sweeps out equal areas in equal intervals of time i.e, the areal velocity of the planet around the sun is constant.

  (iii) **Kepler's Third Law (Law of Period) :** The square of the time period of revolution of a planet around the sun is directly proportional to the cube of semi-major axis of the elliptical orbit i. e., $T^2 \propto R^3$.

where R is the semi major axis of the elliptical orbit of the planet around the sun.

Conservative and Non-conservative Force

S.	Conservative Forces		Non Conservative Forces
1.	Work done by/against such forces in displacing a particle does not depend upon the path along which particle is displaced.	1.	Work done by/against such forces in displacing a particle depends upon the path along which particle is displaced.
2.	Work done by/against such forces in displacing a particle around a closed path is zero.	2.	Work done by/against such forces in displacing a particle around a closed path is NOT zero.
3.	K.E. of particle remains constant	3.	K.E. of particle changes.

SOLID & LIQUID

- **Interatomic Forces :** These are those forces w hich are acting between the atoms due to electrostatic interaction between the charges of the atoms. These forces are electrical in nature and are active between the atoms if the distance between them is of the order of atomic size (= 10^{-10}m.)

- **Intermolecular Forces :** These are those forces w hich are acting between the molecules due to electrostatic interaction between the charges of the molecules. These forces are also of electrical origin and are active between the molecules w hose separation is of the order of molecular size (= 10^{-9}m).

Molecular forces are w eaker than interatomic forces.

- **Crystalline Solids :** These are solids w hich have a d efinite exter nal geo m etrical for m an d w hose constitutent atoms / ions / molecules are arranged in a definite pattern in three dimensions within the solid.

  Examples, are quartz, calcite, rocksalt, sugar, mica, diamond, etc.

  Crystalline solids have sharp melting p oint an d they are anisotro pic in behaviour.

- **Amorphous Solids :** These are those solids which have no definite external geo m etrical for m an d w hose constitutent atoms / ions / molecules are not arranged in a defintie pattern in three dimensions within the solid.

Exa mples. Ru bber, glass, plastic, cement, paraffin, etc. Crystalline solids do not have sharp melting point and they are isotropic in behaviour.

- **Deforming Force :** It is that force which w hen a pplie d, changes the configuration of the body.
- **Elasticity :** It is the property of the body by virtue of which the body regains its original configuration (length, volume or shape) when the deforming forces are removed.
- **Stress :** The internal restoring force acting per unit area of a deformed body is called stress i.e.,

  stress = restoring force / area.
- According to Newton's third law of motion, the restoring force is equal and opposite to the external deforming force applied, when there is no permanent change in the configuration of the body. Thus,

$$\text{stress} = \frac{\text{external deforming force}}{\text{area}}$$

- **Stress is a Tensor Quantity:** Its S.I. unit is Nm^{-2} and c.g.s unit is dyne / cm^2. Its dimensional formula is $[M^1L^{-1}T^{-2}]$.

  Stress can be of two types :

  (i) Normal stress

  (ii) Tangential stress.
- **Strain :** It is defined as the ratio of change in configuration of the deformed body due to a deforming force on it to the original configuration of the body i.e.,

$$\text{Strain} = \frac{\text{change in configuration}}{\text{original configuration}}$$

  Strain can be of three types :

  (i) Longitudinal strain

  (ii) Volumetric strain

  (iii) Shearing stream
- **Hooke's Law :** It states that the extension produced in the wire is directly proportional to the load applied within the elastic limit. Hook's law also states that the stress is directly proportional to strain within the elastic limit.
- Modulus of Elasticity or Coefficient of elasticity of a body is defined as the ratio of the stress to the corresponding strain produced, within the elastic limit.

  Modulus of elasticity is of three types :

Elastic and Inelastic Collisions

	Perfectly elastic collision		Perfectly Inelastic collisions
1.	Particles do not stick after collision.	1.	Particles stick after collision.
2.	Rel. vel. of separation after collison = rel. vel. of approach before collision.	2.	Rel vel. of separation after collision is zero.
3.	Coeff. of restitution, e = 1	3.	Coeff. of restitution e = 0
4.	Linear momentum is conserved	4.	Linear momentum is conserved
5.	K.E. is conserved	5.	K.E. is not conserved

(i) **Young's Modulus of Elasticity (Y):** It is defined as the ratio of normal stress to the longitudinal strain within the elastic limit i.e.,

$$Y = \frac{\text{normal stress}}{\text{longitudinal strain}}$$

(ii) **Bulk Modulus of Elasticity (K) :** It is defined as the ratio of normal stress to the volumetric strain within the elastic limit i.e.,

$$K = \frac{\text{normal stress}}{\text{volumetric strain}}$$

(iii) **Modulus of Rigidity (η) :** It is defined as the ratio of tangential stress to the shearing strain, within the elastic limit i.e.,

$$\eta = \frac{\text{tangential stress}}{\text{shearing strain}}$$

- Where Shearing strain is defined as the angle through which a line perpendicular to the fixed face gets rotated under the effect of a tangential force acting on the opposite face of the body.
- The S.I. units of modulus of elasticity of Y or K or η is Nm $^{-2}$ or Pa and c.g.s. unit is dyne / cm^2. The dimensional formula = $[M^1L^{-1}T^{-2}]$.
- **Ductile Materials :** These are those materials w hich show large plastic range beyond the elastic limit. Examples are copper, silver, iron, aluminium, etc.
- **Brittle Materials :** These are those material which show very small range beyond elastic limit. For such materials, the breaking point lies close to the elastic limit. Examples are cast iron, glass etc.
- **Elastomers :** These are those materials for which stress and strain variation is not straight line within elastic limit and strain produced is much larger than the stress applied. Such materials have no plastic range. Example is rubber.
- **Elastic after Effect :** The temporary delay in regaining the original configuration by the elastic body after the removal of a deforming force is called elastic after effect. It is least for quartz or phosphor bronze.
- **Elastic-Fatigue :** It is the property of the elastic body by virtue of which its behviour becomes less elastic under the action of repeated alternating deforming forces.
- **Breaking force** = breaking stress × area of cross section of the wire.

  Breaking stress is fixed for a material but breaking force will vary, depending on area of cross-section of the wire.
- **Elastic Potential Energy in a Stretched Wire:** Elastic potential energy per unit volume of the stretched wire is,

$$u = \frac{1}{2} \times \text{stress} \times \text{strain}$$
$$= \frac{1}{2} \times \left(\text{Young's modulus}\right) \times \left(\text{strain}\right)^2$$

- **Thrust:** The total normal force exerted by liquid at rest on a given surface in contact with it is called thrust of liquid on that surface.
- **Pressure of Liquid or Hydrostatic Pressure (P):** It is defined as the thrust acting per u nit area of the su rface incontact with liquid i.e.,

$$P = \frac{thrust\ (F)}{area\ (A)}$$

  S.I. unit of P is Nm $^{-2}$ or pascal (denoted by Pa). Pressure is a scalar quantity.
- **Pascal's Law :** It states that if gravity effect is neglected, the pressure at every point of liquid in equilibrium of rest is same. Pascal's law also states that the increase in pressure at one point of the enclosed liquid in equilibrium of rest is transmitted equally to all other points of liquid provided the gravity effect is neglected.

- **Atmospheric Pressure :** The pressure exerted by atmosphere is called atmospheric pressure. At S.T.P. the value of atmospheric pressure is 1.01×10^5 Nm $^{-2}$ or 1.01×10^6 dyne / cm^2.
- **Archimede's Principle :** It states that when a body is immersed partly on wholly in a liquid at rest it loses some of its weight, which is equal to the weight of the liquid displaced by the immersed part of the body. Observed weight of the body in a liquid = true weighh - weight of liquid displaced.
- **Law of Floatation:** It states that a body will float in a liquid if weight of the liquid displaced by the immersed part of the body is atleast equal to or greater than the weight of the body.
- **Molecular Range :** It is the maximum distance upto which a molecule can exert some measurable attraction on other molecules. The order of molecular range is = 10^{-9}m in solids and liquids.
- **Sphere of Influence :** It is a sphere drawn with molecule as centre and molecular range as radius.
- **Surface Film :** It is the top most layer of liquid at rest with thickness equal to the molecular range.
- **Surface Tension :** It is the property of the liquid by virtue of which the free surface of liquid at rest tends to have minimum surface area and as such it behaves as a stretched membrane. Quantitatively surface tension.

  $$S = \frac{F}{l}$$

  where F is the force acting on the imaginary line of length l, drawn tangentially to the liquid surface at rest.

