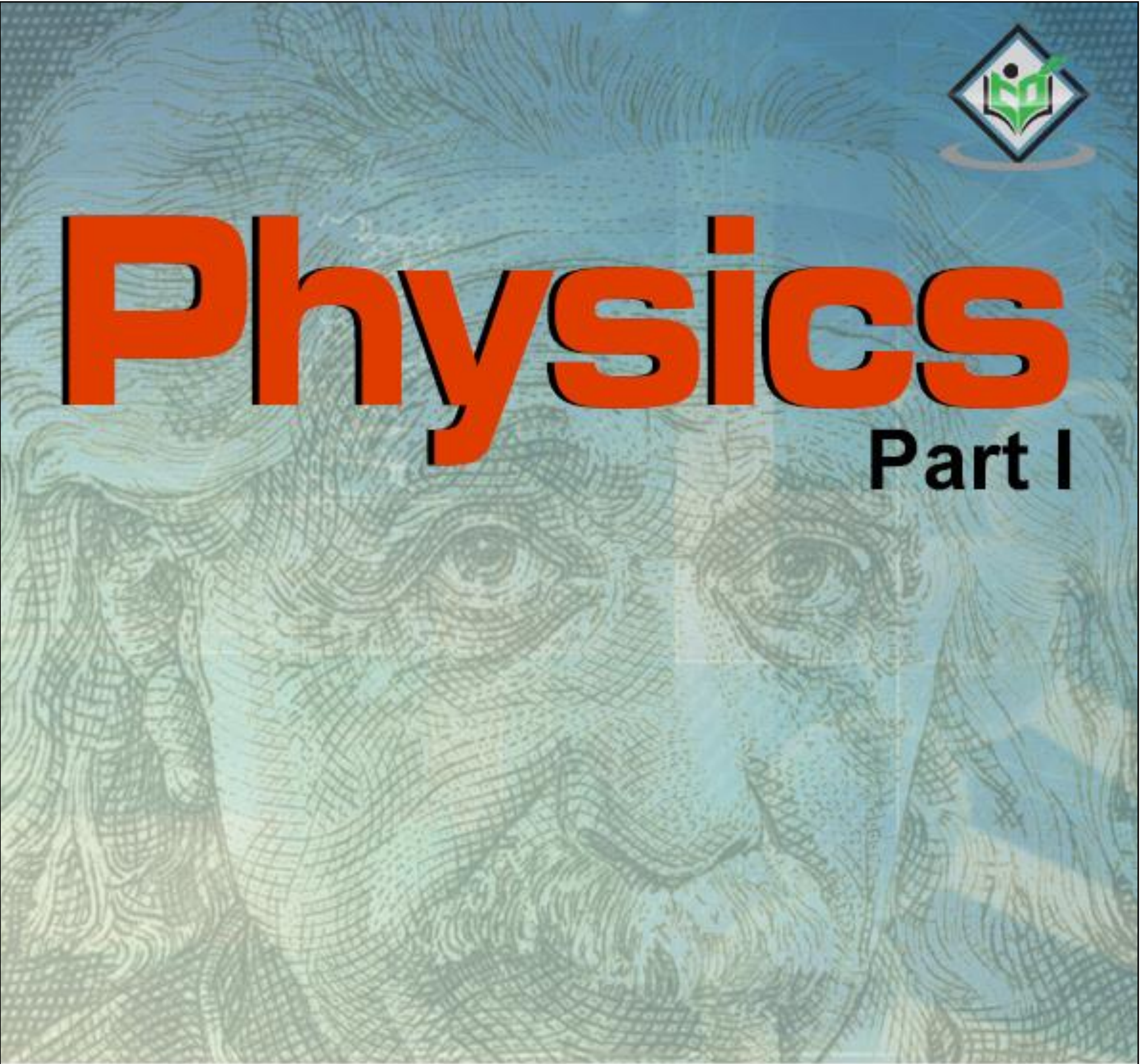

Physics

Part I

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About the Tutorial

Physics is one of the disciplines of natural science that studies about the various aspects of the matters and energy. The major topics those are studied in physics are mechanics, electricity, magnetism, heat, sound, light and other radiation, and the structure of atoms. In addition, physics also explains the evolution, structure, and functions of various elements of the universe.

Because of having wide range of topics, this tutorial is divided into two parts namely Physics Part 1 and Physics Part 2. Further, these two parts are divided into different chapters for an easy understanding.

Audience

This tutorial is designed exclusively for the students preparing for the different competitive exams including **civil services, SSC, banking**, **railway**, **eligibility test**, and all other competitive exams of such kind.

Prerequisites

This tutorial is partly based on **NCERT Physics** (class 8^{th} to 10^{th}) i.e. Part I and Part 2 is prepared from the different reliable sources and represents largely the significant facts and figures vital for the competitive exams.

This tutorial starts with the basic concepts of Physics; however, prior experience of reading the NCERT science (Physics) books is recommended for the easy understanding.

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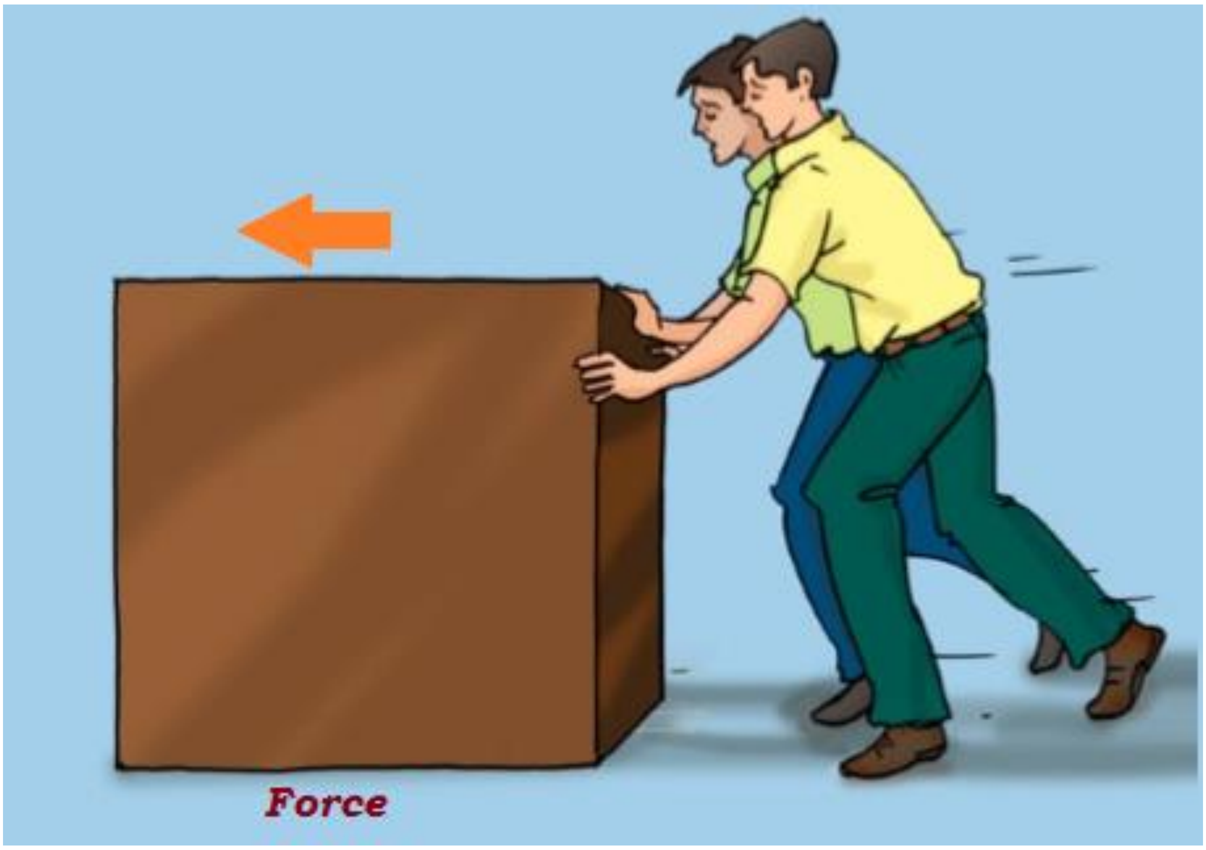
Table of Content

1. FORCE AND PRESSURE

Introduction

- When an object is either pushed or a pulled is known as a force.
- Motion, generated in an object, is because of an action of a force.



- The applied force makes the table move in a given direction.
- The strength of a force is commonly expressed by the magnitude.
- Force also has direction; likewise, if the magnitude or direction changes, it directly affects the force.
- If the force is applied in the direction opposite to the direction of motion, then it results in a decrease in the speed of the object.

- If an object is in motion, then external force may change in the state or direction of motion of that object.

- The state of motion of an object is explained by its speed and the direction of motion.

- The state of '**rest**' of an object is considered to be the zero speed, as

    - An object cannot move by itself.

    - An object cannot change its speed by itself.

    - An object cannot change its direction by itself.

    - An object cannot change by itself.

    - A force may make an object move from rest.

    - A force may change the speed of a moving object.

    - A force may change the direction of a moving object.

    - A force may change the shape of an object.

- The force caused by the action of muscles is known as the **muscular force**.

- Some force, decreases the speed of a moving object, is known as '**friction**.' E.g. moving wheel on road; once the source of force stops working, then wheel stops because of friction.

- The force applied by a charged body on another charged or uncharged body is known as '**electrostatic force**.'

- Objects or things that fall towards the earth, as earth pulls it towards itself; this force is known as the **force of gravity** or **gravity**.

- The force of gravity is applicable on all objects. In fact, every object in this universe, irrespective of its size and shape, exerts some force on every other object. It happens only because of the '**gravitational force**.'

Pressure

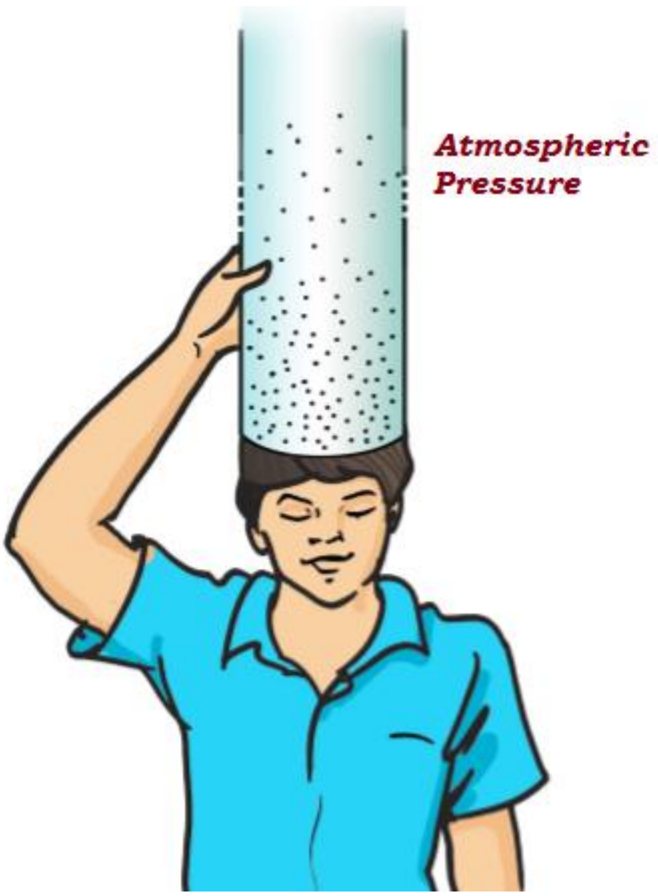
- The force, applied on a unit area of a surface is known as **pressure** (Pressure = force/area on which it acts).

- If the area is smaller, then the pressure on a surface would be greater; e.g. this is the reason that the area of one end of a nail is pointed (to exert sufficient pressure) and other end is bigger (as shown in the image given below).

- This envelop of air is known as the **atmosphere** that extends up to many kilometers above the surface of the earth.

- The pressure exerted by the air is known as **atmospheric pressure**.

- The pressure inside our bodies is exactly equal to the atmospheric pressure and annuls the pressure acting from outside (see the image given below).



- Liquids and gases also exert pressure on the walls of their respective containers.

2. FRICTION

Introduction

- **Friction** is result of the irregularities on the two surfaces in contact of each other.

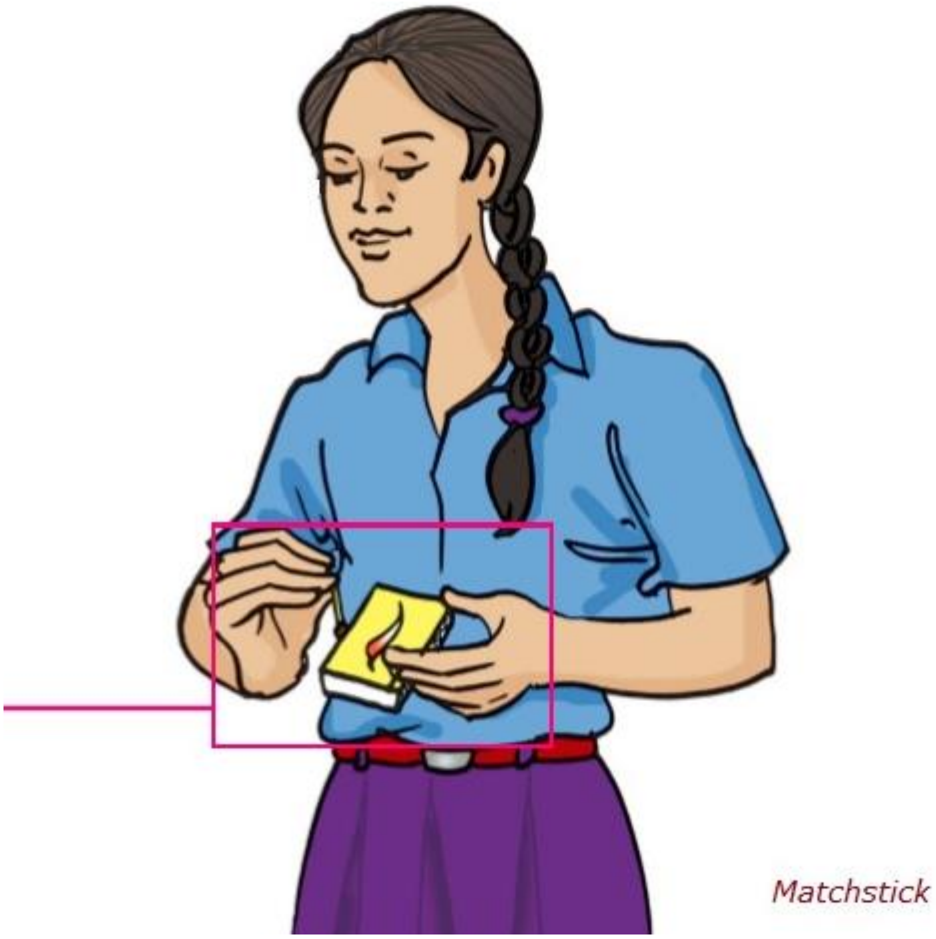
- The force of friction is dependent on the irregularities of the surface; if it is greater, then the friction will be greater and if it is smooth, then the friction will be lesser.

- Effectively, the friction is result of the **interlocking** of irregularities in the two surfaces.

- If the two surfaces (in contact) are pressed harder, then the force of friction will increase.

- On a frictionless surface, if an object starts moving, it would not stop ever; Without friction, it is not possible to construct a building.

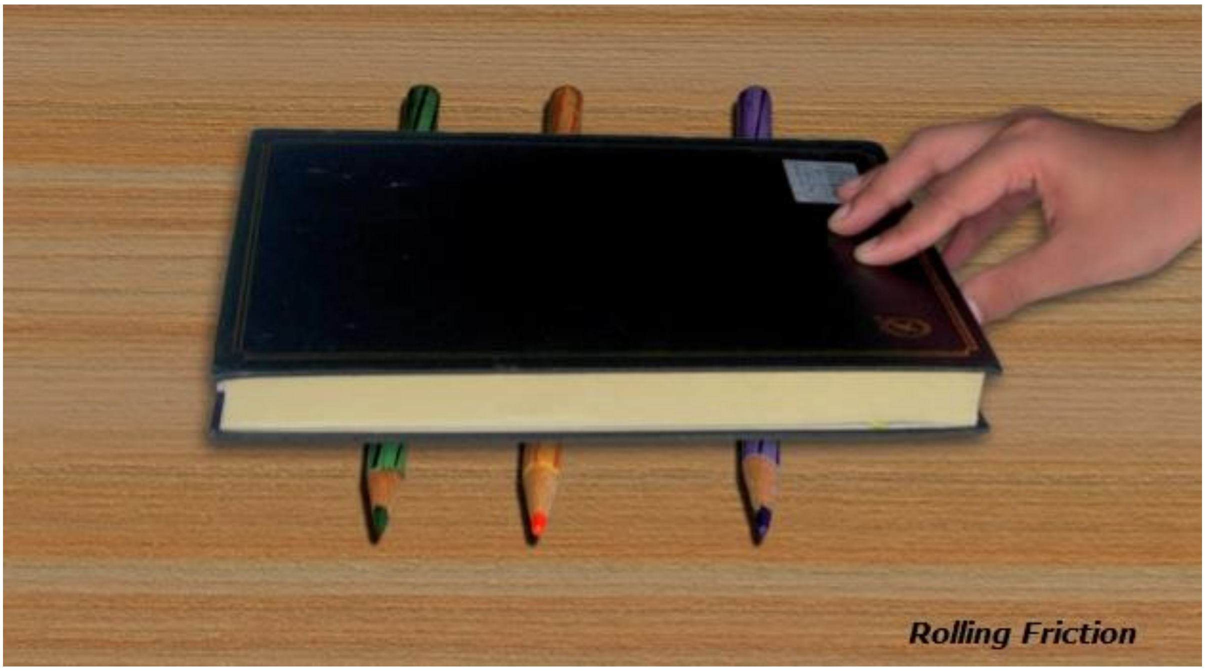
- Friction produces heat; when a matchstick is rubbed against the rough surface, it catches fire.



Substances Reducing Friction

- The substances that reduce friction are known as **lubricants**. E.g. when oil, grease, or graphite is applied between the moving part of a machine, then it creates a thin layer; resultantly, moving surfaces do not directly rub against each other that ultimately reduces friction.

- When a body rolls over the surface of another body, the resistance to its motion is known as the **rolling friction**. The rolling reduces the force of friction.



- The frictional force exerted by fluids is known as **drag**.
- The frictional force, on an object in a fluid, is dependent on its speed with respect to the fluid.
- The frictional force depends on the shape of the respective object and also on the nature of the fluid.
- Fluid friction is minimized by giving suitable shapes to the bodies moving in fluids.

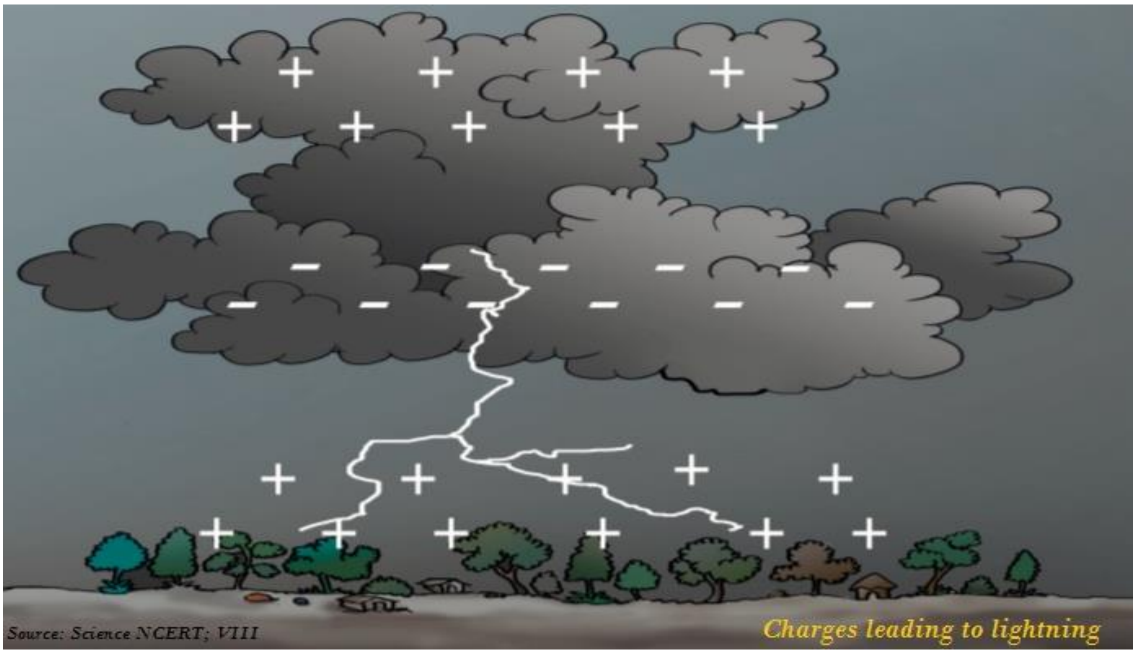
3. SOME NATURAL PHENOMENA

Introduction

- Lightening, cyclone, earthquake, etc. are the natural phenomena.
- Benjamin Franklin, an American scientist, showed that the lightning and the spark from clothes are essentially the same phenomena.
- When a plastic comb is rubbed with dry hair, it acquires some charge and the object is known as **charged** objects.
- When charges move, they constitute an electric current.
- Some natural phenomena can cause large scale destruction of human life and property.

Lightning

- The process of transferring of charge from a charged object to the earth is known as earthing.
- When negative and positive charges meet, it produces streaks of bright light and sound and the process is known as an **electric discharge**.
- The process of electric discharge also occurs between two or more clouds, or between clouds and the earth (as shown in the image given below).