  S.I. unit of surface tension is Nm $^{-1}$ and c.g.s unit is dyne / cm. Surface tension is a scalar quantity as it has no specific direction for a given liquid.
- Surface energy = surface tension × area of the liquid surface.
- (i) Excess of pressure inside a liquid drop.

  $p = 2 S / R$

  (ii) Excess of pressure inside a soap bubble,

  $p = 4 S / R$

  where S is the surface tension and R is the radius of the drop or bubble.
- **Angle of Contact :** The angle of contact between a liquid and a solid is defined as the angle enclosed between the tangents to the liquid surface and the solid surface inside the liquid, both the tangents being drawn at the point of contact of the liquid with the solid. The value of angle of contact is less than 90° for a liquid which wets the solid surface and is greater than 90° if a liquid does not wet the solid surface.
- **Capillarity :** The phenomenon of rise or fall of liquid in a capillary tube is called capillarity. The height (h) through which a liquid will rise in a capillary tube of radius r which wets the sides of the tube will be given by

  $$h = \frac{2\,S\cos\theta}{r\rho g}$$

  where S is the surface tension of liquid, θ is the angle of contact, ρ is the density of liquid and g is the acceleration due to gravity.
- **Surface tension** of a liquid / water decreases with rise of temperature or when a detergent is dissolved in it.

- **Viscosity :** Viscosity is the property of a fluid (liquid or gas) by virtue of which an internal frictional force or viscous drag comes into play when the fluid is in motion and opposes the relative motion of its different layers. The coefficient of viscosity of liquid is defined as the tangential force (= backward viscous drag) required to maintain a unit velocity gradient between two layers of fluid each of unit area.
- Viscous drag F acting between two layers of liquid each of area A, moving with velocity gradient dv / dx is given by

  $F = -\eta A dv / dx$

  where η is the coefficient of viscosity, and its c.g.s unit is poise or dyne cm $^{-2}$ sec.
- **Stoke's Law :** It states that the backward dragging force F acting on a small spherical body of radius r, moving through a medium of viscosity η, with velocity v is given by

  $F = 6\pi\eta rv.$
- **The Viscosity of Liquid decreases with increase in Temperature :** The viscosity of gases increases with the increas in temperature. With the increase in pressure, the viscosity of liquid increases but of water decreases where as of gases remains unchanged.
- **Stream** line flow of a liquid is that flow in which every particle of the liquid follows exactly the path of its preceding particle and has the same velocity in magnitude and direction as that of its preceding particle while crossing through that point. A stream line flow is accompanied by stream lines of liquid.
- **Laminar Flow :** That steady flow in which the liquid moves in the form of layers is called a laminar flow. In this flow, one layer slides over the other layer of liquid. The velocity of liquid flow is always less than the critical velocity of the liquid.
- **Turbulent Flow :** It is that flow of liquid, in which a liquid moves with a velocity greater than its critical velocity. The motion of the particles of liquid becomes disorderly or irregular.
- **Critical Velocity** : It is that velocity of liquid flow, upto which the flow of liquid is a streamlined and above which its flow becomes turbulent.
- **Reynold's Number :** It is pure number which determines the nature of flow of liquid through a pipe. Quantitatively, Reynold's number N_R is given by

  $$N_R = \frac{\rho D v_e}{\eta}$$

  where η is the coefficient of viscosity of liquid, g is the density of liquid. D is the diameter of the tube and v_e is the critical velocity of liquid flowing through the tube. For streamline or laminar flow, the value of N_R is less than 2000 and for turbulent flow the value of N_R is more than 3000. For N_R in between 2000 to 3000, the flow is uncertain.
- Equation of continuity, a v = a constant of $v \alpha 1 / a$.

  i.e., deep water runs slow.
- **Bernoulli Theorem :** It states that for the stream line flow of an ideal liquid, the total energy (the sum of pressure energy, the potential energy and kinetic energy) per unit volume remains constant at every cross-section throughout the tube i.e.,

  $$P + pgh + \frac{1}{2}\rho v^2 = \text{a constant}$$

or, $\frac{p}{\rho g}+h+\frac{1}{2}\frac{v^2}{g}$ = another constant

Here, $\frac{p}{\rho g}$ = pressure head

h = potential head

and $\frac{1}{2}\frac{v^2}{g}$ = velocity head.

If the liquid is flowing through a horizontal tube, then h is constant. Bernoulli's Theorem states that

$P+\frac{1}{2}\rho v^2$ = a constant

The Bernoulli's Theorem, also states that in a stream line flow of an ideal liquid through a horizontal tube, the velocity increases where pressure decreases and vice-versa.

- **Torricelli's Theorem :** It states that the velocity of efflux i.e., the velocity with which the liquid flows out of an orifice (i.e., a narrow hole) is equal to that which a freely falling body would acquire in falling through a vertical distance equal to the depth of orifice below the free surface of liquid. Quantitatively velocity of efflux, $v=\sqrt{2gh}$, where h is the depth of orifice below the free surface of liquid.

HEAT

- The ratio of work done (W) to the amount of heat produced (Q) is always a constant, represented by J. i.e., $\frac{W}{Q}=J$

  where J is called Joule's mechanical equivalent of heat. The value of

  J = 4.186 joule / calorie.

- When a body of mass m falls under gavity through a height h, then W = mgh.

  When a body of mass m, moving with a vel. v is made to stop, $W=\frac{1}{2}mv^2$

  If temperature of a body of mass m rises by ΔT, then Q = m L, where L is latent heat of the body.

- **Temperature on Celcius Scale:** Fahrenheit scale, Reumer scale and Kelvin scale are related as:

  $$\frac{T_C-0}{100}=\frac{T_F-32}{180}=\frac{T_R-0}{80}$$
  $$=\frac{T_K-273.15}{100}$$

- **Various Thermometers used for measuring unknown temperatures are :** Jolly's constant volume air thermometer; Platinum resistance therometer; Thermoelectric thermometer; radiation Pyrometer.

- **All Solids expand on Heating:** The coefficient of linear expansion, coefficient of superficial expansion and coefficient of cubical expansion are related as $\alpha=\frac{\beta}{2}=\frac{\gamma}{3}$

- Thermal capacity of a body is the amount of heat required to raise its temperature through one degree ΔQ = mc. From here, we may define specific heat of a body as the heat capacity per unit mass of the body.

- Water Equivalent of a body is the mass of water which absorbs or emits the same amount of heat as is done by the body for the same rise or fall in temperature. It is represented by w = mc.

When two substances at different temperature are mixed together they exchange heat. If we assume that no heat is lost to the surroundings, then ac- cording to principle of calorimetry,

Heat lost = Heat gained.

- **Specific Heat of Gases :** Specific heat of a gas is the amount of heat required to raise the temperature of one gram of gas through 1°C. As the gas can be heated under different conditions, and different amounts of heat is required in each case, therefore, a gas does not possess one single value of specific heat. Out of many values of specific heat of a gas, two are important. These are called two principal specific heats of a gas :

  1. Specific heat of a constant volume (c_v)
  2. Specific heat of a constant pressure (c_p)

- **Boyle's Law:** It states that the volume V of the given mass of a gas is inversely proportional to its pressure P, when temperature is kept contant i.e. V = 1 / P or V = K / P

  PV = K a constant.

- **Charle's Law:** It states that the pressure remaining constant, the volume of the given mass of a gas is directly proportional to its kelvin temperature i.e., $V \propto T$ if P is constant.

- Standard gas equation, PV = nRT

  where n is the number of moles con- tained in the given ideal gas of volume V, pressure P and temperature TK.

- **Gas Constant:** R is a universal gas constant and r is a gas constant for 1 gram of a gas. The universal gas constant is defined as the work done by (or on) a gas per mole per kelvin i.e.,

$$R = \frac{PV}{nT} = \frac{\text{pressure} \times \text{volume}}{\text{no. of moles} \times \text{temperature}}$$

The value of gas constant r for different gases is different.

- **Ideal Gas or Perfect Gas:** It is that gas which strictly obeys gas laws. for such a gas, the size of the moelcules of a gas is zero and there is no force of attraction or repulsion amongst its molecules.

- **Assumptions of Kinetic Theory of Gases:**

(i) A gas consists of a very large number of molecules which are perfectly elastic spheres and are identical in all respects for a given gas and are different for different gases.

(ii) The molecules of a gas are in a state of continous, rapid and random motion.

(iii) The volume occupied by the molecules is negligible in comparison to the volume of the gas.

(iv) The molecules do not exert any force of attraction or repulsion on each other, except during collision. on each other, except during collision.

(v) The collision of the molecules with themselves and with the walls of the vessel are perfectly elastic.

(vi) Molecular density is uniform throughout the gas.

(vii) A molecule moves along a straight line between two successive collisions.

(viii) the collisions are almost instantaneous.

- **Pressure exerted by a Gas :** It is due to continous bombardment of gas molecules against the walls of the container and is given by the relation.

$$P = \frac{MC^2}{3V} = \frac{1}{3}pC^2$$

where C is the r.m.s. velocity of gas molecules.

Cell Profile

	Daniel Cell	Leclanche Cell	Dry Cell
Positive electrode	Copper vessel	Carbon rod	Carbon rod with brass cap
Negative electrode	Zinc rod	Zinc rod	Zinc vessel
Electrolyte	dil H_2SO_4	NH_4Cl solution	Paste of NH_4Cl and saw dust
Depolariser	$CuSO_4$ solution	Manganese dioxide	Manganese dioxide

- Average K.E. per molecule of a gas $= \frac{1}{2}mC^2 = \frac{3}{2}kT$. It is independent of the mass of the gas but depends upon the temperature of the gas.

- **Absolute Zero :** It is that temperature at which the root mean square velocity of the gas molecules reduces to zero.

- **Thermodynamical System :** An assembly of extremely large number of particles (such as gas molecules in a container) is called a thermodynamical system. Such a system has a certain value of pressure P, volume V and temperature T and heat content Q. These are called Thermodynamical parameters.

  The equation of state of gaseous phase of a substance is PV = n RT where n is number of moles of the gas.

  The other two phases are solid phase and liquid phase.

- Internal Energy of a Gas is the sum of kinetic energy and the intermolecular potential energy of the molecules of the gas.

  Intermolecular potential energy of a real gas is a function of its volume. K.E. of gas molecules is a function of its veloc- ity and hence the temperature T.

  K.E. / molecules $= \frac{1}{2}mC^2 = \frac{3}{2}kT$ where k is Boltzmann's constant.

  In an ideal gas, intermolecular forces do not exist. Therefore, it possesses no intermolecular potential energy. Thus internal energy of an ideal gas is wholly kinetic.

- First Law of Thermodynamics is restatement of the principle of conservation of energy as applied to heat energy. According to this law

  $dQ = dU + dW$

  where dQ is the small amount of heat energy given to a system, dU is small increase in internal energy of the system and dW is the small external work done by the system.

- **Thermodynamical Operations :** Isothermal Changes are the changes in pressure and volume of the system when temperature is kept constant. Free exchange of heat between the system and the surroundings is allowed. The container must be perfectly conducting and the changes must be brought about slowly.

  Equation of isothermal changes is PV = constant or $P_2V_2 = P_1V_1$

- Adiabatic Changes are the changes in pressure and volume of the system, when heat content of the system is kept constant. No exchange of heat is allowed between the system and the surroundings. The container must therefore be perfectly insulating and the changes must be sudden.

- Second Law of Thermodynamics states that it is impossible for self-acting machine, unaided by an external agency to convey heat from the body at lower temperature to another at higher temperature. This statement of the law was made by Calusius.

According to Kelvin, it is impossible to derive a continuous supply of work by cooling a body to a temperature lower than that of the coldest of its surround- ings.

- **Heat Engines :** A heat engine is a de- vice which converts heat energy into mechanical energy. Efficiency of a heat engine is the ratio of useful work done (W) by the engine per cycle to the heat energy absorbed from the source (Q_1) per cycle.

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

where Q_2 is the heat rejected to the sink
Power of a steam engine = 2 PLAN (watt)

$= \frac{2PLAN}{746}$ (Horse power) where P is the pres- sure of steam measured in Nm^{-2}, L is half the length of the stroke in metre, A is area of cross section of the piston in m^2 and N is number of strokes per second.

Steam engine is an external combus- tion engine. There are internal combus- tion engines like petrol engine and die- sel engine. These are four stroke en- gines.

- Carnot engine is an ideal heat engine which is based on Carnot's reversible cycle. Its working consists of four steps viz. isothermal expansion, adiabatic expansion, isother m al comp ression and aidabatic compression. The effi- ciency of Carnot engine is given by

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_1}{T_1}$$

where Q_1 is heat energy absorbed from the source maintained at a constant high te mp erat u re T_1°K an d Q_2 is amount of heat energy rejected to the sink at constant low temperature T_2°K.

- A Refrigerator or a Heat pump absorbs heat Q_2 from a sink at lower tempera- ture T_2°K. The sink is the substance to

Cell Chemistry

	Lead Accumulator	Alkali Accumulator
In charged Positive electrode	Perforated lead plates coated with PbO_2	Perforated steel plate coated with $Ni(OH)_4$
Negative electrode	Perforated lead plates coated with pure lead	Perforated steel plate coated with Fe
Electrolyte KOH + 1%	Dil. H_2SO_4	20% solution of LiOH

be cooled. Heat absorbed from the sink is rejected to the source (i.e., surround- ing air) at high temperature T_1°K. Elec- tric energy W has to be supplied for this purpose $Q_1 = Q_2 + W$.

Coefficient of performance (C.O.P.) of a refrigerator is the ratio of the heat absorbed from the sink (Q_2) to the elec- tric energy supplied (W) for this pur- pose per cycle i.e.,

$$C.O.P. = \frac{Q_2}{W}$$

$$\text{i.e., } \beta = \frac{Q_2}{Q_1 - Q_2} = \frac{Q_2/Q_1}{1 - Q_2/Q_1} = \frac{T_2/T_1}{1 - T_2/T_1}$$

$$\beta = \frac{T_2}{T_1 - T_2} = \frac{1-\eta}{\eta}$$

- **Transfer of Heat:** Three modes of trans- fer of heat are : conduction; convec- tion; and radiation. Coefficient of ther- mal conductivity (K) of a solid conduc- tor is calculated from the relation.

$$\frac{\Delta Q}{\Delta t} = KA\left(\frac{\Delta T}{\Delta x}\right),$$

where A is area of hot face, Δx is dis- tance between the hot and cold faces,

ΔQ is the small amount of heat con- ducted in a small time (Δx), ΔT is differ- ence in temperature of hot and cold faces.

Here (ΔT / Δx) temperature gradient i.e., rate of fall of temperature with dis- tance in the direction of flow of heat.

All liquids and gases are heated by convection. Heat comes to us from the sun by radiation.

- **Wien's Displacement Law :** It states that the wavelength (λ_m) corresponding to which energy emitted by a perfectly black body is maximum is inversely proportional to the temperature

  (T) of the black body i.e., $\lambda_m \alpha \frac{1}{T}$ or $\lambda_m \alpha \frac{b}{T}$ where b is a constant of proportionality and is called Wien's constant. Its value is b = 2.898 × 10^{-3} mK.

- **Stefan's Law :** It states that the total amount of energy radiated per second per unit area of a perfectly black body is directly proportional to the fourth power of the absolute temperature of the body i.e., $E \propto T^4$ or $E = \sigma T^4$ where σ is called Stefan's constant. Its value is σ = 5.67 × 10^{-8} watt $m^{-2}K^{-4}$

  In case a perfectly black body at temperature T is placed in an enclosure at temperature T_0, then net amount of energy radiated per second per unit area by the black body is given by $E = \sigma (T^4 - T_0^4)$

  If the body and enclosure are not perfectly black and have relative emissivity $\in$ we, may rewrite.