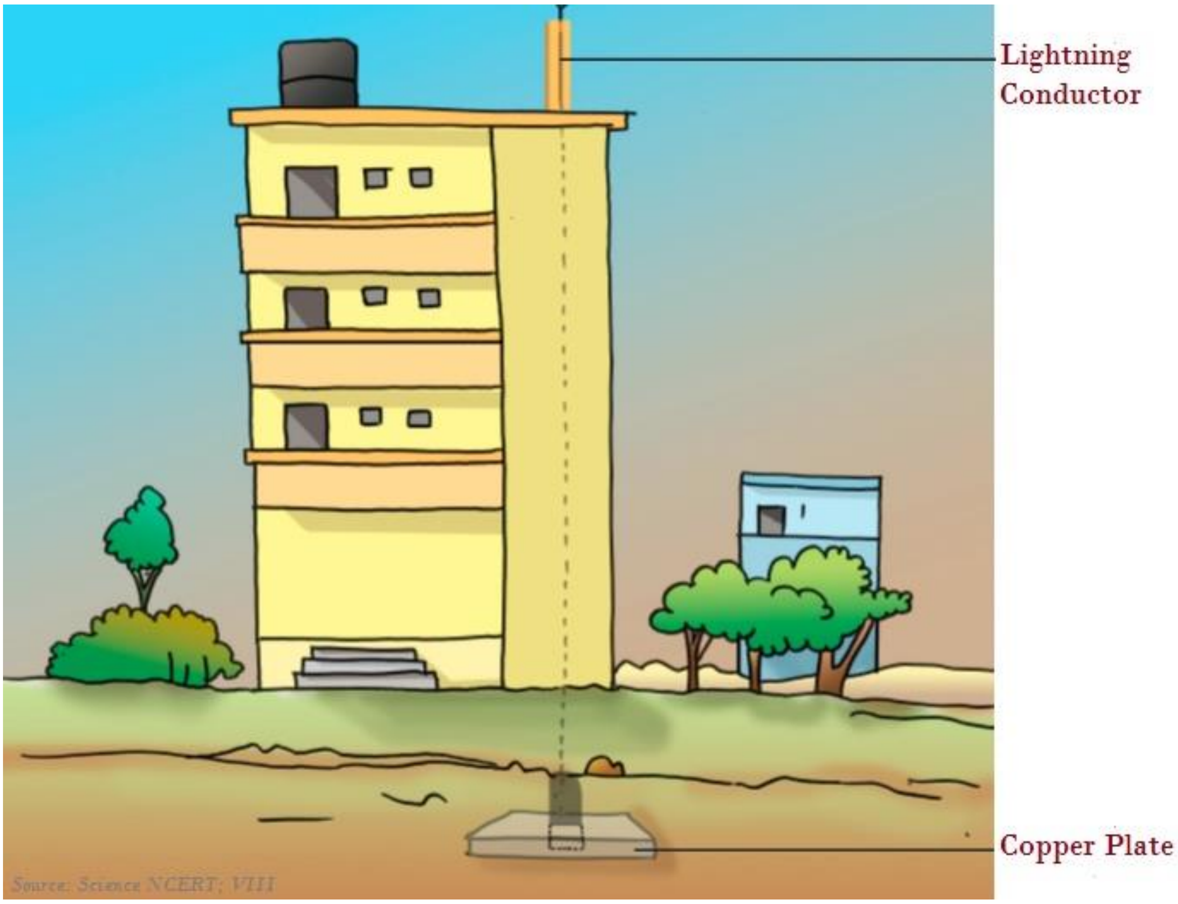


- During the lightning and the thunderstorm no open place is safe.

- Electrical appliances such as computers, TVs, etc., should be unplugged; however, electrical lights can be left on, as they do not cause any harm.

- The device, used to protect buildings from the effect of lightning, is known as **Lightning Conductor**.

- A metallic rod, taller than the building, is fixed in the walls of the building from top to toes during its construction protects from thunderstorm (as shown in the image given below).



- The metal columns used during the fixing of electrical wires and water pipes in the buildings also protect from the thunderstorm and lightning.

- If a thunderstorm occurs there is also a possibility of lightning and cyclones.

Earthquakes

- An earthquake is a sudden shaking or trembling of some region of the earth for a very short time.

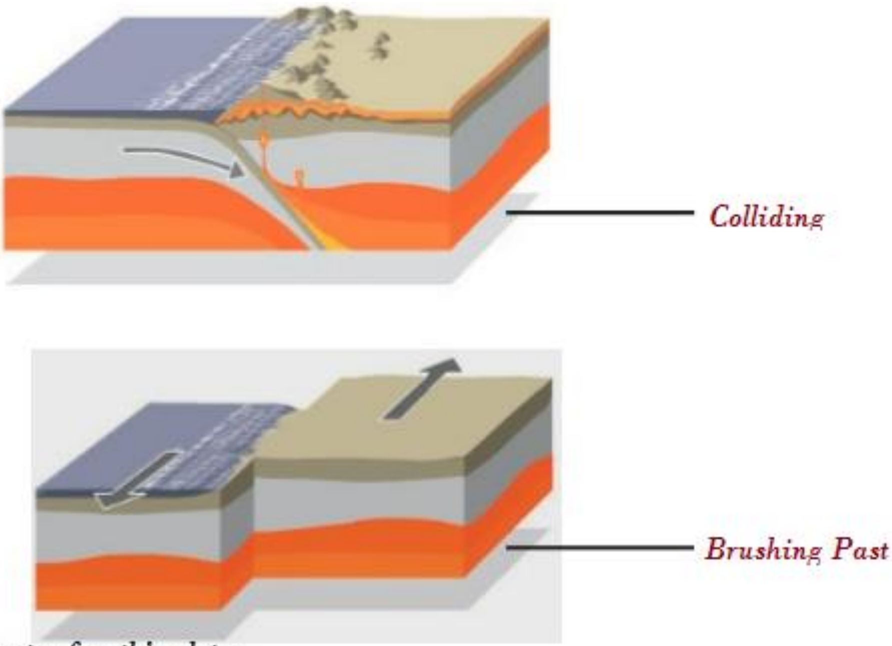
- An earthquake is normally caused by a disturbance originated inside the earth's crust.

- Earthquakes keep occurring almost all the time, all over the earth, but most of them are not even noticeable.

- The major earthquakes are rare, but very much destructive.

- The last major earthquake occurred in India on 8th October 2005 in Uri and Tangdhar towns of North Kashmir and before that a major earthquake occurred on 26th January 2001 in Bhuj, Gujarat.

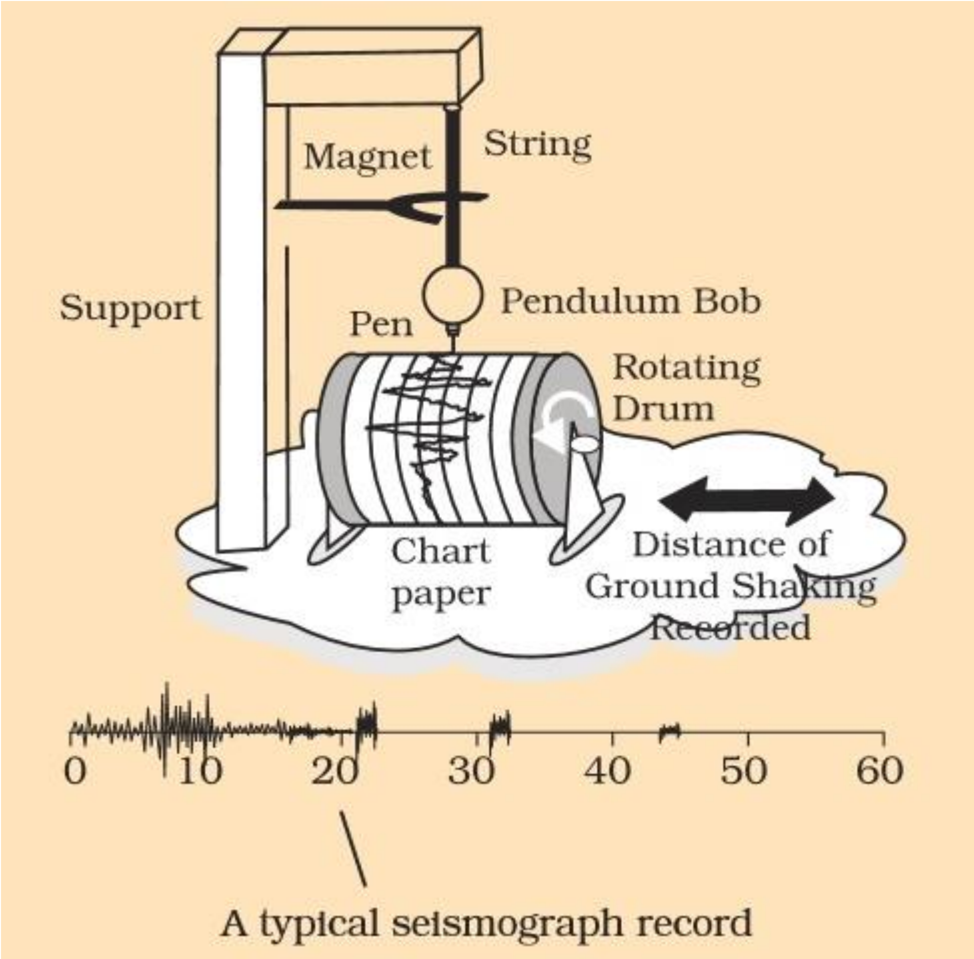
- The earthquakes mostly are caused by the movement of earth’s plates (as shown in the image below).



Movements of earth’s plates

- Earthquakes are also caused by volcanic eruption/activity, when a meteor hits the earth, or an underground nuclear explosion.

- The power of an earthquake is expressed in terms of a magnitude and measured on a scale known as **Richter scale** (as shown in the image given below).

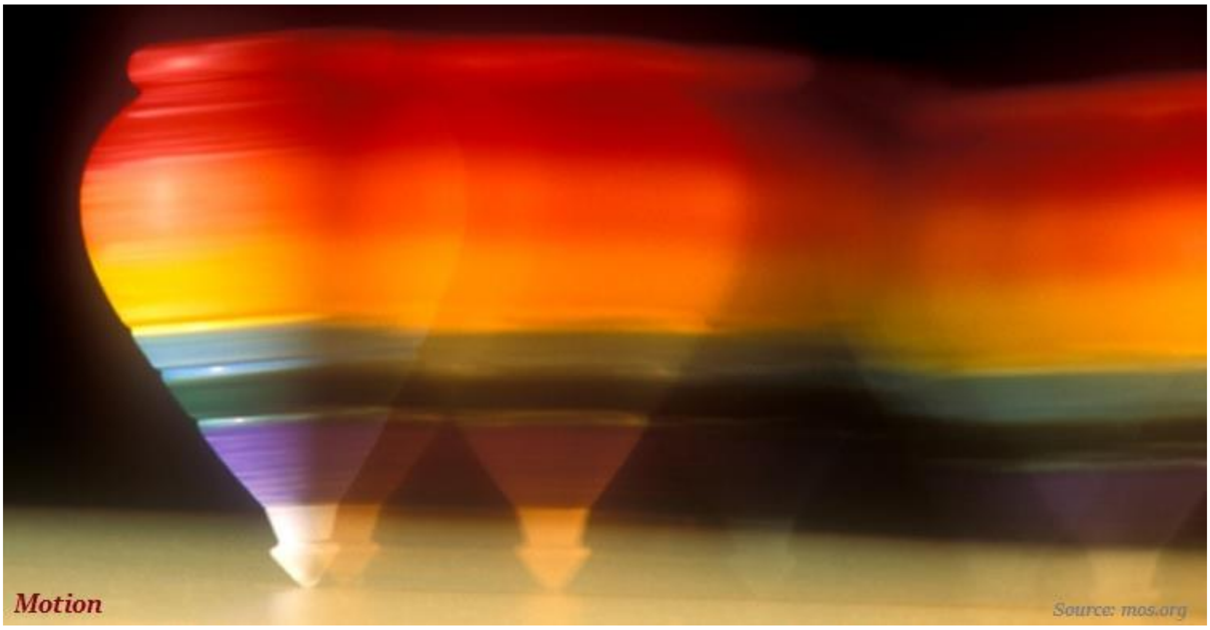


- The earthquake, which magnitude is higher than 7 on the Richter scale, is highly destructive.

4. MOTION

Introduction

- Motion means change in position of an object in given period of time.
- Motion, normally, is described in terms of displacement, velocity, acceleration, distance, time, and speed.



Motion Along a Straight Line

- Motion along a straight line is the simplest form of motion.
- **Magnitude** is the numerical value of a physical quantity.
- The shortest distance, which is measured from the initial to the final position of an object is called as the '**displacement**.'
- The magnitude of the displacement for a path of motion may be zero but the corresponding distance covered cannot be zero.
- If an object travels equal distances in equal intervals of time, it is said to be in '**uniform motion**.'
- If an object travels unequal distances in equal intervals of time, it is said to be in '**non-uniform motion**.'

Speed

- The distance travelled by the object in unit time is known as the rate of motion or simply **speed**.
- The SI unit of speed is meter per second (symbol **m s^{-1} or m/s**).
- The average speed of an object can be obtained by dividing the total distance travelled by the total time taken: represented as:

$$Average\ Speed = \frac{Total\ Distance\ Travelled}{Total\ Time\ Taken}$$

Velocity

- If a quantity specifies the direction of motion along with its speed, it is known as velocity.
- Velocity is the speed of a given object, which is moving in a defined direction.
- Speed and velocity have the same measuring units, i.e., m s^{-1} or m/s.

$$Average\ Velocity = \frac{Initial\ Velocity + Final\ Velocity}{2}$$

Acceleration

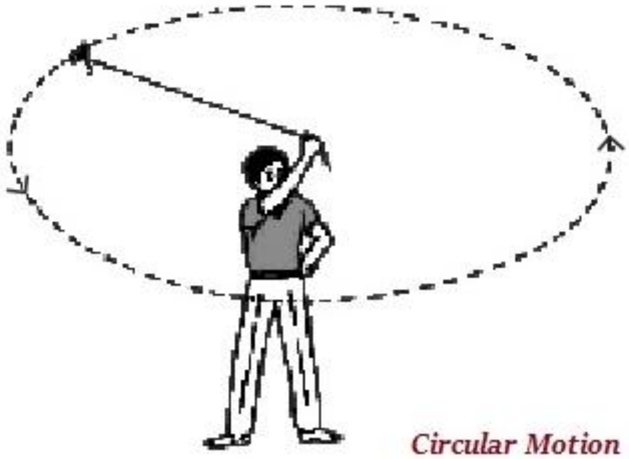
- The change in the velocity of an object per unit time is defined as acceleration.
- The acceleration is calculated as:

$$Acceleration = \frac{Change\ in\ Velocity}{Time\ Taken}$$

- The SI unit of acceleration is **m s^{-2}**.

Uniform Circular Motion

- When an object moves in a circular path in uniform speed, its motion is known as uniform circular motion.



Circular Motion

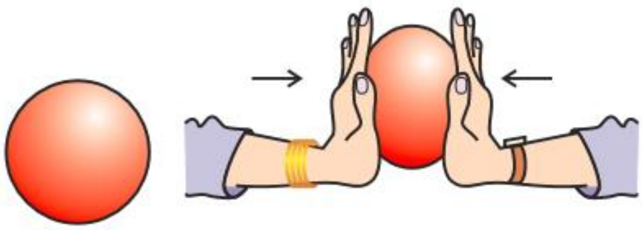
- The motion of the earth and all other planets and their satellites is almost in a circular orbit at constant speed.

5. FORCE AND LAWS OF MOTION

Introduction

- If we apply a force on an object, it may change its position or/and shape as well (as shown in the image given below).

Change in Position of Hockey Ball



Change in Shape of Ball

- Galileo Galilei and Isaac Newton explained a different approach to understand motion and applied force.

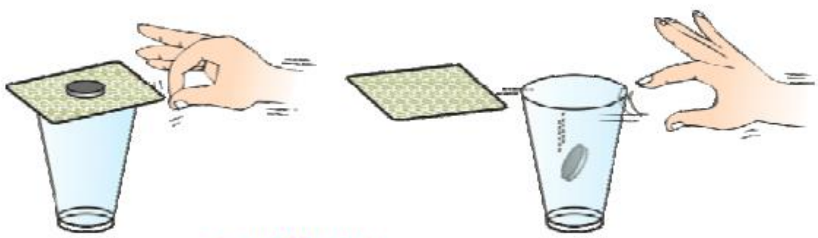
First Law of Motion

- According to Galileo an object moves with a constant speed when no force acts on them.

- According to Newton's First Law of Motion, "*an object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force*."

- The tendency of uninterrupted objects to stay at rest or to keep moving (if in motion) with the same velocity is known as **inertia**.

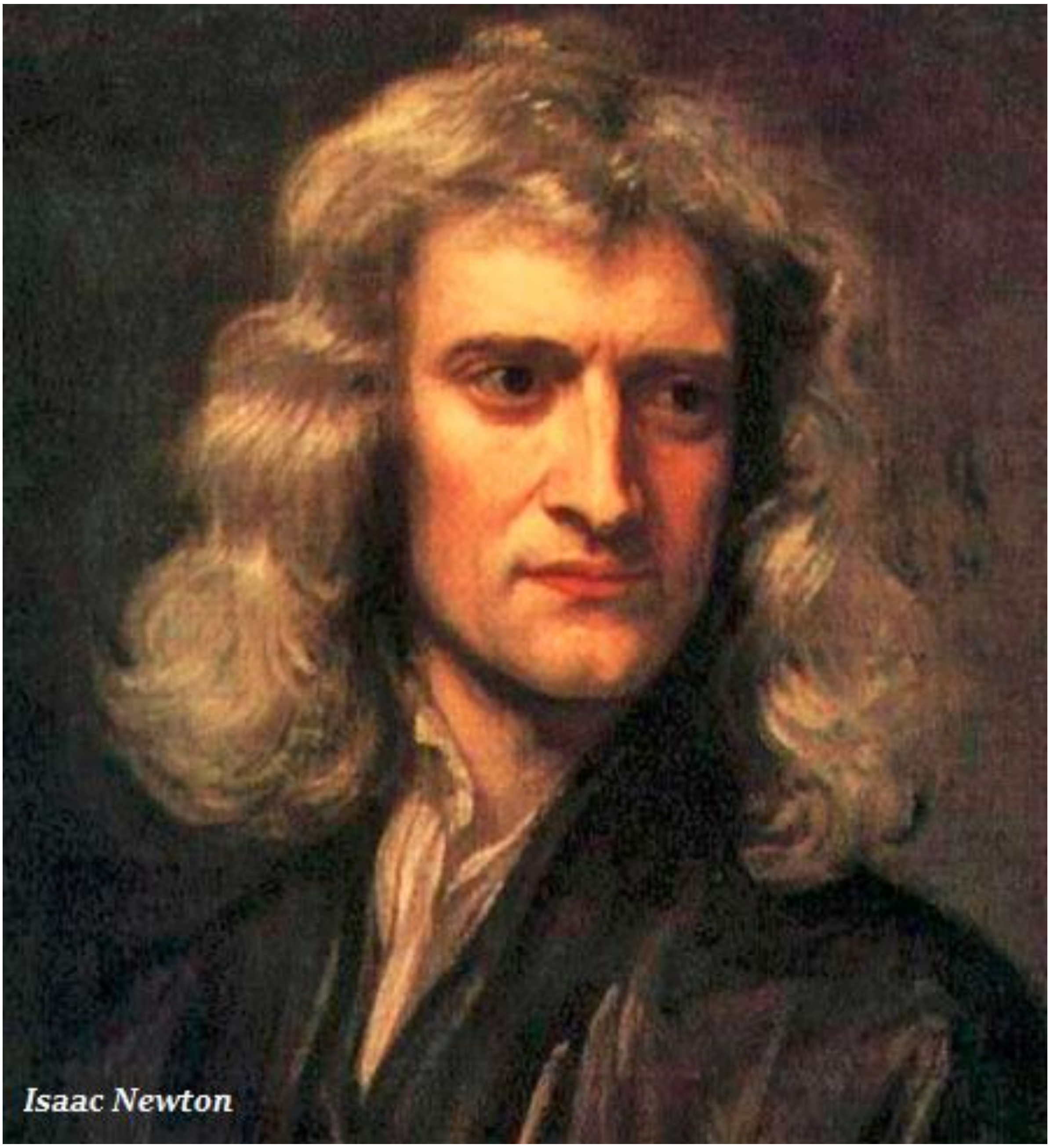
- Newton's first law of motion is also popular as the **law of inertia**.



Law of Intertia

- As shown in the image given above, when the playing card is flicked by the finger, the coin placed on it falls in the glass; it explains the law of inertia.

- Therefore, inertia is a natural tendency of any object to resist a change in its state of motion or of rest.



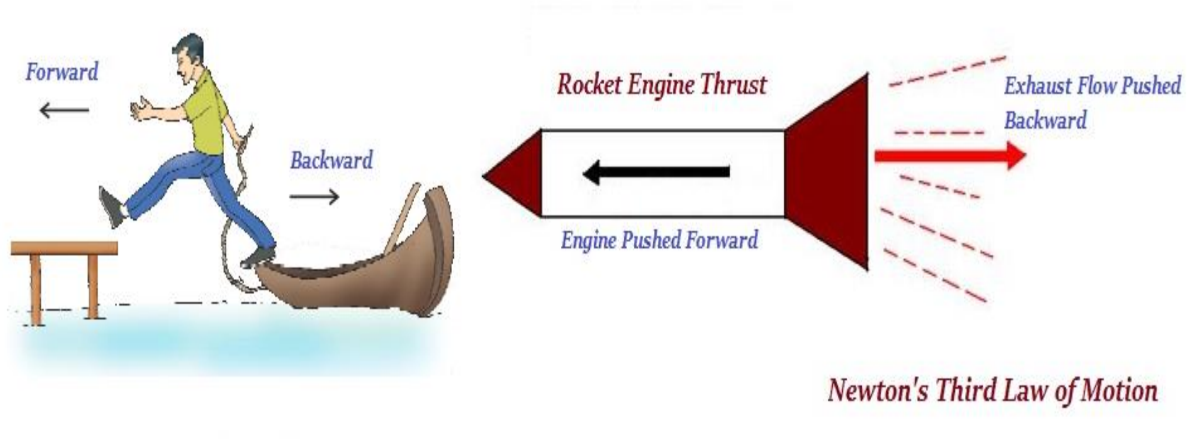
- Quantitatively, the inertia of an object is measured by its mass, as the heavier or bigger objects have greater inertia and lighter or smaller objects have lesser inertia.

Second Law of Motion

- The second law of motion states that "*the rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force*."
- The momentum (represented as p) of an object is defined as the product of its mass (represented as m) and velocity (represented as v).
- Likewise, Momentum (m) = Mass (m) X Velocity (v).
- Momentum possesses both the direction as well as magnitude.
- The SI unit of momentum is represented as kilogram-meter per second (kg m s^{-1}).
- The second law of motion illustrates a method to measure the force, which is acting on an object as a product of its mass and acceleration.

Third Law of Motion

- The third law of motion states that – "*to every action there is an equal and opposite reaction*."



- It is important to remembered that the action and reaction always act on two different objects.
- It is important to remember that action and reaction forces are always equal in magnitude, but these forces may not produce accelerations of equal magnitudes because each force acts on a different object, which may have a different mass.

Conservation of Momentum

- The conservation of momentum states that, in a given area, the amount of momentum remains constant.

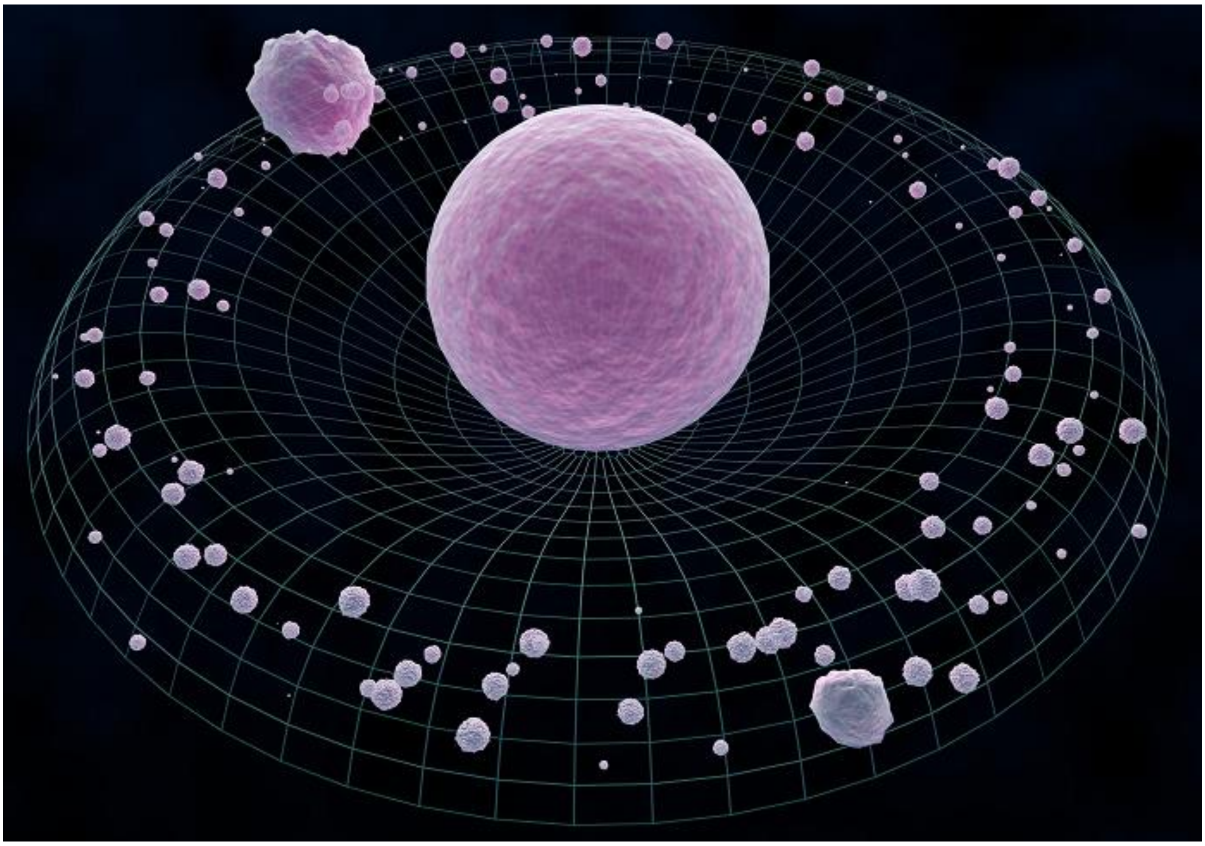
- The momentum is neither created nor destroyed; however, it can be changed through the action of forces (described by Newton's laws of motion).

- The mass of an object multiplied by the velocity of the object is known as momentum.

6. GRAVITATION

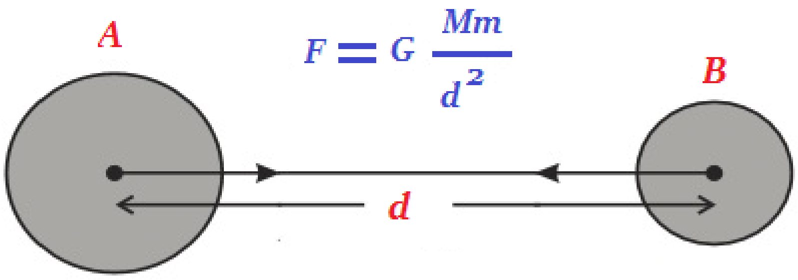
Introduction

- All celestial bodies those found in the universe attract each other and the force of attraction among these bodies is called as the **gravitational force**.



Universal Law of Gravitation

- Every object in the universe has the property to attract every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them (see the image given below).



Gravitational force between two uniform objects

- **F** = force of attraction between two the objects 'A' & 'B'
- **M** = mass of 'A'
- **m** = mass of 'B'
- **d^2** = the square of the distance between 'A' & 'B'
- **G** = is the constant of proportionality and is known as the universal gravitation constant.
- The SI unit of G is **N m2 kg^{-2}**. It is obtained by substituting the units of force, distance and mass (as given in the following equation:

$$G = \frac{Fd^2}{Mxm}$$

- Henry Cavendish had calculated the value of '**G**' as **6.673 × 10–11 N m^2 kg^{-2}**.
- Henry Cavendish had used a sensitive balance to find the value of 'G.'

Significance of Universal Law of Gravitation

- Following are the salient significance of the Universal Law of Gravitation:
  - It explains the force that binds all objects (including human beings) to the earth
  - It describes the motion of the moon around the earth

- It explains the motion of planets around the Sun
- It clarifies the tides due to the moon and the Sun

Free Fall

- Whenever an object falls towards the earth, it involves an acceleration; this acceleration is produces due to the earth's gravitational force.

- The acceleration, produces due to the earth's gravitational force, is known as the acceleration due to the gravitational force of the earth (or acceleration due to gravity).
- The acceleration produces due to the gravitational force is denoted by **g**.
- As the radius of the earth increases towards the equator (from the poles) the value of '**g**' becomes greater at the poles than at the equator.

The Value of g

- Value of g is calculated as:

$$g = G\frac{M}{R^2}$$

- G = universal gravitational constant, which is = **6.7×10^{-11} N m^2 kg^{-2}**

- M = mass of the earth, which is = **6×10^{24} kg**
- R = radius of the earth, which is **= 6.4×10^{6} m**
- So,

$$g = \frac{6.7 x 10^{-11}\ N m^{2}\ kg^{-2}\ x 6\ x 10^{24}\ kg}{(6.4 x 10^{6}\ m)^{2}}$$

$= 9.8\ m\ s^{-2}$

- So, the value of acceleration due to gravity of the earth (g) is $9.8\ m\ s^{-2}$.

7. MASS & WEIGHT

Introduction

- The mass of an object is always constant and does not change from place to place.

- The mass remains same whether the object is on the earth, the moon, or even in outer space.

- The force of attraction of the earth (due to gravitational force) on an object is called as the **weight** of the object.

- Weight is denoted by English capital letter '**W**.'

- Weight is calculated as:

W= m x g

- Where **m** is equal to mass of the object &

- **g** is equal to the acceleration due to gravity

- The SI unit of weight is the same as that of force, i.e., newton (N).

- Since, weight of an object is dependent on certain factors; therefore, weight is changeable (depending upon the place where it is), but mass of the same object remains constant irrespective of its location (where it is).

Thrust

- The force that acts on an object perpendicular to the surface is known as **thrust**.

- The effects of forces of the same magnitude on different areas are different because the effect of thrust depends on the area on which it acts.

- For example, if someone is standing on loose sandy surface, then the force, that is, the weight of his body is acting on an area equal to area of his feet. But when he lies down on the same surface, the same force acts on an area equal to the contact area of his whole body, which is larger than the area of his feet. Thus the effect of thrust on sandy surface is larger while standing than while lying.

Pressure

- The thrust on unit area is known as pressure. It is calculated as:

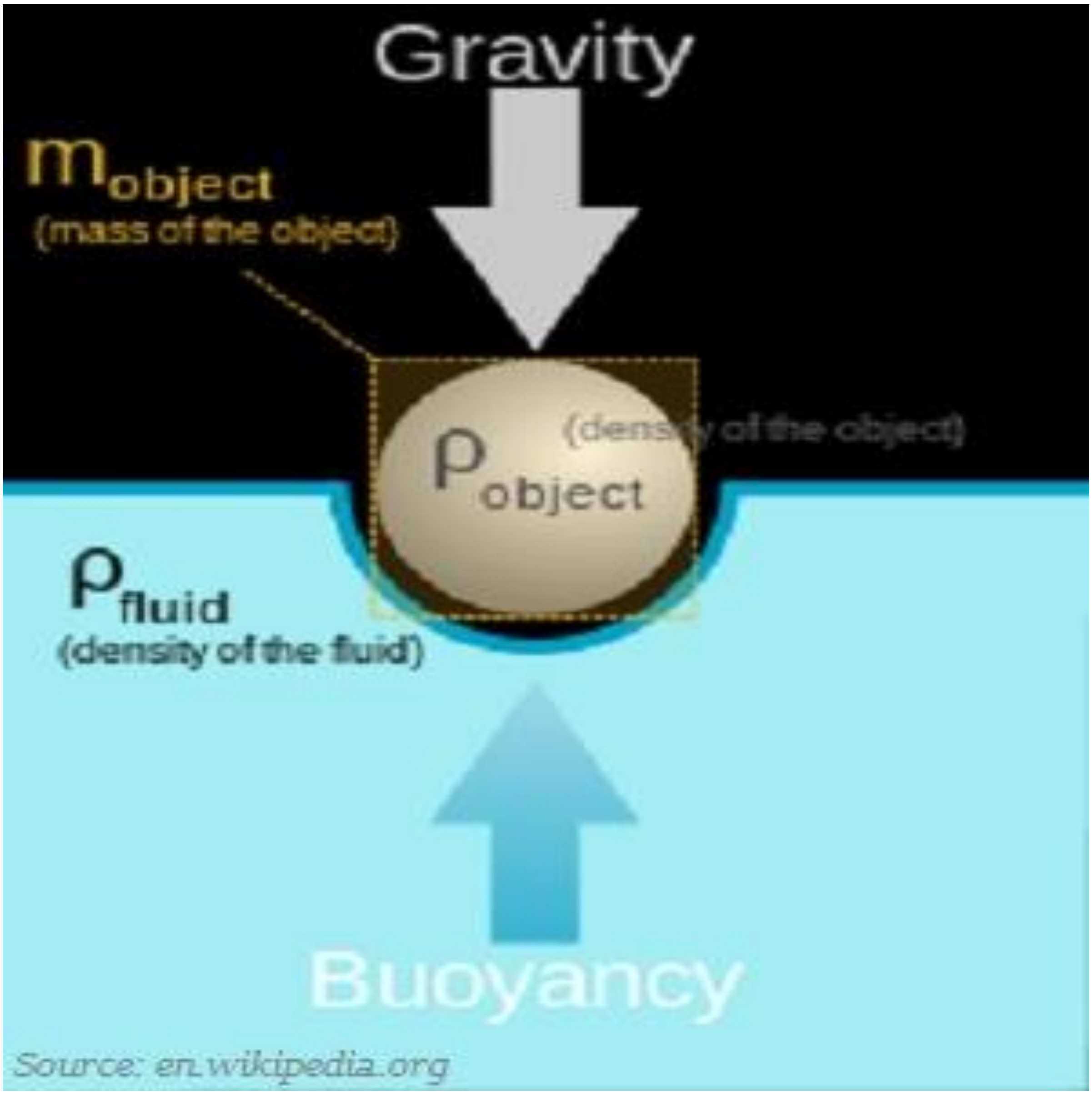
$$Pressure = \frac{Thrust}{Area}$$

- The SI unit of pressure is known as **pascal**, symbolized as **Pa**.

- The same force, if acting on a smaller area, exerts a larger pressure, but if acting on a larger area, exerts smaller pressure. Because of this reason - a nail has a pointed tip, knives have sharp edges, etc.

Buoyancy

- The upward force exerted by the water molecules on the object is known as up thrust or **buoyant force**.



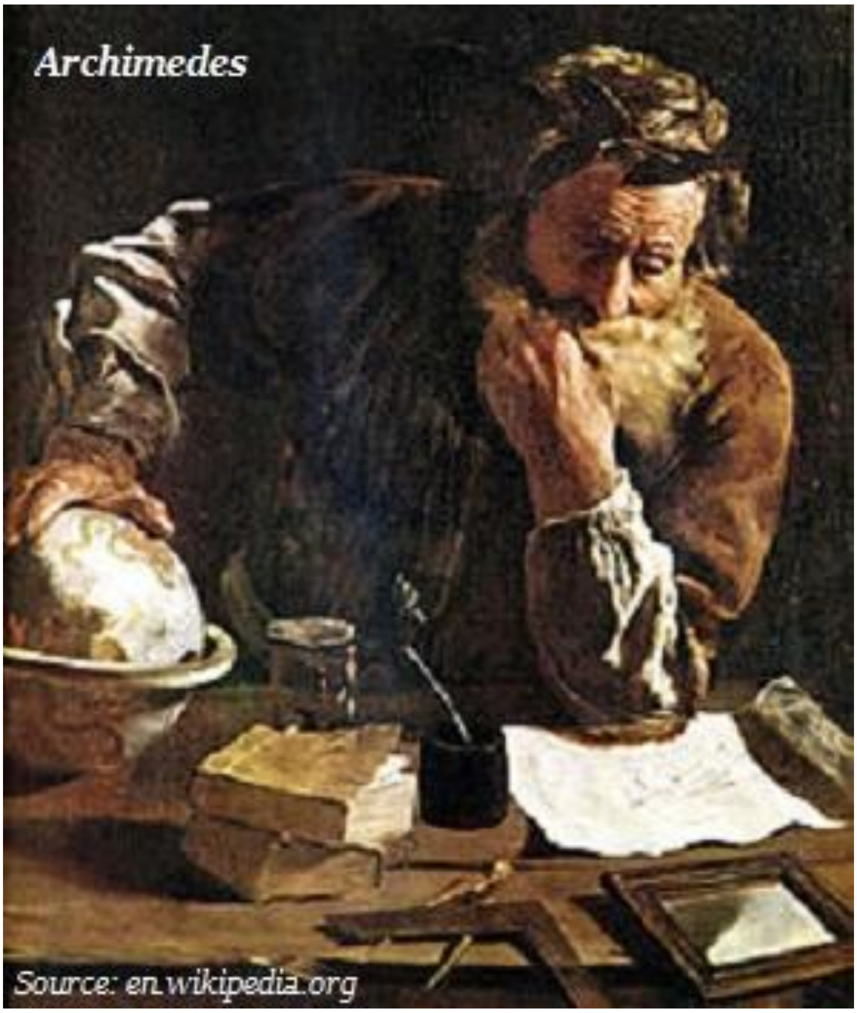
- The magnitude of the buoyant force depends on the density of the water/fluid.

- The objects, which have the density lesser than that of water/liquid float on the water/liquid; whereas, the objects, which have the density greater than that of water/liquid sink in the water/liquid.

- Mass of a unit volume is known as **density**.

Archimedes' Principle

- The force of buoyancy was first time noticed by Archimedes (a Greek Scientist) and to explain the phenomenon, he proposed a principle known as Archimedes' Principle.



- Archimedes' principle:

- *“When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.”*

8. WORK & ENERGY

Introduction

- When acting (applying force), there is a displacement of the point of application in the direction of the force, is known as work.

- The term work was first introduced by the French mathematician Gaspard-Gustave Coriolis in 1826.

- Work done by a force acting on the object is equal to the magnitude of the force multiplied by the distance moved in the direction of the force and it is calculated as:

- Work done (W) = Force (F) x Displacement (s)

- Work has the only magnitude and no direction.

- The SI unit of work is the **joule (J)**.

Energy

- Energy can be converted in form, but cannot be created or destroyed. For example, producing electric energy from solar energy, etc.

- The object which does the work loses energy and the object on which the work is done gains energy.

- Further, the object that possesses energy can exert a force on another object to transfer energy from former to later.

- The energy possessed by an object is therefore measured in terms of its capacity of doing work.

- The SI unit of energy is **joule (J)**.

Forms of Energy

- Following are the major forms of the energy:

  - Potential energy
  - Kinetic energy
  - Heat energy
  - Chemical energy
  - Electrical energy
  - Light energy

- Let's discuss each one in brief:

Potential Energy

- The energy, possessed by a body by virtue of its position relative to others, is known as Potential energy.

- So, potential energy is the stored energy in an object. For example, gravitational potential energy, elastic potential energy, electrical potential energy, etc.

- The SI unit of potential energy is joule (J).

- The term potential energy was introduced by Scottish engineer and physicist William Rankine.

Kinetic Energy

- The energy that an object possesses because of its motion, is known as **kinetic energy**.

- The running/moving body maintains its kinetic energy unless its speed changes (increases or decreases).

- The SI unit of kinetic energy is joule (J).

Heat Energy

- Heat is a form of energy transferred spontaneously from a hotter to a colder body.

Chemical Energy

- The potential of a chemical substance to experience a transformation through a chemical reaction and transform other chemical substances is known as chemical energy. E.g. Breaking or making of chemical bonds, batteries, etc.

- The chemical energy of a (chemical) substance can be converted to other forms of energy by a chemical reaction. E.g., green plants convert solar energy to chemical energy (commonly of oxygen) by the process of photosynthesis.

Electrical Energy

- The energy, derived from electric potential energy or kinetic energy, is known as electrical energy.

- Electricity is normally produced by electromechanical generators at a power station.

- The electromechanical generators primarily are driven by heat engines fueled by the kinetic energy of flowing water and wind.

- The electromechanical generators are also driven by heat engines fueled by chemical combustion or nuclear fission.

Light Energy

- Light is a form of electromagnetic radiation.

- Light energy most likely is the only form of energy that we can really see.

- Light is transferring energy through the space in a natural way. E.g. solar energy.

Law of Conservation of Energy

- Law of conservation of energy states that energy can neither be created nor be destroyed; however, it can be only transformed from one form to another.

- According to the law of conservation of energy, the total energy before and after the transformation remains the same.

- The law of conservation of energy remains valid in all conditions and locations and for all kinds of transformations.

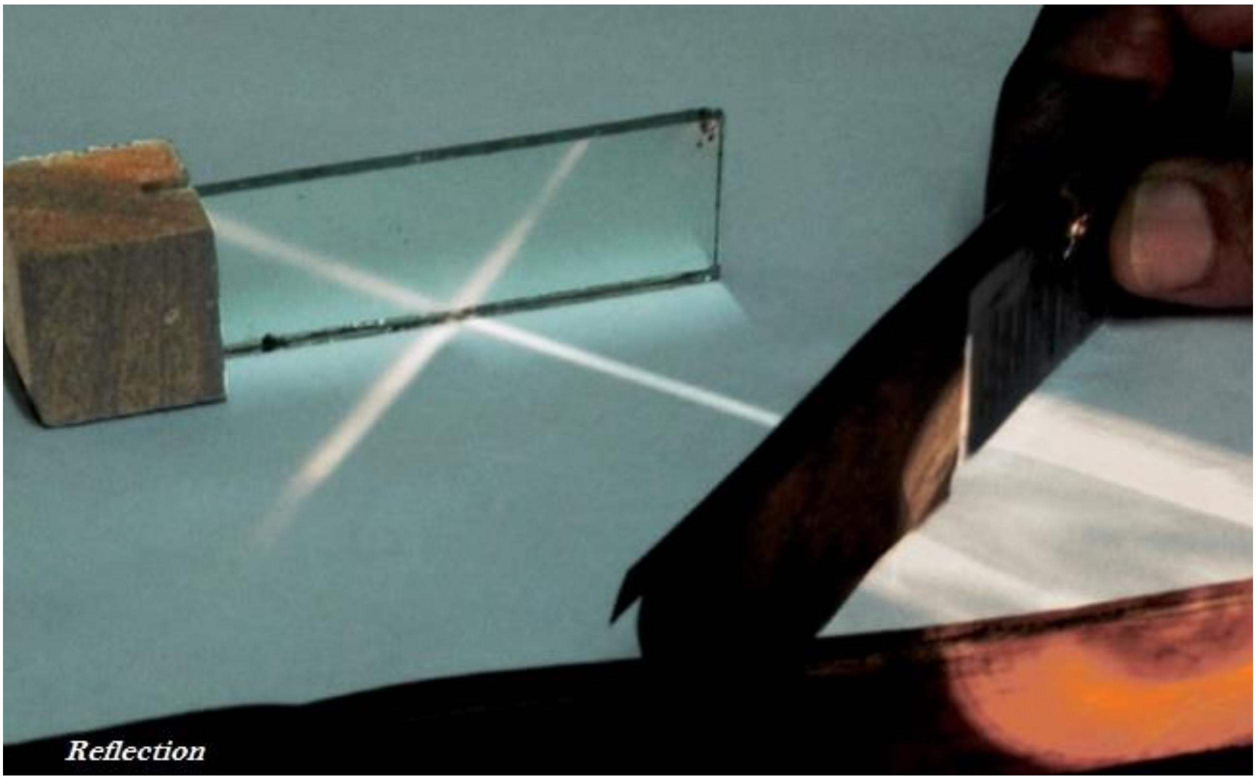
9. LIGHT

Introduction

- The fact is – our eyes alone cannot see any object until light helps.
- The light may be emitted by the object, or may have been reflected by it.