  $E = \in \sigma \left(T^4 - T_0^4\right)$

- **Newton's Law of Cooling :** It states that the rate of loss of heat of a liquid is directly proportional to difference in temperature of the liquid and the surroundings provided the temperature difference is small (= 30°C). i.e., E α (T– T_0)

ASTRONOMY

- It is a branch of science that deals with the study of position, composition, motion and other related facts of heavenly bodies.

- **Windows of Astronomy :** The visible light and radio waves coming from the heavenly bodies are two windows to study about the sun, stars i.e., about the universe, hence called windows of the astronomy.

- **Universe :** The limitless expanse of space around us consisting of solar system, stars, galaxies etc. is called universe.

  Main constitutents of universe are: (i) Solar system (ii) Stars (iii) Galaxies.

- **Solar System :** It is the name given to the family of sun. Our solar system consists of sun, nine planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto) orbiting around the sun, satellites (or moons) orbiting around the planets, asteroids, comets and meteroids.

- **Direction and time period of revolution of a planet about its axis:** The sense of rotation of all the planets (except for Venus and Uranus) is normally from west to east. For Venus and Uranus, the sense of rotation is east to west and is called retrograde. Our earth rotates about its north axis to south axis from west to east in 23 hrs. and 58.1 minutes.

- **Surface Temperature of a Planet :** It can be estimated by two methods.

  (i) Using Stefan's law, i.e, E = s T^4

where E is the thermal energy emitted per second per unit area of the planet and T is its surface temperature, s is the Stefan's constant.

(ii) Using Wien's Displacement law.

$$\lambda_m T = b.$$

where λ_m is the wavelength correspond- ing to maximum intensity of radiation emitted from the black body at temperature T and b is the Wien's con- stant.

- **Existence of Atmosphere on a Planet :** The existence of atmosphere on a planet can be decided by two factors :

(i) Acceleration due to gravity; and

(ii) Surface temperature of the planet.

The planets like Mercury, Mars and Pluto have large value of acceleration due to gravity but they have high temperature also. With the increase in temperature, the average velocity of the gas molecules increases and becomes more than their escape velocities. Due to this, the gas molecules have escaped one by one and there is no atmosphere.

- **Chemical Composition of Atmosphere:** The spectrum of the radiations emitted by a planet helps us to decide the nature of the gases present in the atmosphere of a planet. In the spectrum, dark lines correspond to particular elements present in the atmosphere of that planet and intensity of the line tells about the relative abundance of the element.

Atmosphere of earth consists of 88% nitrogen, 21% oxygen with som e carbondioxide and water vapour.

- Basic conditions for the existence of life on a planet are :

(i) There should be suitable temperature range as required for the life to exist on a planet.

(ii) There should be proper atmosphere free from poisonous gases.

(iii) There should be plenty of water.

These conditions donot exist on any other planet excep t o u r earth. Hence, the life is not possible on any other planet except earth.

- **Sun :** It is the nearest star that we can see. It is the heaviest body of our solar system. It is also known as yellow dwarf star.

(i) The composition of the material of the sun is 78% hydrogen, about 21% helium and remaining 2% all other heavier elements from lithium to uranium. The temperature at the centre of the sun is about 14×10^6K and on the surface is 6000 ^{0}K. The density of the material of the sun at the surface is about 10^{-4}kg m^{-3} and at the centre is 10^4 kg m^{-3}.

(ii) Surface energy of the sun is due to fusion process taking place inside the sun, in which certain mass disappears and equivalent amount of energy is produced. The fusion reaction can be represented as

$$4\,{}_1H^1 \rightarrow {}_2He^4 + e^0 + {}_1 26.7 \text{ MeV}$$

- **Stars :** A star is a fiery luminous body which emits light of its own. After sun the next nearest star to earth is Alpha centauri. Its distance is 4.3 light years.

- **Brightness of a Star :** The brightness of a star is expressed through the system of magnitude. Whereas the observed magnitude of a star is the measure of its brightness when observed from the earth and absolute magnitude of a star is the measure of its brightness at 10 per second distance.

- **Steller Spectra** : The different stars are of different colours and the spectrum of a star is related to its colour. There are seven classes of stellar spectra denoted by letters O,B, A, F, G, K and M.

  Our sun belongs to G class star.

- **Birth of a Star :** When the interstellar dust and gas particles come closer to form a cloud due to gravitational force of attraction between them, the birth of a star begins if the original cloud has a mass of at least one thousand solar masses. As the particles of cloud come closer, the gravitational attraction increases. As the contraction of the cloud continues, the pressure and temperature of the cloud continues, the pressure and temperature inside the cloud rise. At a certain stage, the cloud breaks up into large number of fragments of smaller size and each fragment continues to shrink and its temperature continues to rise. When the temperature of a fragment reaches millions of degrees, nuclear fusion begins to take place due to which the fragment begins to radiate light energy from its surface and it becomes a star.

- **Death of a Star :** In each born star, during the fusion process, the hydrogen is converted into helium. When the content of hydrogen of a star decreases to a certain proportion, the core begins to contract while the outer regions expand.

  As a result, the surface temperature of star drops and the star becomes giant or supergiant star. At the end, this star produces energy at a very high rate to such an extent that it explodes in the form of nova or supernova, throwing out the major portion of its mass into interstaller space. This is the death of a star. The core left behind may end in three ways:

  (i) If the original mass of a star is less than two times the mass of the sun, a white dwarf is produced. When it ceases to emit light, it becomes black dwarf.

  (ii) If the original mass of a star is between 2 to 5 times the mass of the sun, neutron star is produced.

  (iii) If the original mass of a star is more than 5 times the solar mass, the black hole is produced.

- **Milky Way or Akash Ganga :** It is the name of the galaxy to which our earth belongs. The milky way is the glowing belt of the sky formed by the combined light of a very large number of stars. It is called milky way or Akash Ganga because the light from the various stars together gives the impression of a stream of milk flowing across the sky.

  Milky way is a spiral galaxy. Its mass is 150 solar masses.

- **Quasars :** These are quasi-stellar Radio sources. Quasars are situated at very large distance from our solar system and are further receding away with a speed of 0.9 times the speed of light.

- **Pulsars :** These are radio sources which emit radio signals at extremely regular intervals of time. Their origin is due to neutron star.

- **Hubble's Law :** It states that the red shift (z) is directly proportional to the distance (r) of the galaxy from us i.e., z α r but

$$z = \frac{d\lambda}{\lambda} = \frac{V}{C} = \frac{\text{speed of the galaxy}}{\text{speed of light}}$$

$$\therefore \frac{V}{c} \alpha \text{ r or, V} \alpha \text{ r or V} = \text{Hr}$$

where H is called Hubble's constant. The quantity (l / H) has the dimensions of time. Hubble's law helps us to estimate the age and evolution of the universe. The value of Hubble's constant is 16 Km-s^{-1} per million light year.

INFORMATION TECHNOLOGY

- All modes of long distance communication have been superceded by communication through electrical signals, as they can be transmitted at extremely high speeds (–3 × 10^8 m /s).
- A basic communication system consists of information source, transmitter, receiver and the link between transmitter and receiver.
- Modulation is the process of super-imposing an audio frequency signal over a radio frequency carrier wave. Three types of modulation are : amplitude modulation (AM), frequency modulation (FM) and pulse modulation (PM).
- In AM, amptitude of high frequency carrier wave is made proportional to the instanteneous amplitude of the audio frequency modulating voltage.
- In FM, frequency of carrier wave is varie d in accor d a nce with t he instantaneous value of the m o dulating voltage. However, the amplitude of the carrier wave is kept constant.
- Modulation index (m $_1$) of FM wave is defined as the ratio of maximum frequency deviation to the modulating frequency.
- Frequency modulation is more advantageous compared to the amplitude modulation.
- Pulse modulation is a system in which continous wave forms are sampled at regular intervals. Information regarding the signal is transmitted only at the sampling times together with any synchronizing pulses that may be required.

  The analog pulse modulation is of two types : pulse amplitude modulation (PAM) an d pulse time modulation (PTM).

  The digital pulse modulation is also of two types : pulse code modulation (PCM) an d pulse delta modulation (PDM).
- Demodulation is the reverse process of modulation which is performed in a receiver to recover the original modulating signal. Tuned frequency receiver (TRF) and superheterodyne receives are commonly used for demodulation.
- Data transmission is through a modulator and data retrieval is through a demodulator.
- A modem is a modulating and demodulating device that connects one computer to another across ordinary telephone line.
- Fax or facsimile telegraphy is the electronic reproduction of a document at a distance.
- The term space communication refers to the sending, receiving and processing of information through space. The information in the term of sound waves can be sent from one place to another place by superimposing it on undamped electromagnetic waves of high frequency called carrier waves. The resulting wave so produced is called m o dulated w ave w hich can travel through space; with the velocity of light. Our earth's atmosphere helps in the propagation of electromagnetic waves.

- The electromagnetic waves of frequency ranging from a few kilo hertz to about a few hundred mega hertz (i.e., wavelength 0.3 m or above) are called radio waves.

  The radiowaves emitted from a transmitter antenna can reach the receiver antenna by following any of the following modes of propagation :

  (i) Ground wave or surface wave propagation.

  (ii) Sky wave propagation.

  (iii) Space wave propagation.

- The radiowaves which travel through atmosphere following the surface of the earth are known as ground waves or surface waves. The maximum range of ground or surface wave propagation depends on (i) the frequency of the radio waves; and (ii) power of the transmitter. The ground wave propagation is suitable for low and medium frequency (i.e. upto 2MHz only).

- The radiowaves of frequency ranging from 2 MHz to 30 MHz are called sky waves. They can propagate through atmosphere and are reflected back by the ionosphere layer of earth's atmosphere. Since these waves travel through sky, their propagation is known as sky wave propagation.

- **Criticial Frequency (CF) :** It is that highest frequency of radiowave which when set straight (i.e., normally) towards the layer of ionosphere gets reflected from ionosphere and returns to the earth. If the frequency of radiowaves is more than the critical frequency, it will not be reflected by ionosphere.

- **Maximum Usable Frequency (MUF) :** It is that highest frequency of radiowaves which when sent at some angle towards the ionosphere gets reflected from that and returns to the earth.

- **Skip Distance :** It is the smallest distance from a transmitter along the earth's surface, at which a sky wave of a fixed frequency, but more than critical frequency is sent back to the earth.

- **Fading :** It is the variation in the strength of a signal at a receiver due to interference of waves. Fading is more at high frequencies.

- **Space Wave Propagation** : The space waves are the radio waves of very high frequency (i.e., between 30 MHz to 300 MHz or more). The space waves can travel through atmosphere from transmitter antenna to receiver antenna either directly or after reflection from ground in the earth's troposphere region. The space wave propagation is also known as line of sight propagation. The range of space wave propagation can be increased by using repeaters at suitable distances from each other on the surface of the earth. The space wave propagation is utilizing radio waves of very high frequency (between 30 MHz to 300 MHz), ultra high frequency and microwaves. They are used in television signal propagation and microwave propagation.

- **Satellite Communication :** It is a mode of communication of a signal between transmitter and receiver through satellite. The satellite communication is like the line-of-sight microwave communication. A geostationary satellite is used for satellite communication. The present Indian communication satellites are INSAT 2B and INSAT 2C.

- **Remote Sensing :** It is a technique which is used to observe and measure the characteristics of the object with respect to its location, size, colour, nature, etc. It is related with measuring some kind of energy which is emitted, transmitted or reflected from the object. Remote sensing systems provide us the data critical to weather prediction, agriculture forecasting, resource exploration and environmental monitoring. The Indian remote sensing satellites are IRS-1A, IRS 1B and IRS-1C.
- Most commonly used wire communication lines are :
  - (i) Parallel wire line, (balanced lines)
  - (ii) Twisted pair wire lines; and
  - (iii) Co-axial wire lines (unbalanced lines).
- **Energy is dissipated in a transmission line in three ways :** Radiation losses, conductor heating & the dielectric heating.
- A co-axial cable system consists of a tube carrying a number of co-axial cables together with repeaters and other ancilliary equipment.
- A telephone link can be established using ground waves, sky waves, micro waves, co-axial cables and the latest optical fibre cables.
- **Optical Communication :** It is a system of communication by which we transfer the information over any distance through optical range of frequencies. The light frequencies used in fibre optical system are in between 10^{14} Hz to 4×10^{14} Hz. (i.e. 100,000 to 400,000 GHz.).
- **Optical Fibre:** It consists of a central core made of glass or plastic which is surrounded by a cladding of material of refractive index slightly less than that of core and a protective jacket of insulating material. There are three types of optical fibre configurations:

  (i) Single mode step-in dex fibre.

  (ii) Multi-mode step-in dex fibre.

  (iii) Multi-mode graded-in dex fibre.
- **Laser:** Laser stands for light amplification by stimulated emission of radiation. The working of laser is based on stimulated emission of radiation. The following types of laser are used:

  (i) Gas lasers (ii) Liquid lasers (iii) Solid lasers (iv) Semiconductor lasers.
- **Light Modulation:** It is achieved by two ways :

  (i) Direct modulation (ii) Indirect or external modulation. Direct modulation suffers from system degradations but indirect or external modulation does not.

LIGHT

- Light is a form of energy which produces the sensation of sight.
- Speed of light in vacuum / air = 3×10^8 ms^{-1}
- **Luminous Body :** A body which emits light of its own. For example, the sun.
- **Non-luminous Body :** A body which does not emit light of its own but reflect the light falling on it. For example, the moon.
- **Medium :** Any substance through which light may or may not pass is called medium.
- **Transparent Medium :** A me dium

through which light can pass is called transparent medium.

For example : Air, glass, clean water.

- **Translucent Medium :** A me dium through which only some parts of light can pass is called translucent medium.

  For example : Greased paper, butter pa- per, ground glass, paraffin wax, etc.

- **Opaque Medium :** A medium through which light cannot pass .

  For Examples : Wood, stone, brick, iron, etc.

- **Ray of Light :** A line drawn in the direction of propagation of light is called ray of light.

- **Reflection of Light :** The phenomenon of returning of light in the same medium after striking a surface is called reflection of light.

- **Types of Reflection :**

  (i) Regular reflection (ii) Irregular reflection.

- **Reflector :** A surface which reflects the light falling on it is called a reflector or a reflecting surface.

- **Laws of Reflection :** The reflection of light from a surface obeys certain laws called laws of reflection.

  (i) Incident angle is equal to the reflected angle i.e. $\angle i = \angle r$.

  (ii) Incident ray, reflected ray and normal to the reflecting surface lie in the same plane.

- **Lateral Inversion :** The exchange of the right and left side of an object and its image is known as lateral inversion.

- Number of images formed by two plane mirrors inclined to each other at an angle $\theta : n = \frac{360}{\theta} - 1$

- **Periscope :** A periscope is a device used to see the objects from a lower level.

- **Concave Mirror :** Concave mirror is a part of a hollow sphere whose outer part is silvered and the inner part is reflecting surface.

- **Convex Mirror :** Convex mirror is a part of a hollow sphere whose outer part is reflecting surface and inner part is silvered.

- **Centre of Curvature :** The centre of hollow sphere of which the spherical mirror forms a part is called centre of curvature. It is denoted by C.

- **Radius of Curvature :** The radius of hollow sphere of which the spherical mirror forms a part is called radius of curvature. It is denoted by R.

- **Pole :** The mid point of a spherical mirror is called its pole. It is denoted by P.

- **Aperture :** The part of the spherical mirror exposed to the incident light is called the aperture of the mirror.

- **Principal Axis :** A line joining the centre of curvature (C) and pole (P) of a spherical mirror and extended on either side is called principal axis.