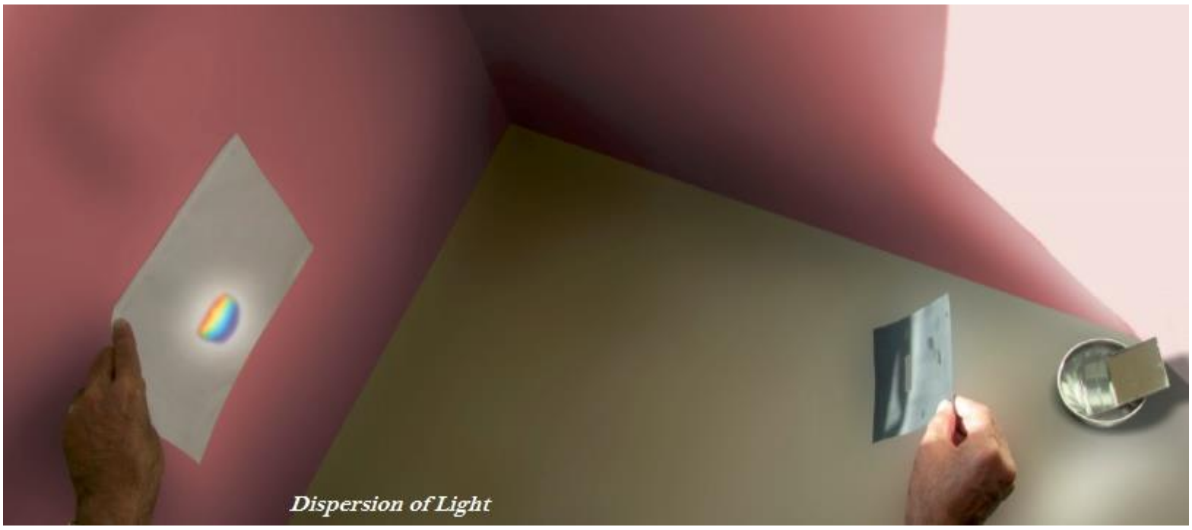
Laws of Reflection

- The light ray, which strikes a surface, is known as the **incident ray**.
- The incident ray that returns back from the surface is known as the **reflected ray** (as shown in the image given below).



- When all the parallel rays reflected from a plane surface are not necessarily parallel and the reflection is known as **diffused** or **irregular reflection**.
- Almost every object that we see around is visible because of the reflected light.
- Some objects generate their own light, such as the sun, electric lamp, fire, flame of a candle, etc. and make themselves visible.

- Splitting of light into its different colors is known as **dispersion of light** (as shown in the image given below).

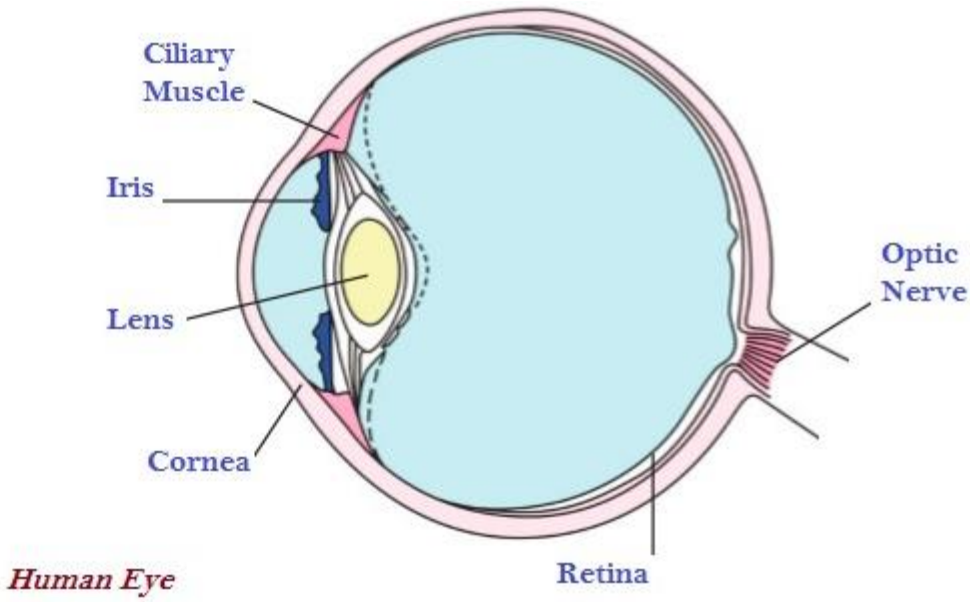


- Rainbow is a natural phenomenon showing dispersion.

Human Eyes

- The human eyes have a roughly spherical shape.

- The transparent front part is known as **cornea** (shown in the image given below).



- The dark muscular structure known as **iris**.

- The size of the pupil (pupil is small opening in iris) is controlled by the **iris**.

- It is the iris that gives eye the distinctive color.
- **Lens** is found behind the pupil of the eye (see the image given above).
- The lens focuses light on the back of the eye, which is known as **retina**.
- Retina contains several nerve cells; based on their features, they are divided into two categories: i.e.

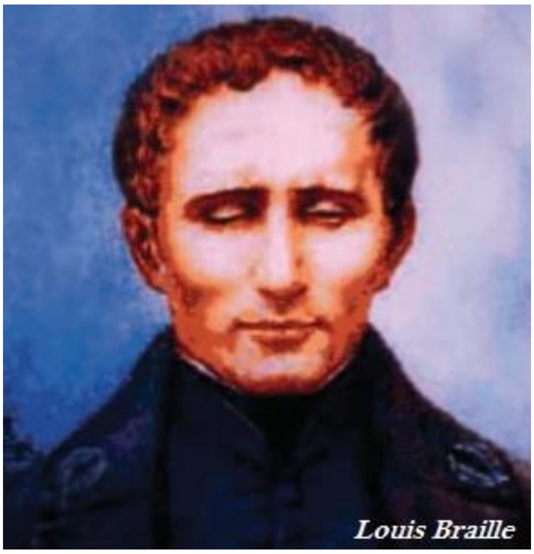
    i. Cones: These are sensitive to bright light and

    ii. Rods: These are sensitive to dim light.

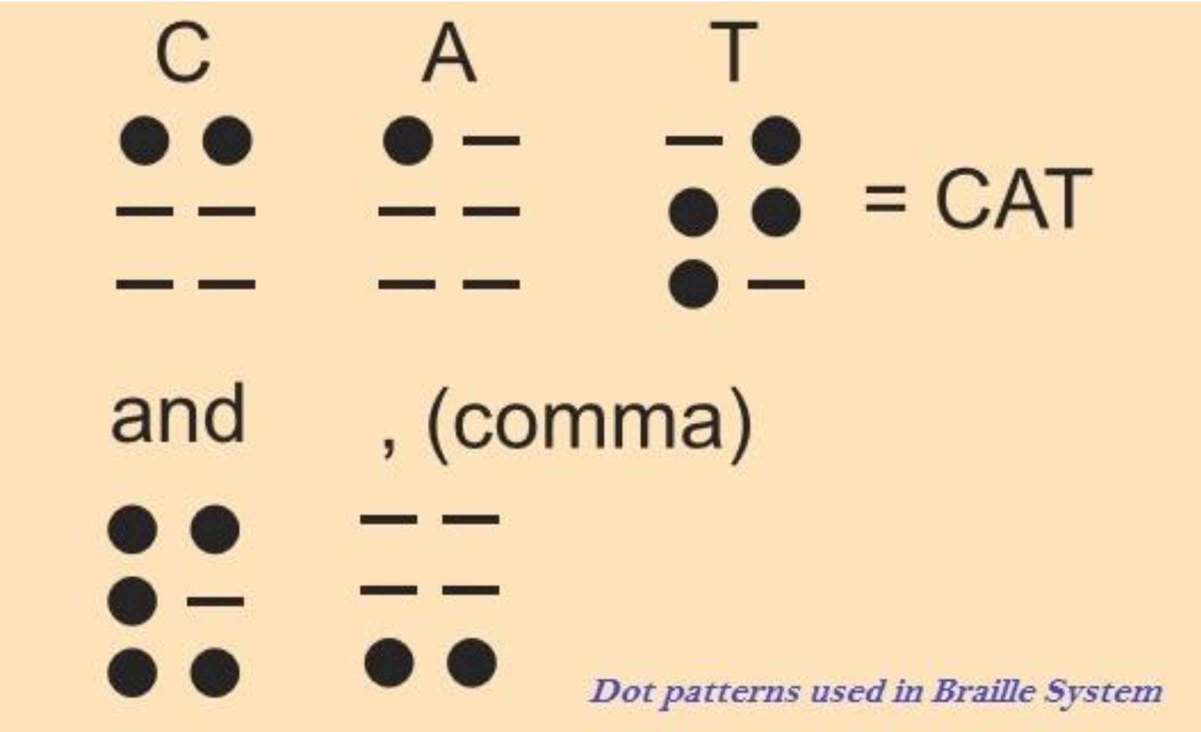
- The impression of an image (on retina) does not disappear immediately rather persists there for about $1/16^{th}$ of a second; therefore, if still images of a moving object are flashed on the retina at a rate faster than 16 per second, then the eye sees this object as moving.
- The minimum distance at which the eye can see an object distinctly varies with growing age.
- The most comfortable distance at which a normal eye can read is about 25 cm.

Braille System

- The most popular and accepted resource for the visually challenged people is known as **Braille**.
- Braille system is developed for the visually challenged people; they can learn the Braille system by beginning with letters, then special characters, and letter combinations.
- **Louis Braille**, a visually challenged person, developed a system of learning especially for the visually challenged persons; and hence, the system is named after his name 'Braille.'



- Braille system has **63** dot patterns or characters and each character represents a letter, a combination of letters, a common word or a grammatical sign.



Dot patterns used in Braille System

- Dots are arranged in cells of two vertical rows of three dots each and when these patterns are embossed on Braille sheets, then it helps visually challenged to identify words by touching them (see the image given above).

10. LIGHT – REFLECTION AND REFRACTION

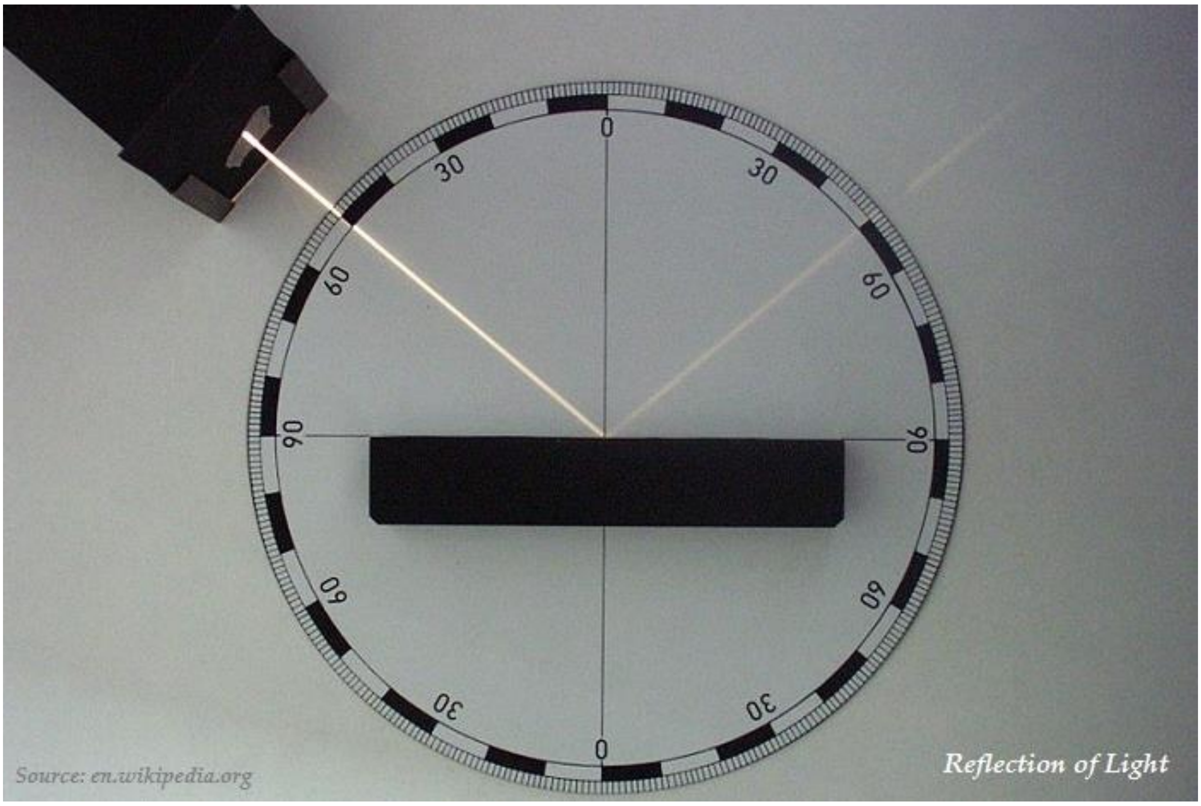
Introduction

- The natural/artificial agent that kindles sight and makes things visible is known as light.

- Light appears to travel in straight lines.

Reflection of light

- The throwing back by a body or surface of light without absorbing it, is known as reflection of light.
- A highly polished surface, such as a mirror or other smooth and plane surface, reflects most of the light falling on it.



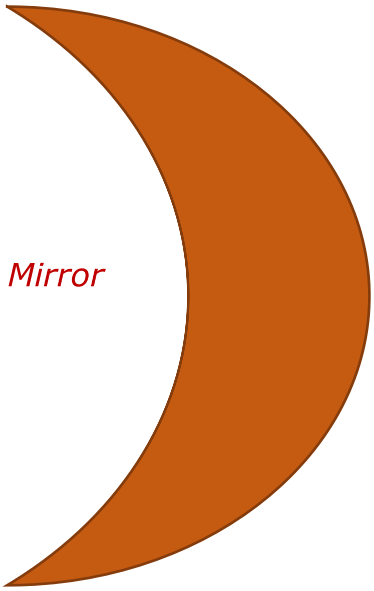
- Reflection of light is either specular (just like mirror) or diffuse (retaining the energy.

Laws of Reflection of Light

- Following are the significant laws of reflection:
    - *The angle of incidence is equal to the angle of reflection, and*
    - *The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.*
- The laws of reflection described above are applicable to all sorts of reflecting surfaces including spherical surfaces.
- Image formed by a plane mirror is always virtual and erect.

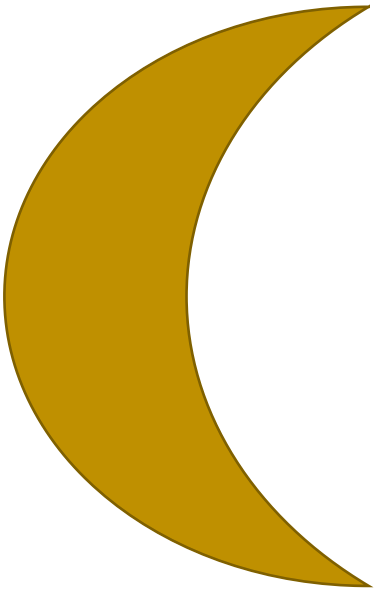
Spherical Mirror

- The spherical mirror, whose reflecting surface is curved inwards (as shown in the image given below), i.e. face towards the center of the sphere, is known as **concave mirror**.



Concave Mirror

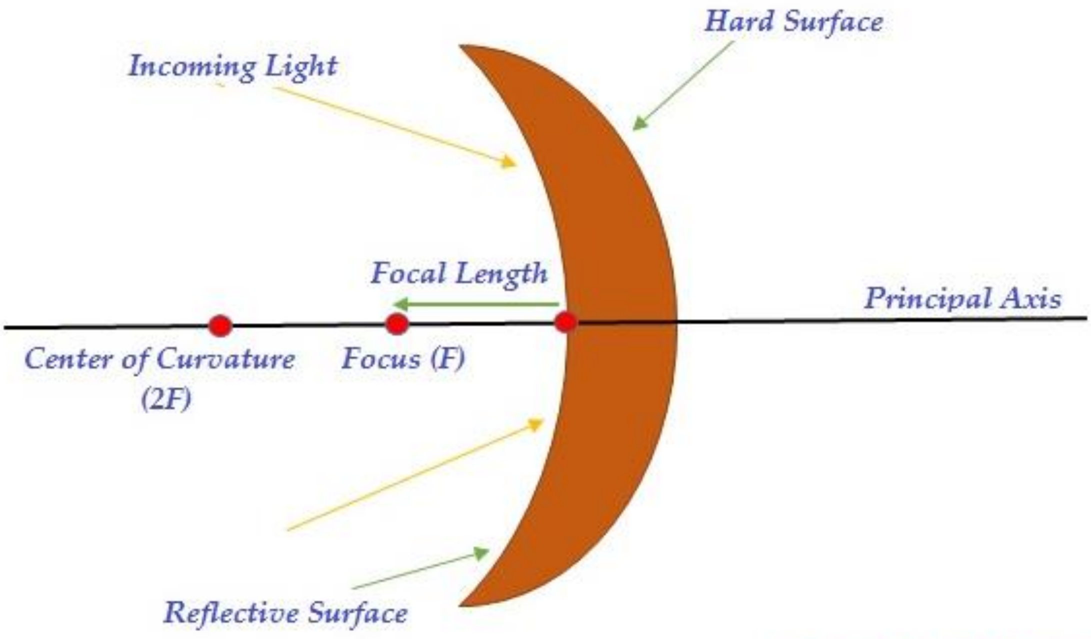
- The spherical mirror, whose reflecting surface is curved outwards (as shown in the image given below), is known as a **convex mirror**.



Convex Mirror

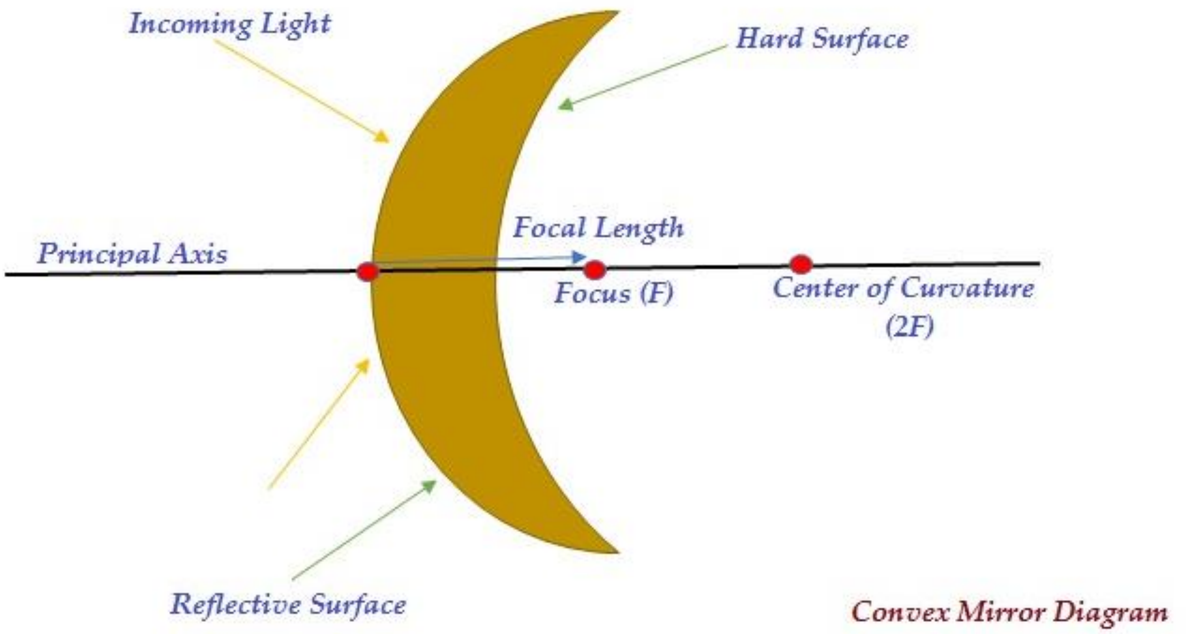
- The center of the reflecting surface of a spherical mirror is a point known as **pole** represented by English letter '**P**.'
- The reflecting surface of a spherical mirror forms a part of a sphere, which has a center, known as the **center of curvature** represented by English letter '**C**.'

- Remember, the center of curvature is not a part of the mirror, but rather it lies outside the reflecting surface.
- In case of concave mirror, the center of curvature lies in front of it.
- In case of convex mirror, the center of curvature lies behind the mirror.
- The radius of the sphere of which, the reflecting surface of a spherical mirror forms a part, is known as the **radius of curvature** of the mirror and represented by the English letter '**R**.'
- Remember, the distance pole (P) and center of curvature (C) is equal to the radius of curvature.
- The imaginary straight line, passing through the pole and the center of curvature of a spherical mirror, is known as the **principal axis** (see the image given below).
- All the reflecting rays meeting/intersecting at a point on the principal axis of the mirror; this point is known as principal focus of the concave mirror. It is represented by English letter '**F**' (see the image given below).



Concave Mirror Diagram

- On the other hand, in case of convex mirror, the reflected rays appear to come from a point on the principal axis, known as the **principal focus** (F) (see the image given below).