- **Principal Focus :** A point on the principal axis of a spherical mirror where the rays of light parallel to the principal axis meet after reflection from the mirror is called principal focus. It is denoted by F.

- **Focal Plane:** A plane normal or perpendicular to the principal axis and passing through the principal focus (F) of the spherical mirror is called focal plane.

- **Focal Length:** The distance between the pole (P) and principal focus (F) of the spherical mirror is called the focal length of the mirror.

- **Sign Conventions:**

(1) All types of distance are measured from the pole of a spherical mirror.

(2) Distance measured in the direction of incident light are taken positive. Distance measured in the direction opposite to that of the incident light are taken as negative.

(3) The upward distances perpendicular to the principal axis are taken as positive, while the downward distances perpendicular to the principal axis are taken as negative.

- **Mirror Formula:** The relation between u, v, and focal length (f) of the spherical mirror is known as mirror formula.

- **Linear Magnification:** Linear magnification produced by a mirror is defined as the ratio of the size (or height) of the image to the size of the object. It is denoted by m.

- **Refraction of Light :** The change in the direction of propagation of light when it goes from one medium to another medium is called refraction of light.

- **Laws of Refraction :**

  (1) The incident ray, the refracted ray and the normal to the surface separating the two media all lie in the same plane.

  (2) The ratio of the sine of the incident angle to the sine of the refracted angle is constant for a pair of two media.

- **Refractive Index** (μ) of a medium is defined as the ratio of the velocity of light in vacuum or air to the velocity of light in the medium.

- **Principle of Reversibility of Light :**

  'If the path of a ray of light is reversed after suffering a number of refractions and reflections, then it retraces its path '. This is known as principle of reversibility of light.

$$\boxed{\mu = \frac{\text{Real depth}}{\text{Apparent depth}}}$$

- **Total Internal Reflection :** The phenomenon of reflection of total light when light travelling in a denser medium falls on the surface separating the rarer medium and the denser medium at an angle greater than the critical angle is called total internal reflection.

- **Condition for Total Internal Reflection :**

  Total internal reflection of light takes place if

  (1) the light travels from denser medium to rarer medium.

  (2) the angle of incidence is greater than the critical angle for the given pair of denser and rarer media.

- **Lens :** Lens is a transparent medium bounded by two refracting surfaces.

- **Convex Lens or Converging Lens :** A lens having both spherical surfaces or one spherical and the other plane such that it is thick in the middle and thin at the edges is known as convex lens or converging lens.

- **Concave Lens or Diverging Lens :** A lens having both spherical surfaces or one spherical and other plane such that it is thin in the middle and thick at the edges is known as concave lens or diverging lens.

- **Principal Axis :** A line joining the centre of curvature to two spherical surfaces forming a lens is called principal axis.
- **Optical Centre :** A point in a lens through which rays of light passes undeviated. It is denoted by C.
- **Principal Focus :** A point in the principal axis where all rays of light parallel to the principal axis meet or appear to meet after passing through the lens is called principal focus of the lens.
- **Focal Length :** The distance between the principal focus and optical centre of a lens is known as focal length of the lens. It is denoted by f.
- **Principal Foci :** A beam of light may fall on either side of a lens. Therefore, a lens has two principal foci. They are denoted by F_1 and F_2. Both principal foci are equidistant from the optical centre.
- **First Principal Focus (F_1) :** The position of a point on the principal axis of a lens so that the rays of light starting from this point after passing through the lens travel parallel to the principal axis is called first principal focus (F_1).
- **First Focal Plane :** A vertical plane passing through the first principal focus is called first focal plane.
- **First Principal Focal Length :** The distance between the optical centre and the first principal focus is called first principal focal length. It is denoted by f_1.
- **Second Principal Focus (F_2) :** The position of a point on the principal axis of a lens where a beam of light parallel to the principal axis meets or appears to meet after passing through the lens is called second principal focus (F_2).
- **Second Focal Plane :** A vertical plane passing through the second principal focus is called second focal plane.
- **Second Principal Focal Length :** The distance between the optical centre and the second principal focus is called second principal focal length. It is denoted by f_2.
- **Sign Conventions :**

(1) All distances are measured from the optical centre of a lens.

(2) Distance measured in the direction of the propagation of incident ray of light are taken as positive, while distance measured in a direction opposite to the direction of incident ray of light are taken as negative.

(3) Upward height with respect to the principal axis are taken as positive, while downward heights with respect to the principal axis are taken as negative.

- **Lens Formula :** The relation between object distance (u), image distance (v) and focal length (f) of a lens is called lens formula.
- **Power of a Lens** is defined as the reciprocal of the focal length of the lens. It is denoted by P.

  Unit of power of a lens is dioptre (D).
- **Dispersion :** The phenomenon of splitting white light into seven colours when it passes through a glass prism is called dispersion of white light.
- **Monochromatic Light :** A light consisting of only one colour or only one wavelength is known as monochromatic light.

Microscope & Telescope

	Compound Microscope	Astronomical Telescope
1.	It is used to observe tiny objects.	It is used to observe large and distant objects.
2.	The focal length of the objective lens is small.	The focal length of objective lens is large.
3.	The focal length of the eyepiece is large.	The focal length of eyepiece is small.
4.	The second focal point of objective lens and first focal point of eye-piece are separated by the distance equal to tube length of the microscope.	The second focal point of objective lens coincides with the first focal point of the eye-piece.

- **Polychromatic Light :** A light consisting of more than two colours or more than two wavelengths is known as polychromatic light.

  For example, White light.

- **Spectrum :** A band of seven colours of white light is known as spectrum.
- **Pure Spectrum :** A spectrum in which various colours of white light occupy distinct positions without overlapping each other on the screen is called pure spectrum.
- Persistance of vision is about $\frac{1}{16}$ second.
- **Pigments :** A substance which absorbs most of the colours of white light and reflects one or more colours is called pigment.
- **Primary Colours :** The colours which are never obtained by mixing two or more colours are called primary colours.

  Example : Red, Blue and Green.

- **Secondary Colours :** When any two primary colours are mixed, then a new colour is formed. This new colour is known as secondary colour. Thus, the colour obtained by mixing two primary colours are known as secondary colour.

  Example : Yellow, Magenta and Cyan.

- **Complimentary Colours :** Any two colours are said to be a pair of complimentary colours if these produce white light when mixed together.
- **Primary Pigments :** Yellow, Cyan and Magenta are the examples of primary pigments.
- **Secondary Pigments :** When a pair of primary pigments are mixed together, we get a new pigment known as secondary pigment.

ELECTRICITY

- **Electric Potential :** Work done per unit charge is called electric potential.
- **Unit of Potential :** S.I. unit of potential is volt.
- Potential is a scalar quantity.
- **Potential Difference :** Potential difference between two points is defined as the work done in moving a unit positive charge from one point to another point.
- Potential difference is a scalar quantity.
- **Equipotential Surface :** A surface whose every point has the same potential is known as equipotential surface.

- **Electric Current :** An electric current is defined as the amount of charge flowing through any cross-section of a conductor in unit time.
- **Units :** S.I. unit of electric current is ampere (A).
- **Ampere (A) :** Electric current through a conductor is said to be 1 ampere if one coulomb charge flows through any cross-section of the conductor in one second.
- Electric current is a scalar quantity.
- **Ohm's Law :** This law states that, 'the electric current flowing in a conductor is directly proportional to the potential difference across the ends of the conductor, provided the temperature and other physical conditions of the conductor remains the same'.
- **Resistance (R) :** Resistance of a conductor is the ability of the conductor to oppose the flow of charge through it.
- Unit of resistance is ohm.
- **Ohm :** Resistance of a conductor is said to be 1 Ohm if a potential difference of 1 volt across the ends of the conductor produces a current of 1 ampere through it.
- **Laws of Resistance :**

  (1) Resistance of a conductor depends upon the nature of the material of the conductor.

  (2) Resistance of a conductor is directly proportional to the length of the conductor.

  (3) Resistance of a conductor is inversely proportional to each of crosssection of the conductor.

  (4) Resistivity of metallic conductor increases with the increase of temperature and decreases with the decrease of the temperature.