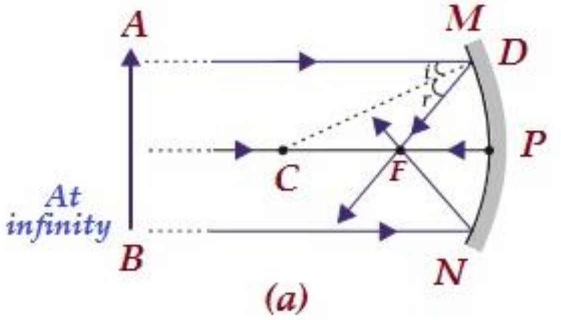
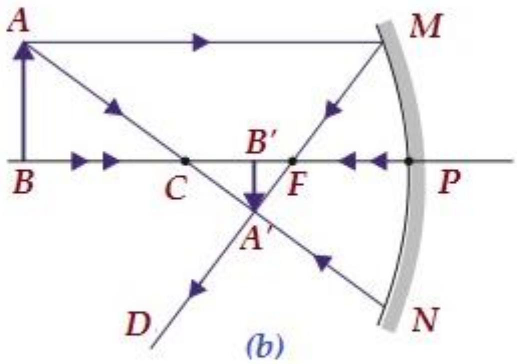
- The distance between the pole (P) and the principal focus (F) of a spherical mirror is known as the **focal length** and it is represented by the English letter '**f**' (see the image given above).

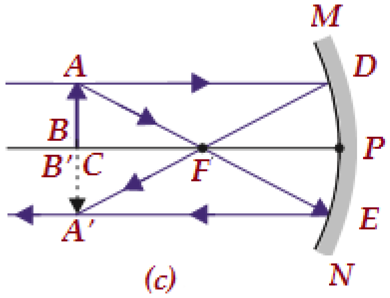
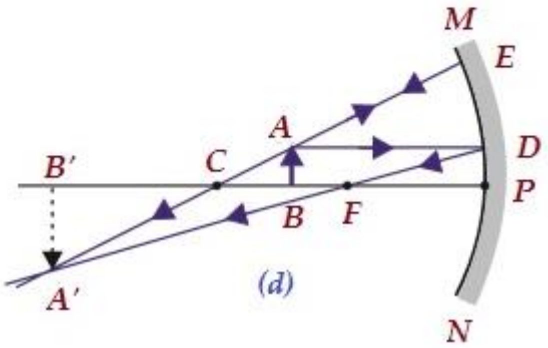
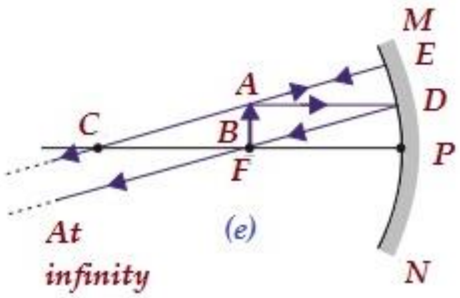
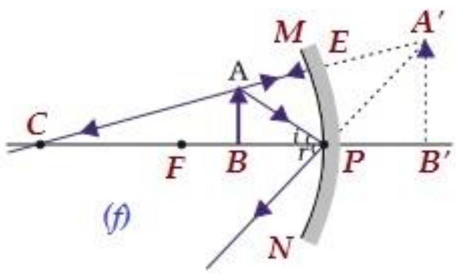
- The diameter of the reflecting surface of spherical mirror is known as its **aperture**.

11. IMAGES FORMED BY SPHERICAL MIRRORS

Introduction

- Drawing the ray diagrams is an ideal way to illustrate the formation of images by spherical mirrors.
- The intersection of at least two reflected rays give the correct position of image of the point object.
- The following table illustrates the image formed by a **concave mirror** for different positions of the given object:

Position of Object	Position of Image	Size of Image	Nature of Image	Image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted	
Beyond C	B/w F and C	Diminished	Real and inverted	
At C	At C	Same size	Real and inverted	

				
B/w C and F	Beyond C	Enlarged	Real and inverted	
At F	At infinity	Highly enlarged	Real and inverted	
B/w P and F	Behind the mirror	Enlarged	Virtual and erect	

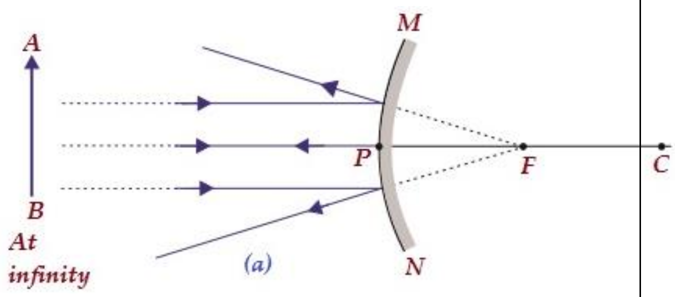
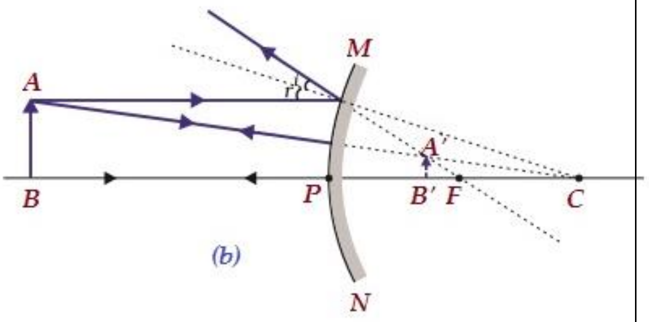
Uses of Concave Mirror

- In order to get powerful parallel beams of light, concave mirrors are universally used in torches, search-lights, and vehicles headlights.
- Concave mirror is also used in barber's saloon, as it gives larger view.
- Concave mirror is also used by dentists, to see the large images of the teeth of patients.

- Large concave mirrors are used to concentrate sunlight to produce maximum heat in the solar furnaces.

Image formation by a Convex Mirror

- The following table illustrates the image formed by a **concave mirror** for different positions of the given object:

Position of Object	Position of Image	Size of image	Nature of Image	Image
At infinity	At the focus F, behind the mirror	Highly diminished, point sized	Virtual and erect	
B/w infinity and pole of the mirror	B/w P and F, behind the mirror	Diminished	Virtual and erect	

Uses of Convex Mirrors

- In all vehicles, convex mirrors are universally used as rear-view (wing) mirrors.

- In vehicles, convex mirrors are preferred, as they give though diminished, but an erect image.

Mirror Formula

- The formula is expressed as:

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

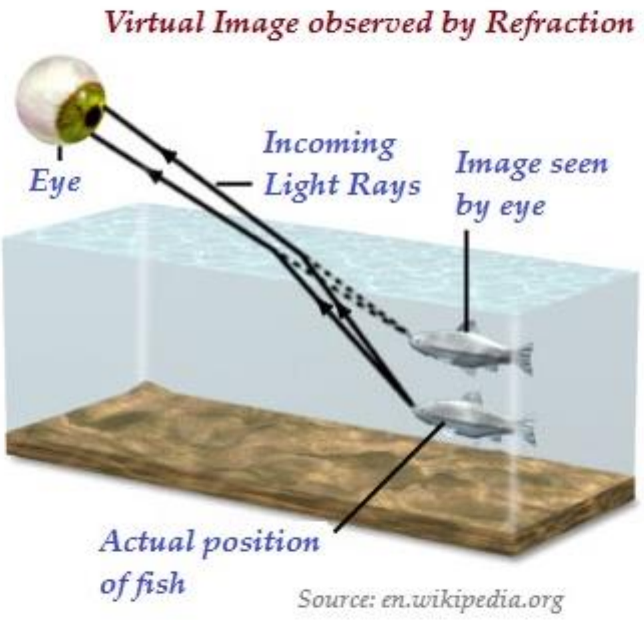
- Mirror formula expresses the relationships among the object-distance (i.e. **u**), image-distance (i.e. **v**), and focal length (i.e. f) of a spherical mirror.

12. REFRACTION OF LIGHT

Introduction

- Light, normally, travel along the straight-line paths in a transparent medium.
- When light is travelling obliquely from one medium to another, then the direction of propagation of light changes in the second medium, the phenomenon is known as **refraction of light**.
- In the image (a) given below, because of refraction in a glass of water, the image is flipped.

- In the image (b) given above, the straw seems to be broken because of the refraction of light.



- As shown in the image given above, because of the refraction in the water, the fish does not appear at its actual position rather a little above of its actual position.

Laws of Refraction of Light

- Following are the significant laws of refraction of light:

i. *The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.*

ii. *The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given color and for the given pair of media. This law is also known as Snell's law of refraction.*

- The constant value of the second medium with respect to the first is known as the refractive index.

The Refractive Index

- In a given pair of media, the extent of the change in direction is expressed in terms of the refractive index.
- For a given pair of media, the value of the refractive index, depends upon the speed of light in the two media.
- The aptitude of a medium to refract light can be also expressed in terms of its **optical density**.

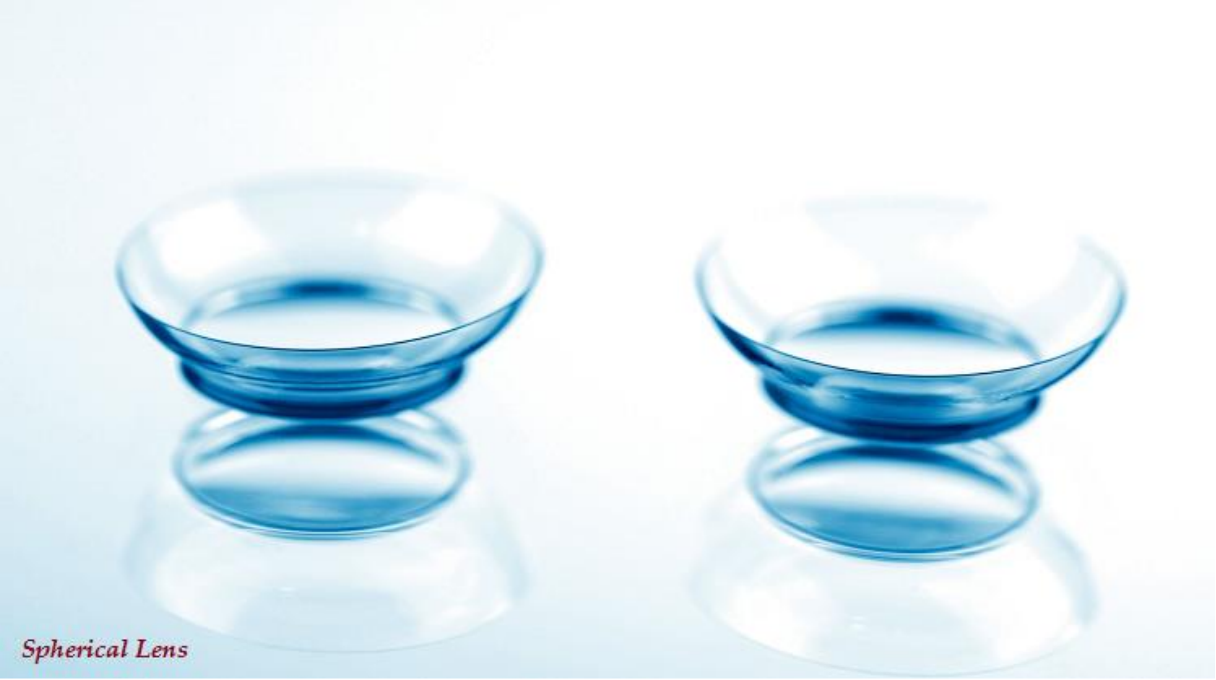
- The following table illustrates the absolute refractive index of some significant material media:

Material Medium	Refractive Index
Air	1.0003
Ice	1.31
Water	1.33
Alcohol	1.36
Kerosene	1.44
Fused Quartz	1.46
Turpentine Oil	1.47
Rock Salt	1.54
Diamond	2.42

13. SPHERICAL LENSES

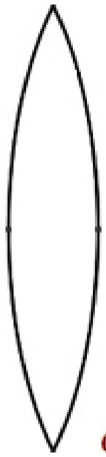
Introduction

- A transparent material (normally glass) bound by two surfaces, of which one or both surfaces are spherical, is known as "spherical lens."



Convex Lens

- A lens may have two spherical surfaces, bulging outwards (as shown in the image given below), is known as convex lens or a double convex lens.

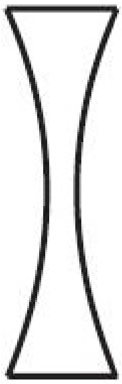


Convex Lens

- The middle part of this lens is bulged (thicker) and at the both ends, it is narrow.
- Convex lens converges the light rays; therefore, it is also known as **converging lens**.

Concave Lens

- A lens may have two spherical surfaces, curved inwards (as shown in the image given below), is known as concave lens or a double concave lens.

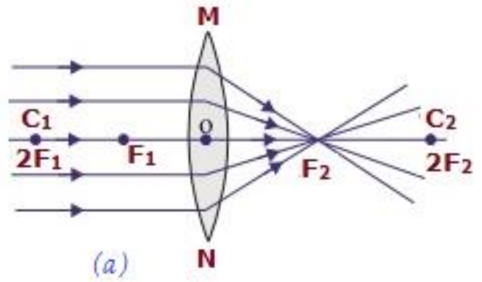
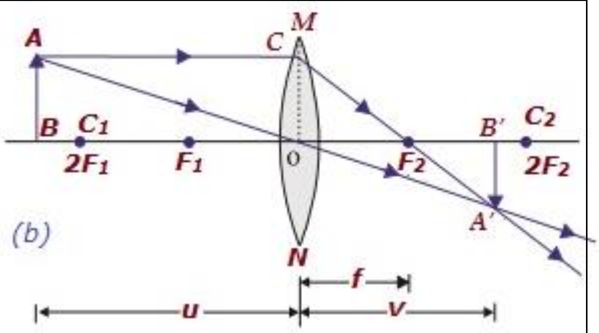
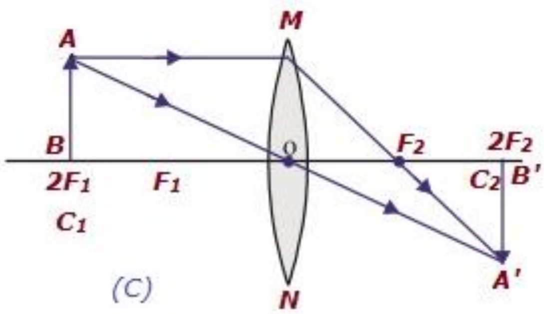


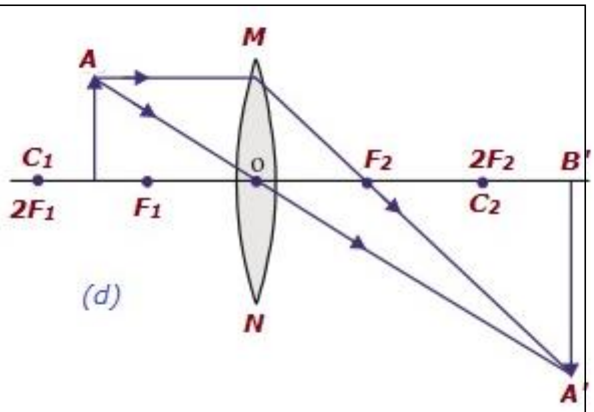
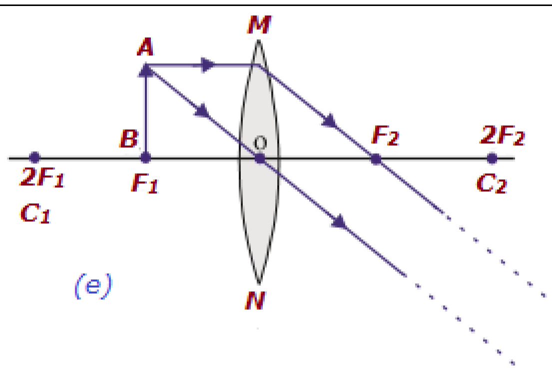
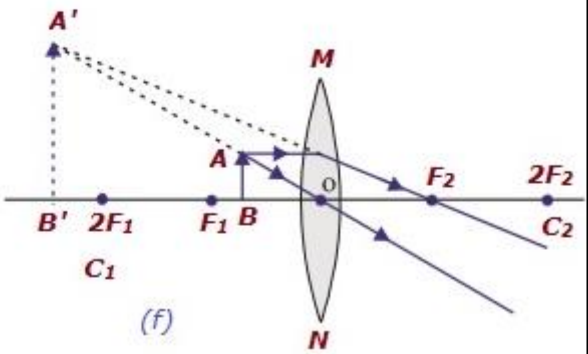
Concave Lens

- The middle part of this lens is narrow (curved inwards) and the both the edges are thicker.
- Concave lens diverges the light rays; therefore, it is also known as **diverging lens**.
- A lens, either a concave or a convex, has two spherical surfaces and each of these surfaces forms a part of the sphere. The centers of these spheres are known as **centers of curvature**, represented by English letter '**C**.'
- As there are two centers of curvature, therefore, represented as 'C1' and 'C2.'

- An imaginary straight line, passing through both the centers of curvature of a lens, is known as **principal axis**.
- Optical center is the central point of a lens. It is represented by '**O**.'
- An aperture is the actual diameter of the circular outline of a spherical lens.
- Principal focus of lens is represented by '**F**.'
- A lens has usually two foci represented as F1 and F2.
- **Focal length** is the distance between the principal focus and the optical center of a lens. It is represented by '**f**.'

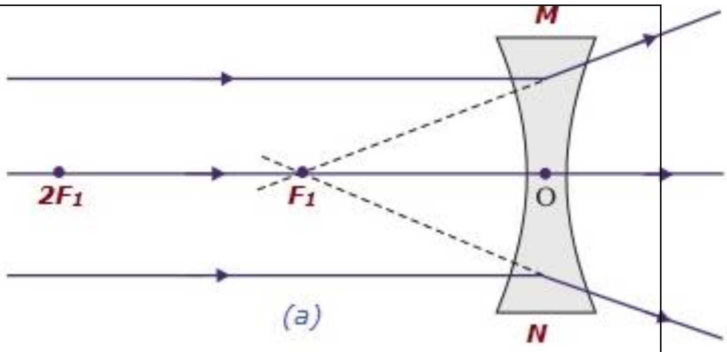
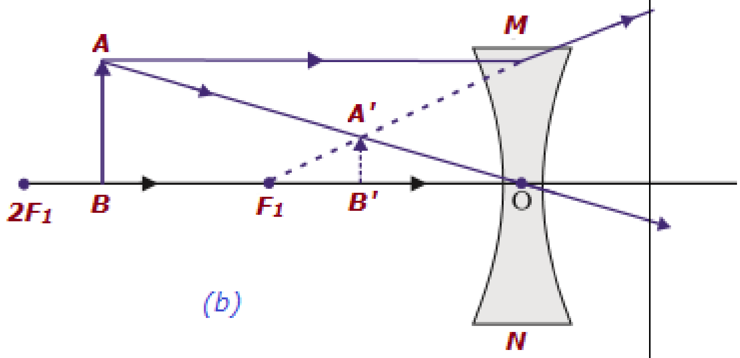
- The following table illustrates, the nature and position of images formed by a convex lens:

Position of object	**Position of image**	**Relative size of image**	**Nature of image**	**Image**
At infinity	At focus F_2	Highly diminished, point-sized	Real & inverted	
Beyond $2F_1$	B/w F2 & $2F_2$	Diminished	Real & inverted	
At $2F_1$	At $2F_2$	Same Size	Real & inverted	

B/w F_1 & $2F_1$	Beyond $2F_2$	Enlarged	Real & inverted	
At focus F_1	At infinity	Infinitely large or highly enlarged	Real & inverted	
B/w focus F_1 & optical center O	On the same side of the lens as the object	Enlarged	Virtual & erect	

- The following table illustrates, the nature and position of images formed by a concave lens:

Position of object	**Position of image**	**Relative size of image**	**Nature of image**	**Image**

At infinity	At focus F_1	Highly diminished, point-sized	Virtual & erect	
B/w infinity & optical center O of the lens	B/w F_1 & optical center O	Diminished	Virtual & erect	

Lens Formula

- The formula is expressed as:

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

- Lens formula expresses the relationships among the object-distance (i.e. **u**), image-distance (i.e. **v**), and focal length (i.e. f) of a lens.

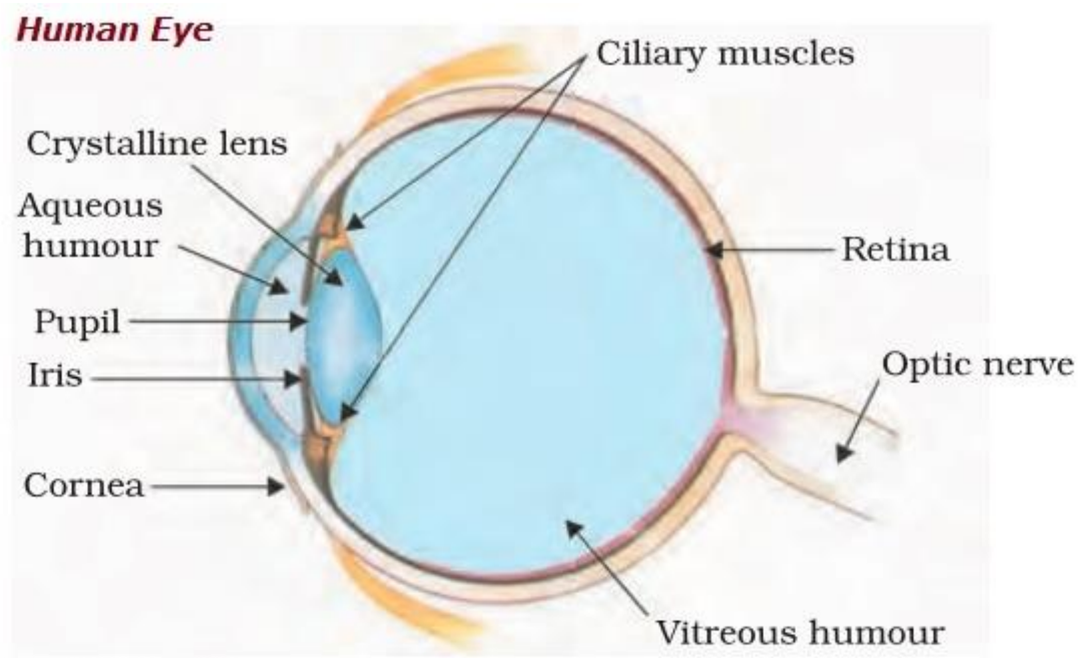
14. THE HUMAN EYE & THE COLORFUL WORLD

Introduction

- The human eye is one of the most valuable and sensitive sense organs. It empowers us to see the wonderful and colorful things around us.

Human Eye

- The human eye is very much similar to a camera.
- The lens system of an eye forms an image on a light-sensitive screen known as the **retina** (see the image given below).
- Light enters the eye through a thin membrane known as the **cornea**.



Source: Science NCERT; X

- With a diameter of about 2.3 cm, the eyeball is almost spherical in shape.
- Behind the cornea, there is a structure, known as **iris** (see the image given above).
- Iris is a dark muscular diaphragm; it has major function to control the size of the pupil.

- The pupil has major function to control and regulate the amount of light entering the eye.
- The lens of eye forms an inverted real image of an object on the retina.

Power of Accommodation

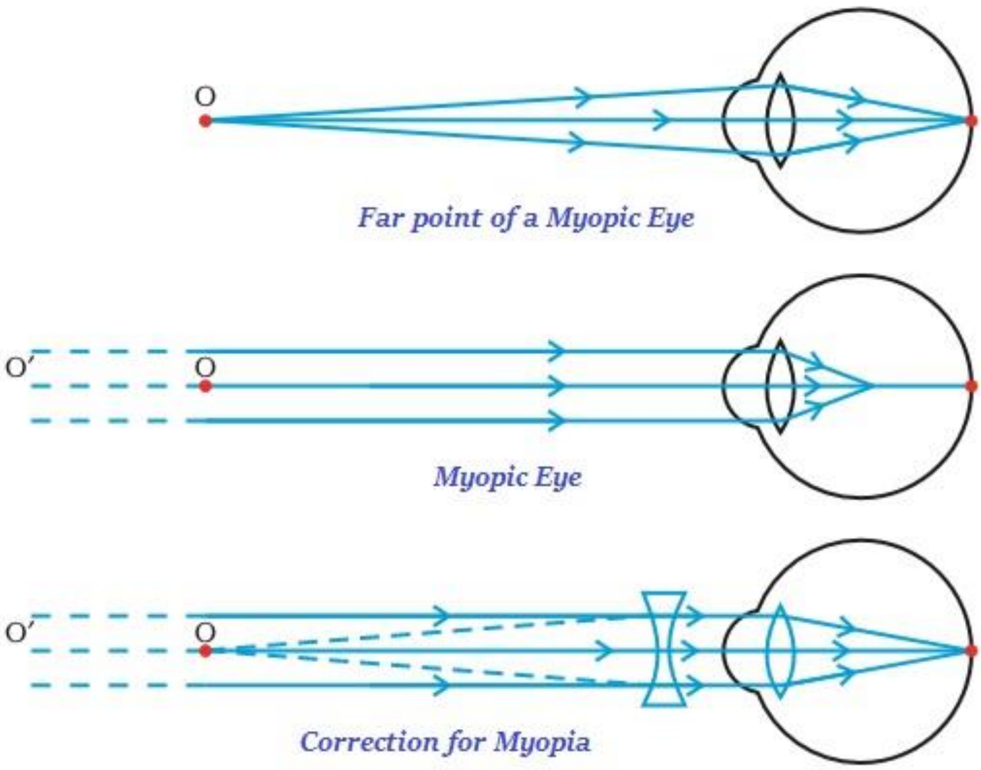
- The eye lens, which is composed of a fibrous, jelly-like material, has an important role; further, the change in the curvature of the eye lens also change the focal length.
- When the muscles are in relax state, the lens shrinks and becomes thin; therefore, its focal length increases in this position and enables us to see the distant objects clearly.
- On the other hand, when you look at an object closer to your eye, the ciliary muscles contract; resultantly, the curvature of the eye lens increases and the eye lens becomes thicker. In such a condition, the focal length of the eye lens decreases, which enables us to see nearby objects clearly.
- Such ability of the eye lens to adjust its focal length is known as **accommodation**.
- Furthermore, the focal length of the eye lens cannot be decreased below a certain (minimum) limit. This is the reason that we cannot read the book kept very close to our eyes rather we have to maintain a certain distance.
- To see an object comfortably and clearly, the object must be kept at the distance of (about) **25 cm** from the eyes.
- However, there is no limit of the farthest point; a human eye can see objects of infinity, e.g. moon, stars, etc.

Defects of Vision and Their Correction

- When the crystalline lens of an eye (normally at old age), becomes milky and cloudy, it is known as **cataract**.
- Cataract causes partial or complete loss of vision; however, it can be treated through a cataract surgery.
- Following are the three common refractive defects of vision:
  - Myopia or near-sightedness
  - Hypermetropia or farsightedness, and
  - Presbyopia
- Let’s discuss each them in brief:

Myopia

- Myopia is also known as near-sightedness.
- A person suffering from myopia can see nearby objects clearly, but cannot see distant objects clearly.



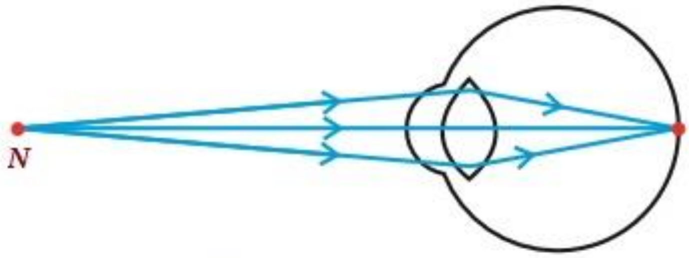
Source: Science NCERT; X

- As shown in the image given above, in a **myopic eye**, the image of a distant object is formed in front of the retina instead of at the retina.
- Myopia may arise because of:
  - Excessive curvature of the eye lens, or
  - Elongation of the eyeball.
- This defect can be corrected by using a **concave lens** of suitable power.
- As shown in the image given above, using of concave lens of suitable power, brings the image back on to the retina; likewise, the defect is corrected.

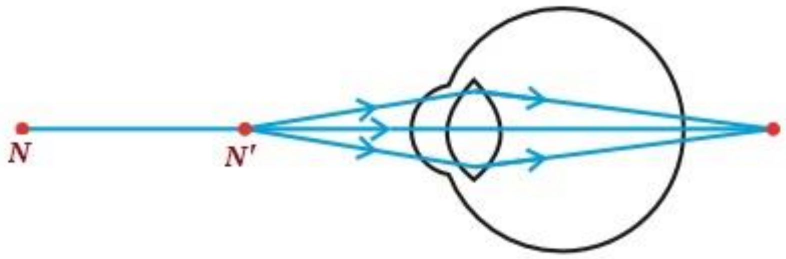
Hypermetropia

- Hypermetropia is also known as far-sightedness.
- A person suffering from hypermetropia can see the distant objects clearly, but cannot see the nearby objects clearly.

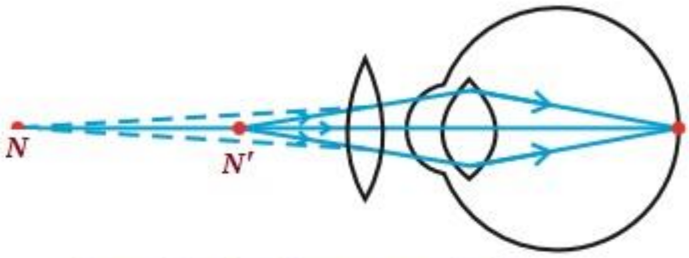
- In such a case, as shown in the image given below, the near point, is farther away from the normal near point (i.e. 25 cm).



Near Point of a Hypermetropic Eye



Hypermetropic Eye



Correction for Hypermetropic Eye

Source: Science NCERT; X

- Hypermetropia may arise because of
- The focal length of the eye lens – when it is too long, or
- The eyeball has become too small.
- Hypermetropia can be corrected by using a **convex lens** of appropriate power.
- As shown in the image given above, eye-glasses with converging lenses provide the additional focusing power that helps in forming the image on the retina.

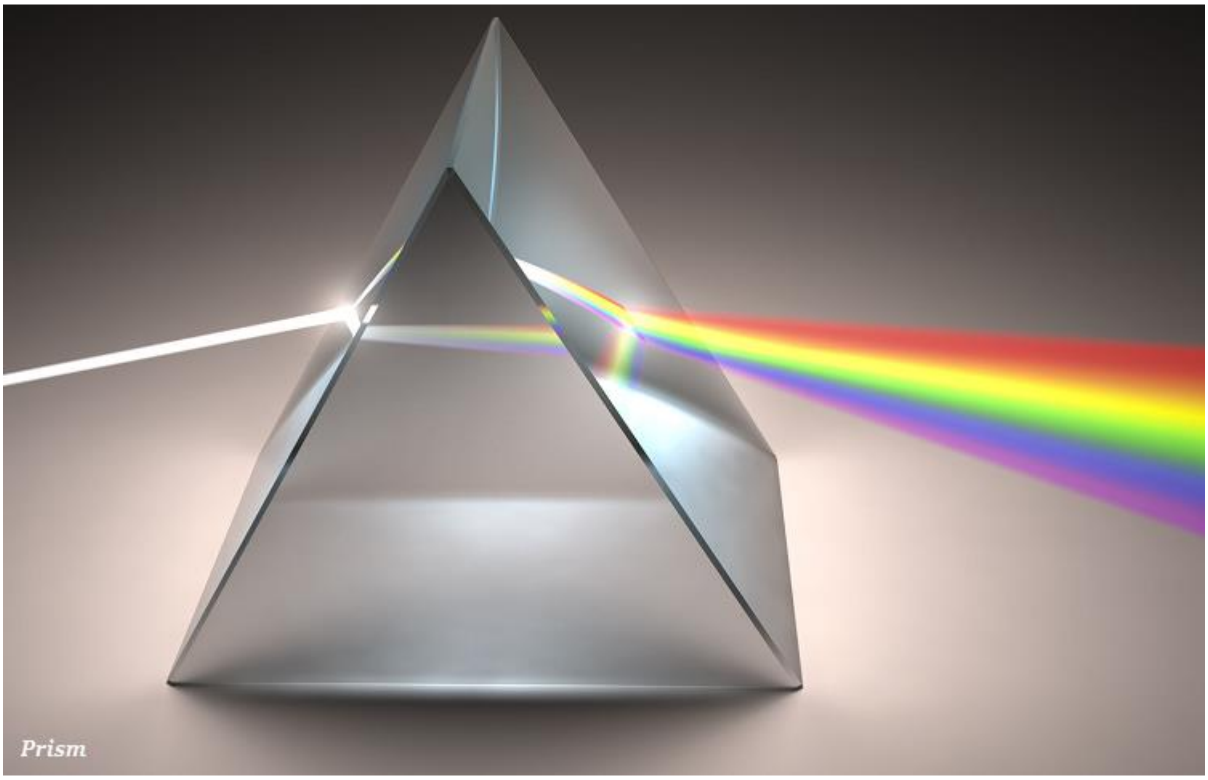
Presbyopia

- Presbyopia, an eye problem, arises because of the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens.
- Some people suffer from both myopia and hypermetropia; such kind of eye defect is treated by using **bifocal** lenses.
- A common type of bi-focal lenses consists of both the concave and the convex lenses.

15. REFRACTION OF LIGHT THROUGH A PRISM

Introduction

- Prism is a triangular glass, which has two triangular bases and three rectangular lateral surfaces (as shown in the image given below).



- The unique shape of the prism makes the emergent ray bend at an angle to the direction of the incident ray and this angle is known as the **angle of deviation**.
- The angle between two lateral faces of a prism is known as the **angle of the prism**.

Dispersion of White Light by a Glass Prism

- As shown in the image given above, the prism has split the incident white light into a band of colors.
- The various colors those are seen through prism are arranged in order; this order is named as '**VIBGYOR**.'
- VIBGYOR is constituted after taking first letter of all the following colors:

- V – Violet
- I – Indigo
- B – Blue
- G – Green
- Y – Yellow
- – Orange
- R – Red

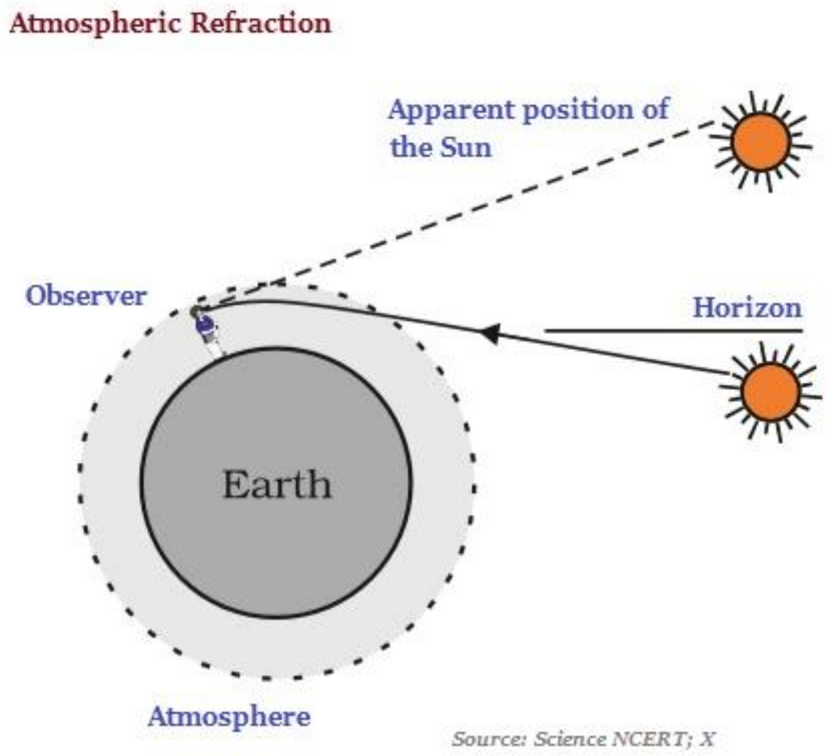
- The band of the colored components of a light beam is known as **spectrum** and VIBGYOR is the sequence of colors that you can see in the above image.
- The splitting of light into different colors is known as **dispersion**.
- All the colors have different bending angles in respect to the incident ray; the red light bends list (can be seen at the top) whereas the violet bends the most (see the image given above).
- Because of having different bending angles, all the colors become distinct.
- Newton was the first scientist who used a glass prism to obtain the spectrum of sunlight and he concluded that the sunlight is made up of seven colors.
- A rainbow is a natural spectrum that most likely appears in the sky after a rain shower (see the image given below).


Rainbow

- Rainbow after the rain is normally result of dispersion of sunlight by the tiny water droplets.
- The tiny water droplets present in the atmosphere act like small prisms.
- A rainbow always forms in the opposite direction of the Sun.

Atmospheric Refraction

- The deviation of light rays from a straight path in the atmosphere (normally because of variation in air density) is known as **atmospheric refraction**.
- Atmospheric refraction nearby the ground produces mirages, which means, the distance objects appear elevated or lowered, to shimmer or ripple, stretched or shortened, etc.
- In the night, the stars appear twinkling, it is also because of the atmospheric refraction.
- Because of the atmospheric refraction, the Sun remains visible and about 2 minutes after the actual sunset and about 2 minutes before the actual sunrise (see the image given below).



Tyndall Effect

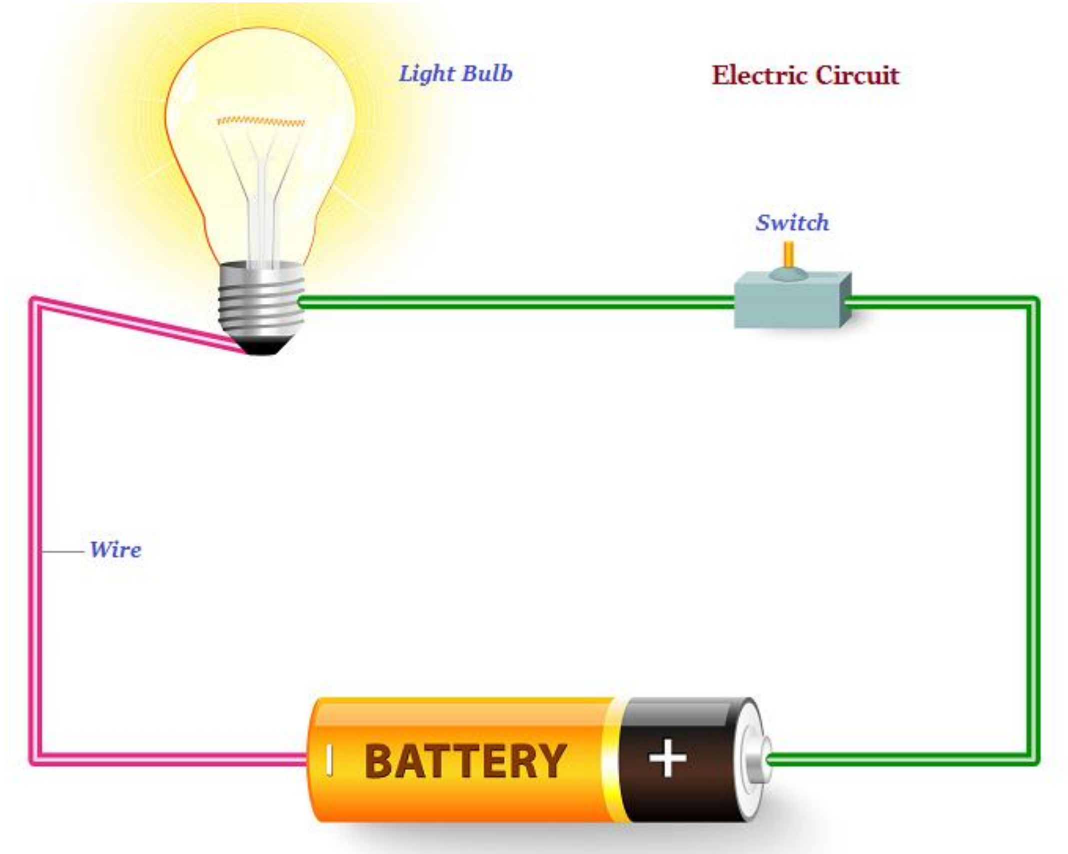
- The earth's atmosphere is largely constituted of a heterogeneous mixture, such as tiny water droplets, suspended particles of dust, smoke, and molecules of air. When a beam of light strikes through such fine particles, the path of the beam gets scattered. The phenomenon of scattering of light by the colloidal particles (of the atmosphere) gives rise to **Tyndall effect**.

- The scattering of light makes the particles visible in the atmosphere.
- Very fine particles scatter largely blue light whereas particles of larger size scatter the light, which has longer wavelengths.
- The red light has a wavelength (about) 1.8 times larger than the blue light.

16. ELECTRICITY

Introduction

- If the electric charge flows through a conductor, such as a metallic wire, it is known as the **electric current** in the conductor.
- A continuous and closed path of an electric current is known as an **electric circuit** (as shown in the image given below):



- In an electric circuit, usually, the direction of electric current (known as positive charges), is considered as opposite to the direction of the flow of electrons, which are considered as negative charges.
- The SI unit of electric charge is **coulomb** (**C**).
- Coulomb is equivalent to the charge contained in closely **6 × 10^{18}** electrons.
- The electric current is expressed by a unit known as an **ampere** (**A**).
- It was named after the French scientist Andre-Marie Ampere.

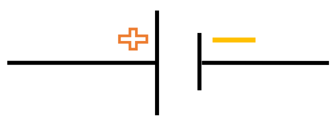
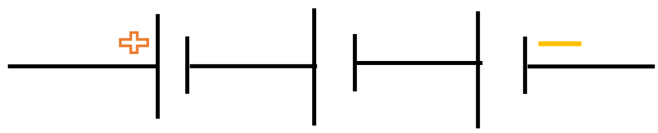
- One ampere constitutes by the flow of one coulomb of charge per second, i.e., **1 A = 1 C/1 s**.
- The instrument that measures electric current in a circuit is known as **ammeter**.
- The electric current flows in the circuit starting from the positive terminal to the negative terminal of the cell through the bulb and ammeter.

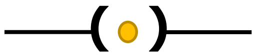
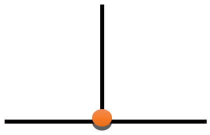
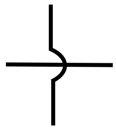
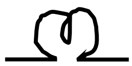
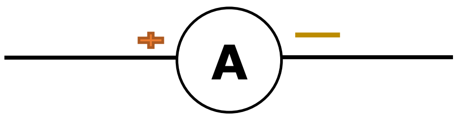
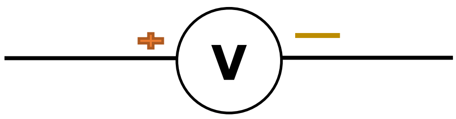
Electric Potential and Potential Difference

- The electrons of a conductor move only if there is a difference of electric pressure, known as the **potential difference**.
- The chemical action within a cell produces the potential difference across the terminals of the cell. Further, when this cell is linked to a conducting circuit element, the potential difference sets the charges in motion (in the conductor) and generates an electric current.
- Alessandro Volta (1745–1827), an Italian physicist, first noticed the electric potential difference; therefore, the SI unit of electric potential difference is given **volt** (**V**).
- The instrument that measures the potential difference is known as the **voltmeter**.

Circuit Diagram

- Some defined symbols are used to illustrate the most commonly used electrical components in circuit diagrams.
- The following table describes some of the symbols commonly used to define the electric components:

Components	Symbols
An electric cell	
A battery or combination of cells	

Plug key or switch (Open)	
Plug key or switch (closed)	
A wire joint	
Wires crossing without joining	
Electric bulb	
A resistor of resistance R	
Variable resistance or rheostat	
Ammeter	
Voltmeter	

Ohm's Law

- A German physicist, Georg Simon Ohm in 1827, stated that
  - *"The electric current flowing through a metallic wire is directly proportional to the potential difference (V), across its ends provided its temperature remains the same*."