- **Resistivity or Specific Resistance :** Resistivity is defined as the resistance of the conductor of unit length and unit area of cross-section.
- **Unit of Resistivity :**

  In CGS system, unit of resistivity is ohm-cm.

  In SI system, unit of resistivity is ohm-metre.

- **Conductance :** Conductance of a conductor is the ability to pass charge or current through it.
- **Joule's Law of Heating :**

  The amount of heat produced in a conductor is

  (i) directly proportional to the square of the electric cu rrent flo wing through it.

  (ii) directly proportional to the resistance of the conductor.

  (iii) directly proportional to the time for which the electric current flows through the conductor.

- **Electric Fuse :** Electric fuse is a safety device used in an electric circuit or electric appliance.
- **Electric Energy :** The work done by a source of electricity to maintain a current in an electric circuit is known as electric energy.
- **Electric Power :** Electric power is defined as the amount of electric work done in one second.

  Unit of Power: S.I. unit of power is watt.

Practical unit of power is horse power (h.p.)

1 h.p. = 746 w

Commercial Unit of Energy : kilowatt-hour (kWH)

1 kWh = 3.6×10^6J

- **Electrolysis :** The process by which a substance is decomposed by the passage of electric current through it is called electrolysis.
- **Electrolytes :** Substances which in molten state or in aqueous solution conduct electricity by decomposing into negative and positive ions are called electrolytes.
- **Strong Electrolytes :** Substances which in molten state or in aqueous solution completely decompose into negative and positive ions are called strong electrolytes.
- **Weak Electrolytes :** Substances which in molten state or aqueous solution partially decompose into negative and positive ions are called weak electrolytes.
- **Mercury** is a liquid which conducts electricity without decomposing into ions.
- **Electrodes :** The conducting rods or plates through which an electric current enters or leaves the electrolyte are called electrodes.
- **Anode :** The positive electrode is called anode.
- **Cathode :** The negative electrode is called cathode.
- **Ion :** Atom which has either lost or gained electrons is called ion.
- **Anion :** When an atom gains electron or electrons, it becomes negatively charged ion known as anion.
- **Cation :** When an atom loses electron or electrons, it becomes positively charged ion known as cation.
- **Electrolytic Cell or Voltameter :** A vessel containing electrolyte and electrodes in which electrolysis takes place is called voltameter.
- When an electrolyte in a solid state is dissolved in water, it decomposes into ions as the force of attraction between ions decrease by a factor of $\frac{1}{81}$ in water.
- **Faraday's laws of Electrolysis :**

1st Law : The mass of any substance liberated at an electrode is directly proportional to the charge flowing through the electrolyte.

i.e., $m \propto q$ or $m = Zq$ or $m = Zlt$

2nd Law : If same amount of charge flows through different electrolytes, the masses of substances liberated or deposited at electrodes are directly proportional to their chemical equivalents.

- **Electro-chemical Equivalent** (Z) is defined as the mass of the substance liberated at an electrode per unit charge flowing through the electrolyte.
- Unit of Z is kg / coulomb or g / coulomb.
- Chemical equivalent

$$= \frac{\text{Atomic mass}}{\text{Valency}}$$

- **Electroplating :** The process of depositing a layer of superior metal over another cheaper metal or article by electrolysis is called electroplating.
- **Electro-chemical Cell :** A device in which a constant potential difference is maintained between two electrodes by a

chemical reaction is called electro chemical cell.

- **E.M.F. of a Cell** is the potential difference between two electrodes when no current is drawn from the cell.
- **Terminal Voltage of a Cell** is the potential difference between two electrodes when current is drawn from the cell.
- **Internal Resistance of a Cell** is the resistance offered by a cell to the flow of current through it.
- **Types of Electrochemical Cells:** (i) Primary cells (ii) Secondary cells.
- **Primary Cell** converts chemical energy into electrical energy by irreversible chemical reactions.
- **Secondary Cell :** A cell in which electrical energy is stored in the form of chemical energy and then chemical energy is obtained in the form of electrical energy by reversible chemical reactions is called a secondary cell.
- Internal resistance of a primary cell is higher than that of a secondary cell.
- **Voltaic Cell is** primary cell in which dilute H_2SO_4 is used as electrolyte. Zinc and copper plates are used as cathode and anode.
- Voltaic cell suffers from two defects: (i) local action (ii) polarization
- The value of e.m.f. of voltaic cell = 1.08 V.
- **Polarization** is the process of formation of hydrogen bubbles on the electrode of a cell, causing the e.m.f. of the cell to drop and internal resistance of the cell to increase.
- Polarization can be removed by a substance known as depolarizer, MnO_2 and $CuSO_4$ are the examples of depolarisers.
- **Daniel Cell :** Electrolyte used is dilute sulphuric acid. Copper sulphate ($CuSO_4$) acts as depolarizer E.M.F. of Daniel cell = 1.5V.
- **Leclanche Cell :** Electrolyte used is ammonium chloride solution, MnO_2 acts as depolarizer, E.M.F. of Leclanche cell = 1.5V.
- Dry cell is the modified and portable form of a Leclanche cell.
- Primary cells cannot be re-charged while secondary cells can be re-charged.
- **Magnetic Field :** The space around a current carrying conductor in which its magnetic effect can be experienced is called magnetic field.
- **Maxwell's Cork Screw Rule :** If a cork screw is driven in the direction of current passing through the wire, then the motion of the thumb shows the direction of the magnetic field.
- **Right Hand Thumb Rule :** If a current carrying conductor is imagined to be held in the right hand such that thumb points in the direction of the current, then the fingers of the hand indicate the direction of magnetic field.
- **Solenoid:** A solenoid is a coil of many turns of an insulated wire closely wound in the shape of a cylinder.
- **Uniform Magnetic Field :** Magnetic field is said to be uniform if its magnitude is equal and direction is same at every point in the space.
- **Electromagnets :** When a soft iron bar is placed inside a solenoid carrying current, it becomes a magnet as long as current passes through the solenoid.

Such magnets are known as electromagnets.

- **Electromagnetic Induction :** Whenever magnetic flux linked with a circuit changes, an induced e.m.f. is set up across the circuit. This effect is known as electromagnetic induction.
- **Faraday's Law of Electromagnetic Induction :**

  First Law : Whenever magnetic flux linked with a circuit changes, induced e.m.f. is produced across it. This induced e.m.f. last so long as the change in magnetic flux continues.

  Second Law : The magnitude of the induced e.m.f. produced in the circuit is directly proportional to the rate of change of magnetic flux linked with it.
- **Lenz's law of Electromagnetic Induction :** According to this law, the direction of induced current is always such that it opposes the cause producing it.

  Lenz's law is in accordance with the law of conservation of energy.
- **Electric Motor :** Electric motor converts electric energy into mechanical energy.
- **D.C. Generator or Dynamo :** A device which converts mechanical energy into direct current energy is called D.C. generator or Dynamo.
- **Direct Current :** An electric current whose magnitude is either constant or variable but the direction of flow in a conductor remains the same is called direct current. It is donated by D.C.
- **Alternating Current :** An electric current whose magnitude changes with time and direction reverses periodically is called alternating current. It is denoted by A.C.
- **Joule's Law of Heating :** It states that the amount of heat produced in a conductor is directly proportional to the-

  (i) square of the current flowing through the conductor.

  (ii) resistance of the conductor and

  (iii) time for which the current is passed.
- **Electric Power:** It is defined as the rate at which work is done in maintaining the current in electric circuit.

  Electric power, $P = VI = I^2R = V^2 / R$ watt or joule / second-
- **Electric Energy :** The electric energy consumed in a circuit is defined as the total work done in maintaining the current in an electric circuit for a given time.

  Electric energy = $Vlt = Pt = I^2 Rt = V^2t / R$

  S.I. unit of electric energy is joule (denoted by J) where 1 joule = 1 watt × 1 second = 1 volt × 1 ampere × 1 second

  Commercial unit of electric energy is kilowatt hour (kWh)

  where 1kWH = 1000 Wh = 3.6×10^6J
- **Electrolysis :** The process of decomposition of a solution into ions on passing the current through it is called electrolysis.
- **Electrolyte :** It is a substance which allows the current to pass through it and also decomposes into positive and negative ions. For example, acids, bases, salts dissolved in water, alochol are common electroytes. Agl is a solid state electroyte and KCl, NaCl are electrolytes in their molten state.
- **Electrodes :** These are the two metal

plates which are partially dipped in the solution for passing the current through the electroyte.

- **Anode :** The electrode connected to the positive terminal of the battery i.e., the electrode at higher potential, is called anode.
- **Cathode :** The electrode connected to the negative terminal of the battery i.e., the electrode at lower potential, is called cathode.
- **Ions :** The charged constitutents of the electrolyte which are liberated on passing current are called ions.
- **Anions :** The ions which carry negative charge and move towards the anode during electrolysis are called anions.
- **Cations :** The ions which carry positive charge and move towards the cathode during electrolysis are called cations.
- **Voltameter :** The vessel, containing electrodes and electrolyte, in which the electrolysis is carried out is called a voltameter. In copper voltameter the electrodes are of copper plates and electrolyte is an aqueous solution of CuSO4. During electrolysis copper is removed from the anode and is deposited at the cathode. In water voltameter the electrodes are of pure platinum. The electrolyte is acidulated water i.e., water mixed with a small quantity of sulphuric acid. During electrolysis hydrogen is liberated at cathode and oxygen at anode. The hydrogen collected at cathode is double the amount than the oxygen collected at anode.
- **Faraday's Laws of Electrolysis.**

  First Law : The mass of the substance liberated or deposited at an electrode during electrolysis is directly proportional to the quantity of charge passed through the electrolyte i.e.,

  $m \propto q$

  or, $m = zq$

  where z is the E.C.E. of the substance.

  Second Law : When same amount of charge is made to pass through any number of electrolytes, the masses of the substances liberated or deposited at the electrodes are proportional to their chemical equivalents i.e., $\frac{m_1}{m_2} = \frac{E_1}{E_2}$ where m_1, m_2 are the masses of the substances liberated or deposited on electrodes during electrolysis and E_1 and E_2 are their chemical equivalents.

  Faraday's second law of electrolysis also states that E.C.E. of a substance is directly proportional to the chemical equivalent i.e., $z \propto E$.

- **Faraday constant**

  Thus Faraday constant is equal to the amount of charge required to liberate the mass of a substance at an electrode during electrolysis, equal to its chemical equivalent in grams.

  One Fara d ay = 1F = 96500 C / g m equivalent.

- **Electrical Cell :** It is a device by which electric current is generated due to chemical action taking place in it. Electric cells are of two types: (i) Primary cells (ii) Secondary cells.
- Primary cell is that cell in which electrical energy is produced due to chemical reaction which is irreversible. For example : Voltaic cell, Daniel cell, Leclanche cell, dry cell, etc.

- Secondary cell is that cell in which the electrical energy is first stored up as chemical energy and when current is drawn from the cell, the stored chemical energy is converted intro electrical energy. The chemical reaction is reversible in this cell. These cells are also known as storage cells or accumulators. Examples are Acid or Lead accumulator and Alkali or Edison cell.
- **Seebeck Effect :** It is the phenomenon of generation of an electric current in a thermocouple by keeping its two junctions at different temperatures.

  Seebeck found that the magnitude and direction of thermo e.m.f. developed in a thermocouple depends upon: (i) the nature of metals forming a thermocouple; and (ii) difference in temperature of the two junctions. Seeback effect is a reversible effect. It means, if hot and cold junctions are inter-changed, the direction of thermo-electric current is reversed.
- **Thermocouple :** The assembly of two different metals joined at their ends to have two junctions in a circuit is called a thermocouple.
- **Seeback Series :** Seeback, from his experimental investigations, arranged a number of metals in a series known as Seeback series. Some of the metals, in this series, in the order Seeback arranged them are bismuth, nickel, platinum, silver, gold, copper, lead, zinc, iron and antimony.
- Direction of thermo-electric current in copper-iron thermocouple is from copper to iron through hot junction. In Sb-Bi, thermocouple, the direction of thermo-electric current is from Sb to Bi through cold junction.
- **Neutral Temperature :** It is that temperature of hot junction for which the thermo e.m.f produced in a thermocouple is maximum. Neutral temperature depends upon the nature of the material of a thermocouple but is independent of the temperature of the cold junction.
- **Temperature of Inversion :** It is that temperature of hot junction at which the thermo e.m.f. produced in a thermo couple becomes zero and just beyond, it reverses its direction. The value of temperature of inversion depends upon: (i) the temperature of the cold junction; and (ii) the nature of materials forming a thermocouple.
- **Sources of energy :** Renewable sources and Non-renewable sources.
- **Solar energy** is the energy emitted by the sun in the form of heat and light.
- **Visible light** consists of seven colours i.e., Red, Orange, Yellow, Green, Blue, Indigo, Violet.
- Wavelength range of visible light is from 0.4 micron to 0.7 micron.
- Red light has the longest wavelength and violet light has the shortest wavelength.
- Infra-red rays are emitted by all hot bodies.
- Infra-red rays are absorbed by CO_2 and water vapours in the atmosphere of the earth.
- Ultra-violet rays are harmful radiations and cause diseases like cancer and leukemia.
- Ultra-violet rays are absorbed by ozone layer of atmosphere.

- Light is a stream of packets of energy called photons.
- Energy of each photon, $E = hv = \frac{hc}{\lambda}$
- Solar energy is harnessed by solar devices like solar cooker, solar furnance, solar cell, etc.
- Nuclear fusion reactions are the source of energy of the Sun.
- Nuclear fusion reactions occur at about 10^7°C.
- German physicist Hans Bethe in 1939, predicted that nuclear fusion of hydrogen nuclei in the Sun is the source of energy of the Sun.
- Atom consists of three particles namely proton ($_1H^1$), neutron ($_0n^1$) and electron ($_{-1}e^0$).
- Nucleus of an atom contains protons and neutrons and hence is positively charged.
- Electrons move around the nucleus in circular orbits.
- Number of protons in the nucleus of an atom is equal to the number of electrons revolving around it, so atom is electrically neutral.
- Mass of electron = 9.1×10^{-31} kg. Mass of proton = 1.672×10^{-27} kg.

  Mass of neutron = 1.674×10^{-27} kg.
- Charge on an electron = -1.6×10^{-19}C. Charge on a proton = $+1.6 \times 10^{-19}$C.
- Protons and Neutrons inside the nucleus are collectively known as nucleons.
- Atomic Number (Z) of an atom is equal to the number of protons in the nucleus of the atom.
- Mass Number (A) of an atom is the sum of the number of protons and neutrons in the nucleus of the atom i.e. A = Z + N.
- **Isotopes :** The atoms of an element having same atomic number (Z) but different mass numbers (A) are known as isotopes of the element.
- All isotopes of an element have the same chemical properties.
- Radioactivity is the phenomenon of spontaneous emission of invisible radiations by heavy elements.
- Radioactivity was discovered by Henri Becquerel.
- The radiations emitted by radioactive elements are alpha particles ($_2He^4$), beta particles ($_{-1}e^0$) and gamma rays (γ). These radiations are very harmful to the living organisms.
- Gamma rays have the highest penetrating power than the other two radiations.
- Radio Isotopes are the isotopes of radioactive elements.
- Nuclear forces keep the nucleons inside the nucleus. Small nuclei are stable and big nuclei are unstable.
- Nuclear fission is the process of splitting a heavy nucleus into two small nuclei of middle weight with the release of large amount of energy.
- Uranium-235, isotope of Uranium is used as a fuel in nuclear fission.
- Energy released in a single nuclear fission of U-235 is about 200 MeV.
- Uncontrolled chain reaction is the principle of atom bomb.

- Nuclear reactor is a device to carry out controlled chain reaction.
- Nuclear fission reaction starts when U-235 absorbs a slow neutron.
- Moderator is a substance used to slow down fast moving neutrons. Heavy water and graphite are the examples of moderator.
- Cadmium rods are used to increase or decrease the nuclear fission reactions in the nuclear reactor.