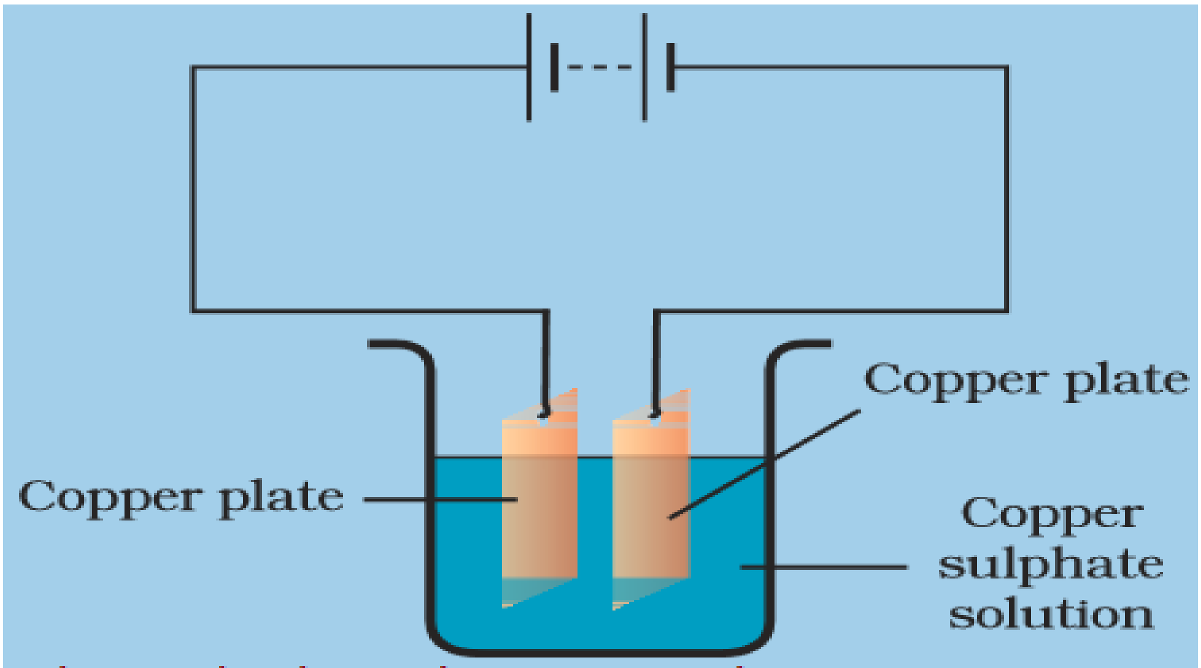
Electric Power

- The rate at which electric energy is dissipated or consumed in an electric circuit is known as **electric power**.
- The SI unit of electric power is **watt** (**W**).

17. CHEMICAL EFFECTS OF ELECTRIC CURRENT

Introduction

- Most of the liquids that conduct electricity belong to solutions of acids, bases and salts.
- Some liquids are good conductors and some are poor conductors of electricity.
- The passage of an electric current through a conducting liquid normally causes chemical reactions and the resulting effects of this reaction are known as **chemical effects of currents**.
- The process of depositing a layer of any desired metal on another material by means of electricity is known as **electroplating**.



Simple Circuit showing Electroplating

- Electroplating is commonly used in industry for coating metal objects with a thin layer of a different metal.

Electroplated Objects

- Coating of zinc is applied on iron to protect it from the corrosion and formation of rust.

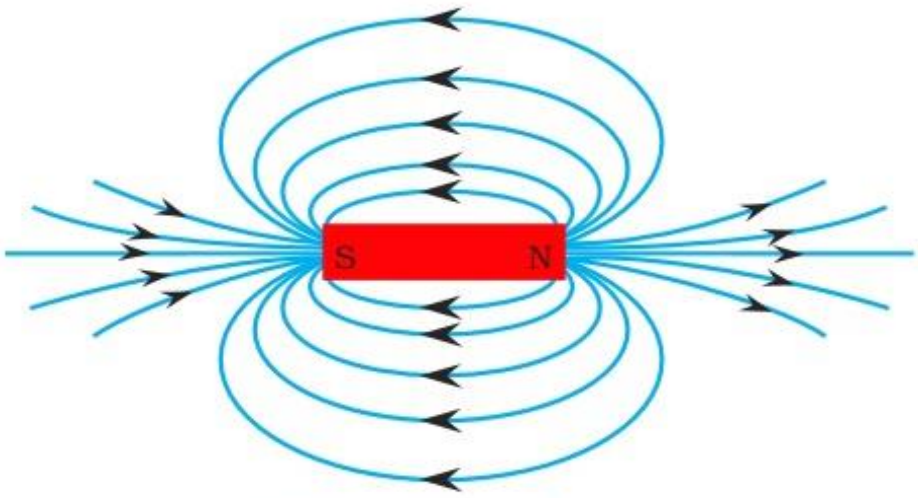
18. MAGNETIC EFFECTS OF ELECTRIC CURRENT

Introduction

- The electricity and magnetism are linked to each other and it is proved when the electric current passes through the copper wire, it produces a magnetic effect.
- The electromagnetic effects first time noticed by Hans Christian Oersted.

Magnetic Field

- Magnetic field is a quantity, which has both magnitude and direction.
- The direction of a magnetic field is usually taken to be the direction in which, a north pole of the compass needle moves inside it.

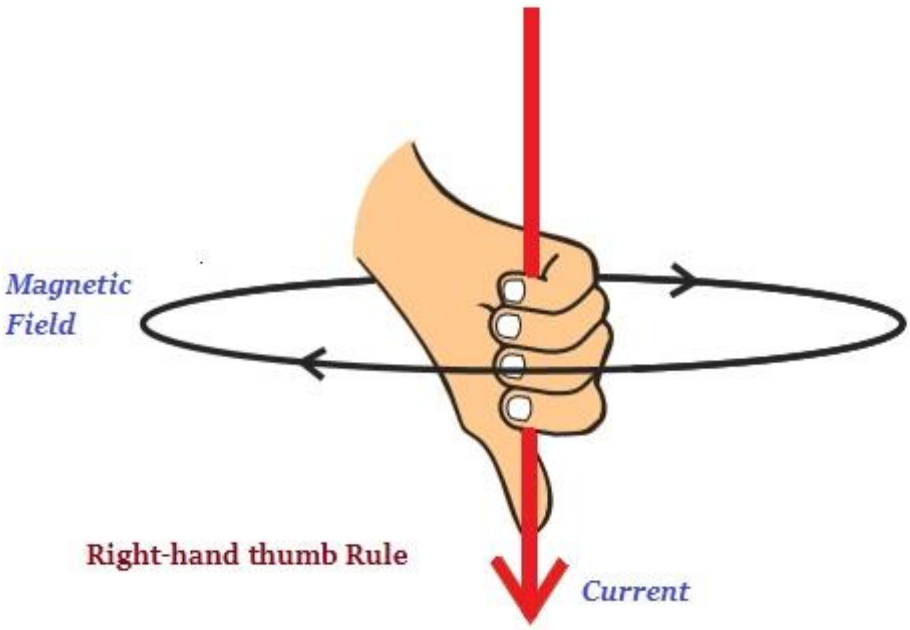


Field lines of magnet bar

- It is the convention that the field lines emerge from north pole and merge at the south pole (see the image given above).
- No two field-lines of a magnet bar are found to cross each other. If it happens, then it means that at the point of intersection, the compass needle would point towards two directions, which is simply not possible.
- The magnitude of the magnetic field (produced by an electric current) at a given point increases with the increase of current through the wire.

Right-Hand Thumb Rule

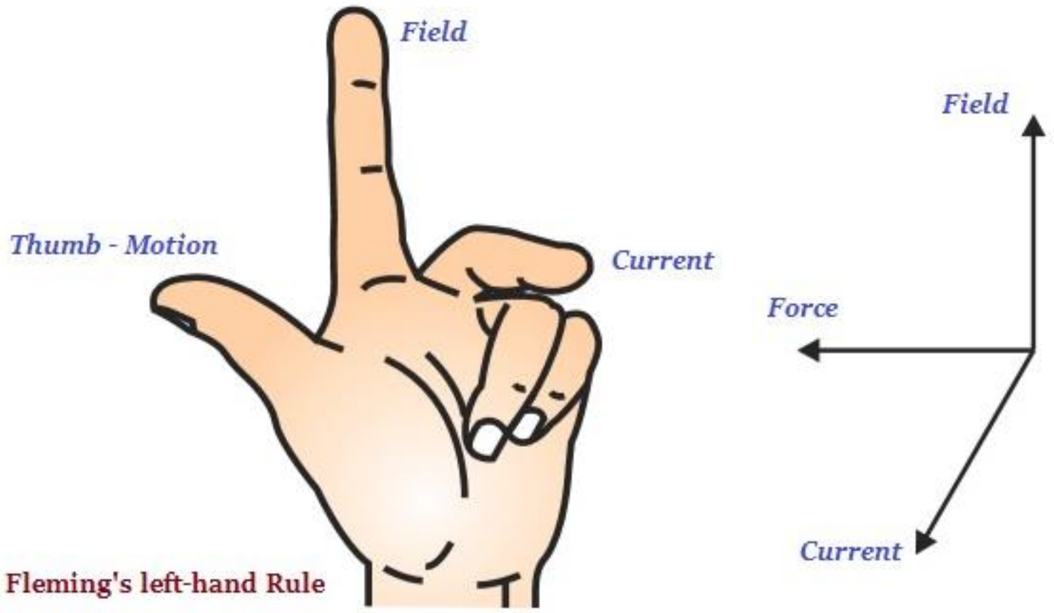
- Also known as Maxwell's corkscrew rule, right-hand thumb rule illustrates direction of the magnetic field associated with a current-carrying conductor (see the image given below).



- Right-hand thumb rule states that
  - "*Imagine that you are holding a current-carrying straight conductor in your right hand such that the thumb points towards the direction of current. Then your fingers will wrap around the conductor in the direction of the field lines of the magnetic field*."

Fleming's Left-Hand Rule

- Fleming's left-hand rule states that
  - "*Stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular (as shown in the image given below). If the first finger points in the direction of magnetic field and the second finger in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor*."

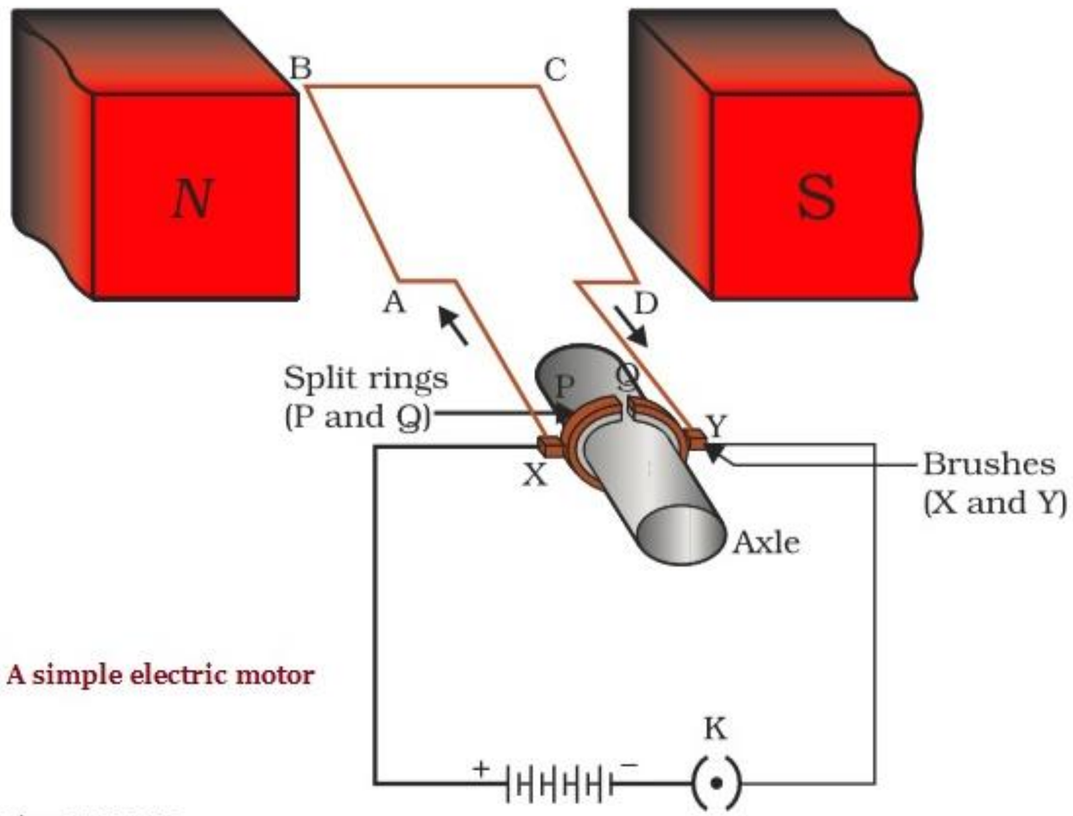


- Human body also produces magnetic field; however, it is very weak and about one-billionth of the earth's magnetic field.
- Heart and brain are the two main organs in the human body where the magnetic field has been produced.
- The magnetic field inside the human body forms the basis of getting the images of different parts of the body.
- The technique used to get the image of body part is known as the **Magnetic Resonance Imaging** (MRI).

19. ELECTRIC MOTOR

Introduction

- An electric motor is a rotating device, which is made to convert electrical energy into mechanical energy.
- We use dozens of devices in which electric motors are used, such as, refrigerators, mixers, fans, washing machines, computers, etc.



A simple electric motor

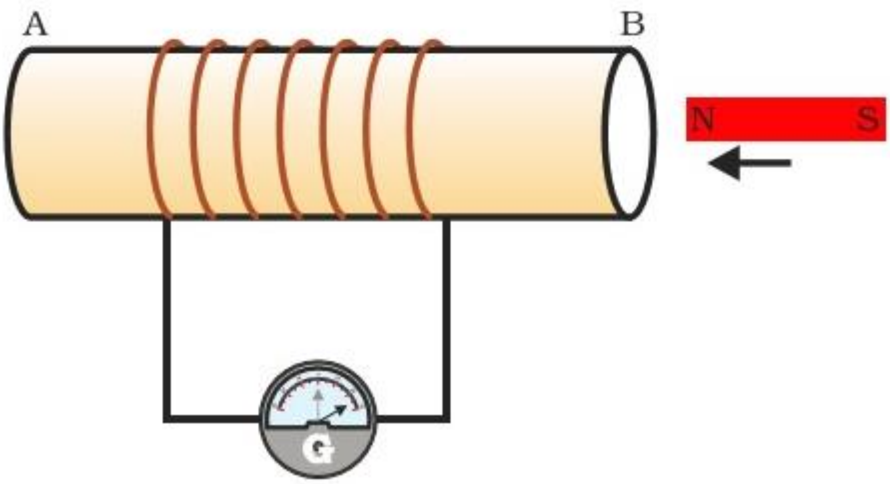
Source: Science NCERT; X

- The commercial and high power motors use:
  - An electromagnet in place of a permanent magnet;
  - Large number of turns of the conducting wire in the electric current carrying coil; and
  - A soft iron core on which the coil is properly wound.
- The soft iron core (wound with the coil) and the coils, are known as an **armature**.

- Armature has main function to enhance the power of the motor.

Electromagnetic Induction

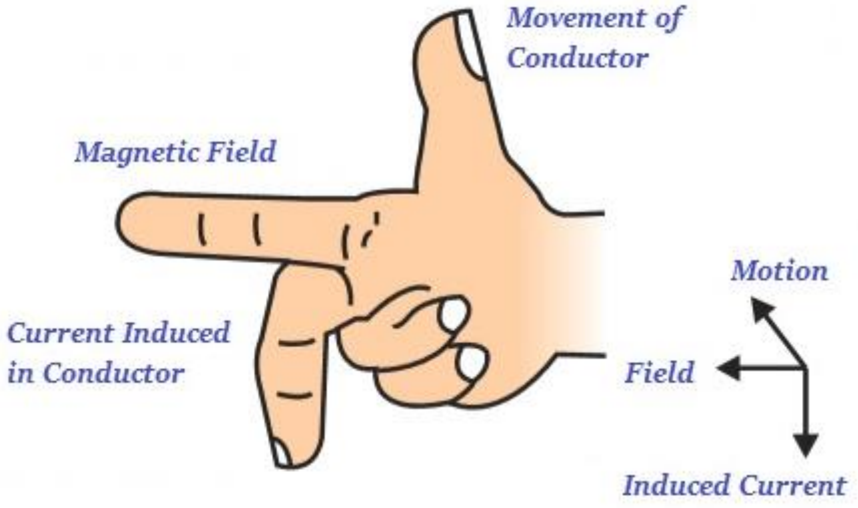
- In 1831, Michael Faraday, an English physicist, had discovered that a moving magnet can be used to generate electric currents.



- As shown in the image given above that the moving magnet towards a coil sets up current in the coil circuit, which is indicated and read by deflection in the galvanometer needle.
- Because of the changing magnetic field, Electromagnetic induction produces an electromotive force (emf) in a conductor.
- A galvanometer is an instrument that is used to detect the presence of a current in a circuit.

Fleming's Right-Hand Rule

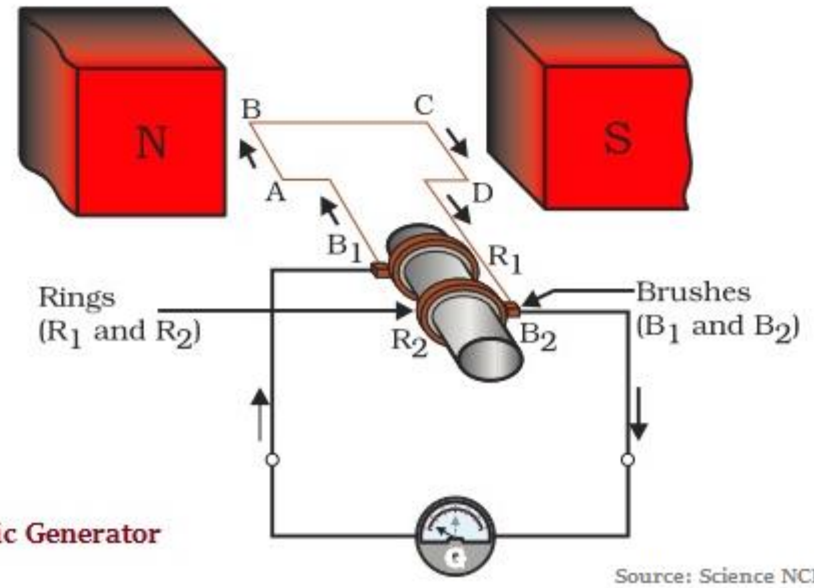
- Fleming's right-hand rule states that
  - "*Stretch the thumb, forefinger and middle finger of right hand so that they are perpendicular to each other (see the image given below). If the forefinger indicates the direction of the magnetic field and the thumb shows the direction of motion of conductor, then the middle finger will show the direction of induced current. This simple rule is called Fleming's right-hand rule*."



Fleming's right-hand rule

Electric Generator

- An electric generator is a device that converts mechanical energy into electrical energy.



Electric Generator

Source: Science NCERT; X

- In an electric generator, mechanical energy is used to rotate the conductor in a magnetic field, as a result of this electricity is produced.

Types of Electric Current

- Following are the two types of electric current:

- Alternating Current (or AC)
- Direct Current (of DC)

- The difference between the alternating current and direct current is - the alternating current keeps reversing its direction periodically; whereas, the direct current always flows in one direction.
- Most of the electric power stations produce alternating current.
- In hour houses, there are different electric appliances, most of run on alternating current.
- In our house wiring, **fuse** is the most important safety device.
- Fuse is used to protect the circuits that may damage due to short-circuiting or overloading of the circuits.

20. SOURCE OF ENERGY

Introduction

- Energy, which is neither created nor destroyed, has many sources; significant of them are:
  - **Muscular energy** – Most of the organisms have it (by default); this is the reason that we have the capacity to do physical works.
  - **Electrical energy** – Most of the electrical appliances in our home run on electrical energy.
  - **Chemical energy** – chemical energy is normally used in cooking, running vehicles, etc.
- Based on the energy reserves, energy is categorized as:
  - **Conventional Source of Energy:** The sources of energy, which is found in limited amount (and exhaustible), are known as conventional source of energy. E.g. fossil fuels (such as coal, petroleum, etc.).
  - **Non-Convention Source of Energy**: It is also known as renewable source of energy. E.g. wind energy, solar energy, geo-thermal energy, etc.

Thermal Power Plant

Huge amount of fossil fuel is burnt to heat up water to produce steam, which ultimately runs a turbine and generate electricity.

- The term thermal power plant is used purposefully, as fuel is burnt to produce heat energy which is ultimately converted into the electrical energy.

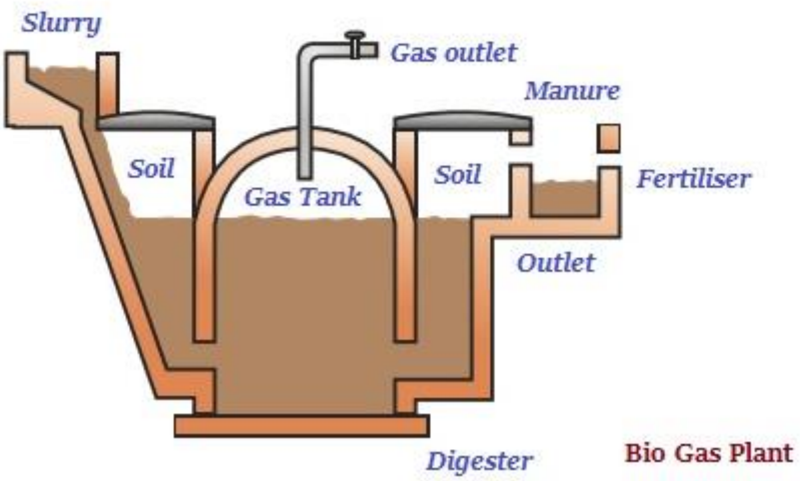
Hydro Power Plants

- Running/falling water has huge potential energy; the hydro power plant converts this potential energy into electricity.

- Dams are purposefully constructed to electricity through water.
- However, construction of big dams is threatful for the respective ecosystem; therefore, big dams are allowed to be constructed only in particular geographic location.

Bio Mass Fuel

- The fuels, generated through the products of plants and animals, are known as bio mass fuel. Gobar Gas (Bio Gas) is the best example of bio mass fuel.



- Bio-gas is an excellent source of fuel, as it contains about 75% methane.
- Bio-gas burns without smoke and leaves no residue like ash in wood.

Wind Energy

- Wind has great amount of kinetic energy, which can be harnessed by wind mills.

- The rotatory motion of the windmill is set to run the turbine that ultimately generates electric energy.

- In Denmark, more than 25% of electricity (of total requirements) are generated through a vast network of windmills; therefore, it is known as '**country of winds**.'
- However, in terms of total output, Germany is ranked first.
- India has fifth position in terms of harnessing wind energy for the production of electricity.
- With the capacity of 380 MW, Kanyakumari (Tamil Nadu), is the largest wind energy farm in India.
- Wind energy is an environment-friendly technology and efficient source of renewable energy.
- However, one of the biggest limitations with the wind energy is – it cannot be set up anywhere, but rather it can be set up in the region where we can get the wind blowing consistently at the speed (at least) 15 km/hour.

Solar Energy

- The energy produced through the solar rays, is known as solar energy.
- Such kind of energy has very low maintenance cost.
- It can be used on small scale (such as only lit a tube light with fan) as well as to run a big industry, as it has a great potential.
- However, the technology is still very costly; therefore, it is difficult to make widespread.

Tidal Energy

- The energy produced by the potential power of tides is known as tidal energy.
- A turbine is set up at the opening of the dam (constructed nearby coast) that converts tidal energy to electricity.

Wave Energy

- Sea waves have great potential energy nearby the coast; hence, the electric energy produced by the sea wave is known as wave energy.

Ocean Thermal Energy

- The electric energy, produced by the temperature difference of oceanic water, is known as ocean thermal energy.

Geothermal Energy

- The electric energy, produced from the natural hot springs, is known as geothermal energy. Manikarn, Himachal Pradesh, is the site of geothermal energy in India.

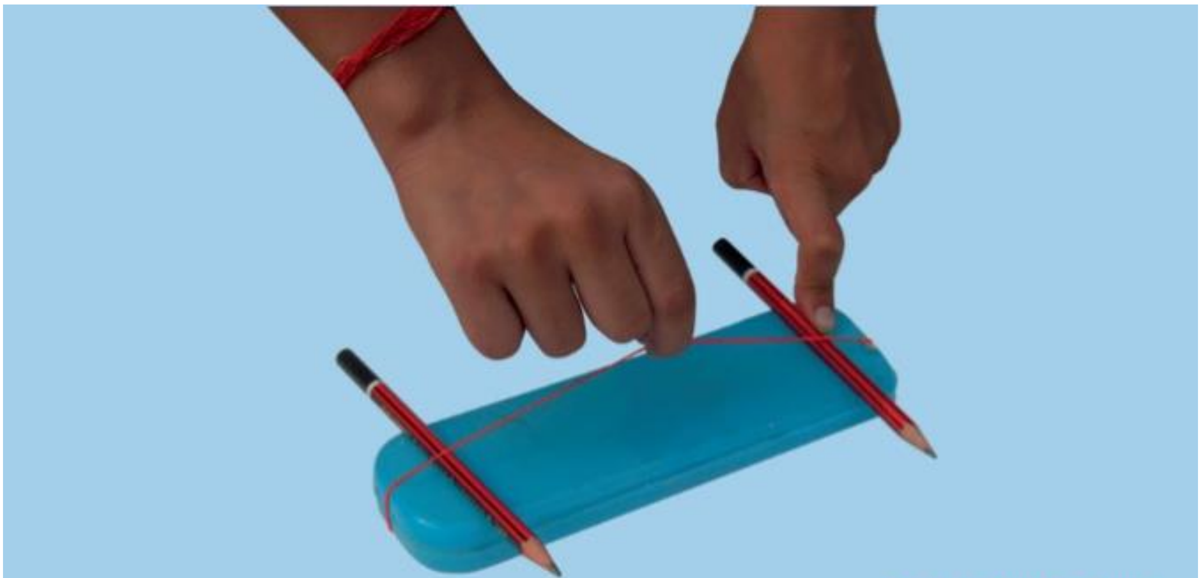
Nuclear Energy

- The energy, released by the process of nuclear fission or fusion, is known as nuclear energy.
- During the process of nuclear reactions, the nuclear energy is released, which is used to generate heat; this heat energy is then used in steam turbines to produce electricity.

21. SOUND PART I

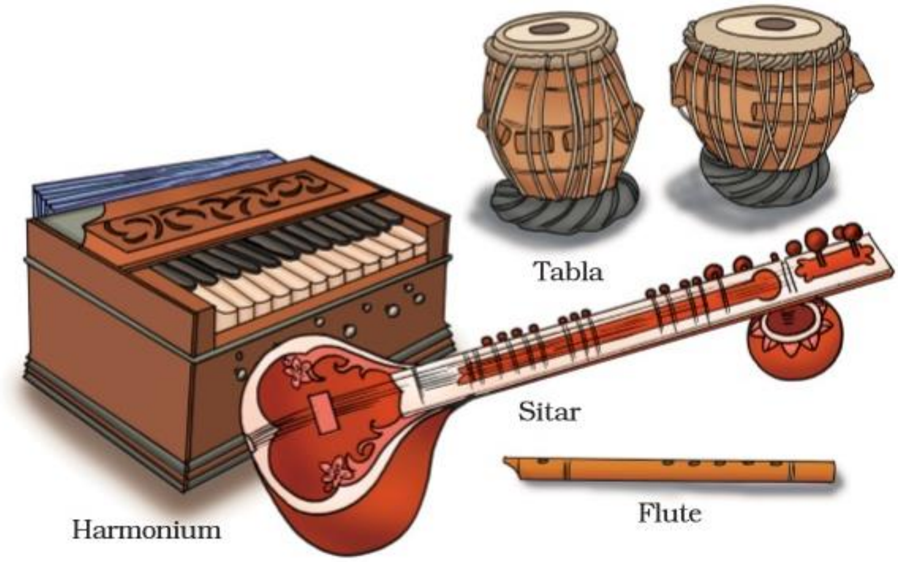
Introduction

- The *to* and *fro* or *back* and *forth* motion of an object is known as ***vibration***. Therefore, when a tightly stretched band is plucked, it vibrates and when it vibrates, it produces **sound**.



Plucking Rubber Band

- In some cases, vibration can be easily observed, but in most of the cases, their amplitude is so small that it is very difficult to see them with naked eye; however, their vibration can be easily felt in the form of sound. E.g. Tabla, Harmonium, Flute, Sitar, etc.



- In human beings, the sound is produced by the larynx (also known as voice box).

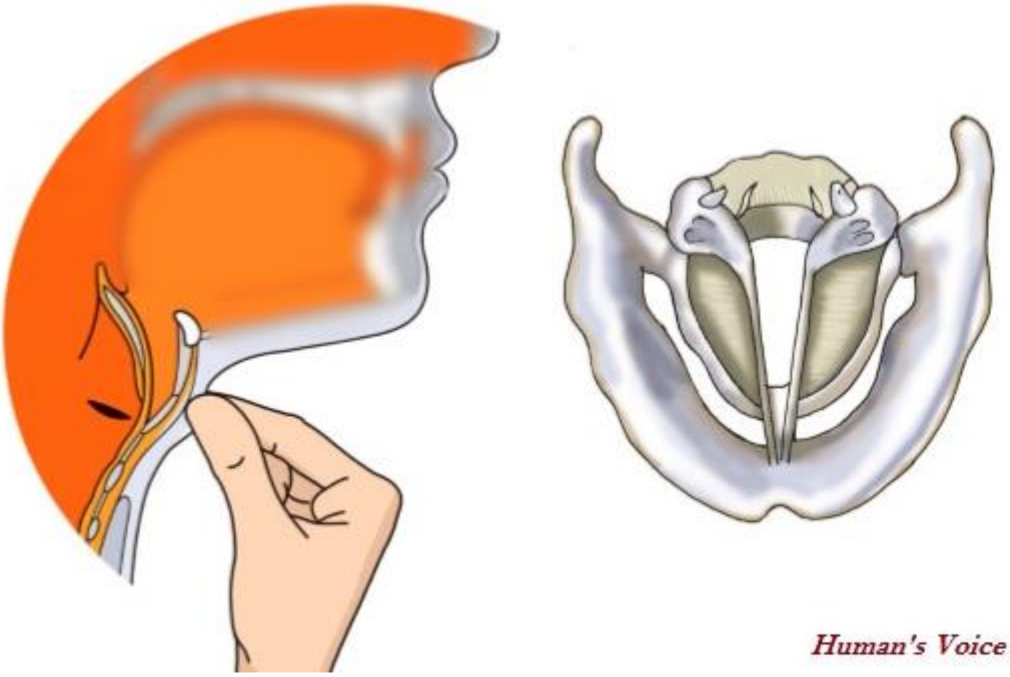
- One can feel the vibration by keeping fingers on the throat; this is the part that is known as the voice box.

Sound Produced By Human Beings

- Two vocal cords (as shown in the given image), are stretched across the voice box (or larynx) in such a way that it leaves a narrow slit between them for the passage of air; this is how sound is produced.

- The vocal cords in men are about 20 mm long.

- The vocal cords in women are about 15 mm long and children's vocal cords are even more shorter; this is the reason that men, women, and children have different voice.

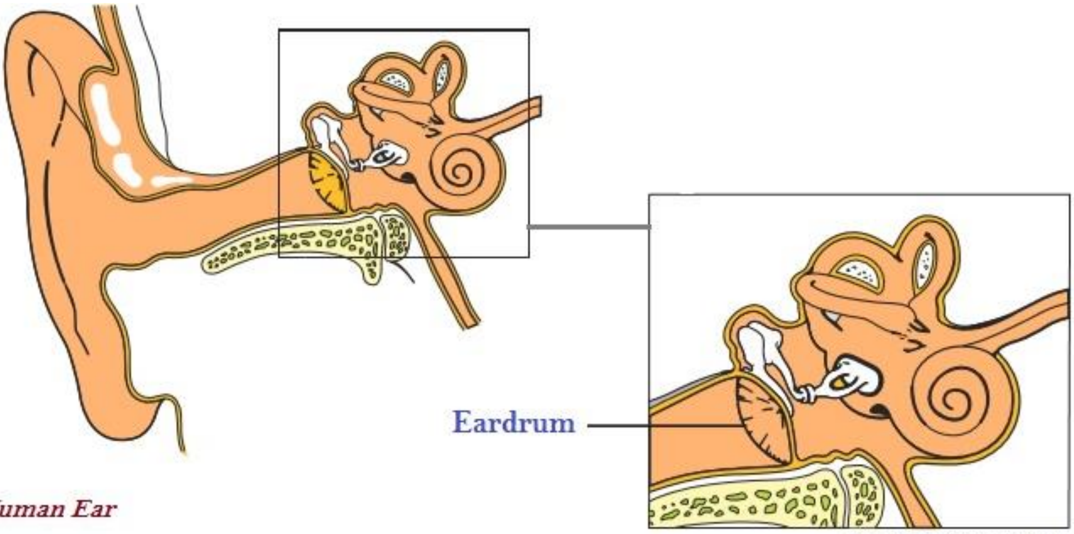


Human's Voice Box

Human Ears

- The part through which we hear is known as **ear**.

- The shape of the outer part of the ear is similar to a funnel; therefore, when sound enters in it, it keeps going down through a canal to the end. At the end, there is a thin membrane stretched tightly; it is known as the **eardrum**.



Human Ear

Source: Science NCERT; VIII

- The eardrum is very similar to a stretched rubber sheet and sound vibrations make the eardrum vibrate.

- The eardrum sends vibrations to the inner ear and from there, the signal goes to the brain; this is how we hear the sound clearly.

Frequency of A Vibration

- The vibration motion is known as **oscillatory motion**.

- The number of oscillations per second is known the **frequency** of oscillation and the frequency is expressed in **hertz** (Hz).

- Amplitude and frequency are the two significant features of any sound.

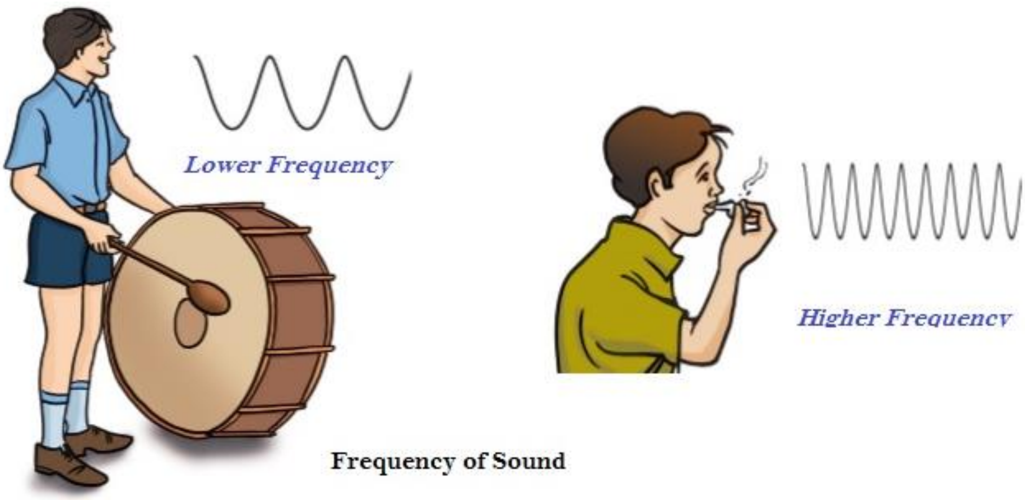
- The loudness of sound depends on its amplitude; if amplitude is higher, then the sound is louder and if the amplitude is lesser, then the sound is feeble.

- The loudness of sound is expressed in a unit and it is expressed in **decibel** (dB).

- The following table illustrates the loudness of sound generated from various sources:

Source of Sound	Loudness of Sound
Normal breathing	10 dB
Soft whisper (at 5m)	30 dB
Normal conversation	60 dB
Busy traffic	70 dB
Average factory	80 dB

- The frequency determines the pitch or shrillness of the sound; therefore, if the frequency of vibration is higher, then the sound has a higher pitch and shrillness is higher and vice versa.



Frequency of Sound

- The frequencies of sound less than about 20 vibrations per second (i.e. 20 Hz) cannot be perceived by the human ear.

- The frequencies of sound higher than about 20,000 vibrations per second (i.e. 20 kHz) cannot be perceived by the human ear.

- For a human ear, the range of audible frequencies roughly range between 20 and 20,000 Hz.

- Some of the animals can hear the sounds of frequencies higher than 20,000 Hz, e.g. dogs.

Noise & Pollution

- Unpleasant sounds are called noise.

- Presence of excessive or annoying sounds in the environment is called **noise pollution**.

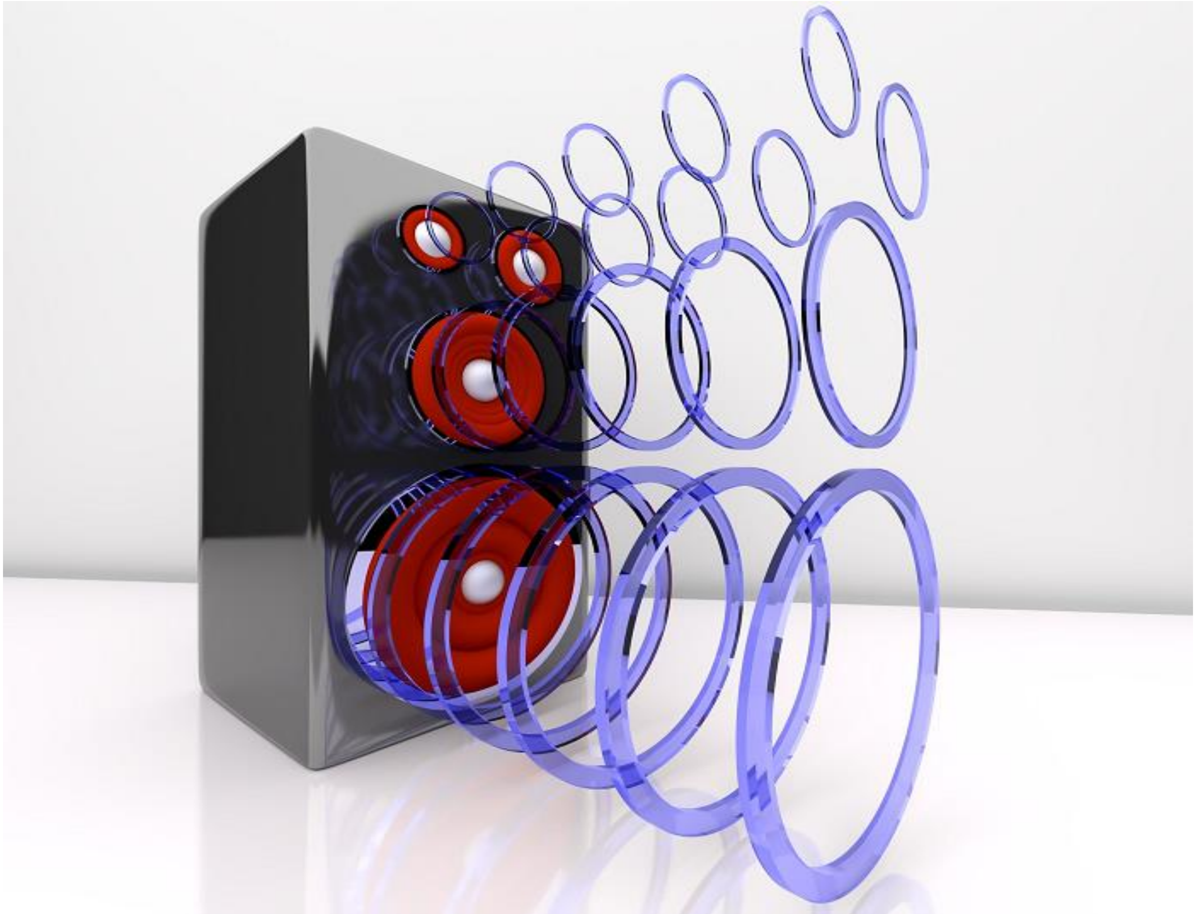
- Noise pollution may cause many health related problems. Such as Lack of sleep, hypertension (high blood pressure), anxiety, impairment of hearing, etc.

- Plantation on the roadside and other places especially in the city region and industrial area can effectively reduce the noise pollution.

22. SOUND PART II

Introduction

- Sound is a form of energy, which produces a sensation when we hear it in our ears.



- Sound can be produce in number of ways, such as, by plucking, scratching, rubbing, blowing or shaking different objects.

- The sound of the human voice is produced because of the vibrations in the vocal cords.

- Sound waves are typically characterized by the motion/vibration of particles in the medium and hence known as **mechanical waves**.

- Sound waves oscillate back and forth on their position; hence, they are known as **longitudinal waves**.

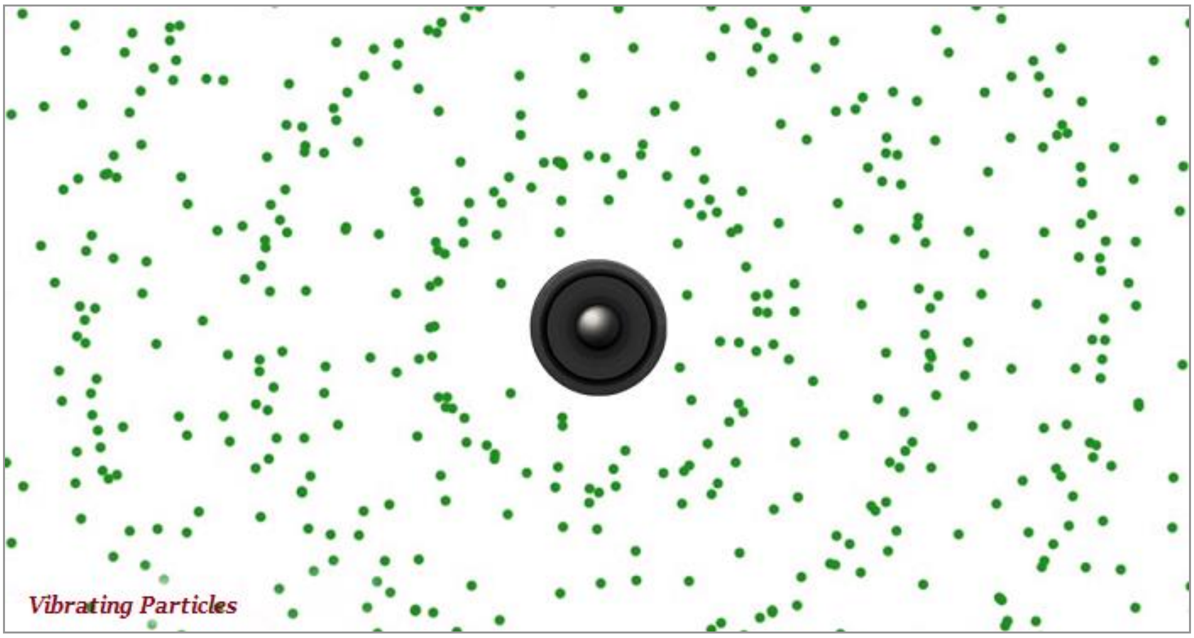
Propagation of Sound

- The substance or object through which sound is transmitted is known as **medium**.

- Sound moves through a medium from the point of the generation to the listener; the sound medium could be solid, liquid, or gas.

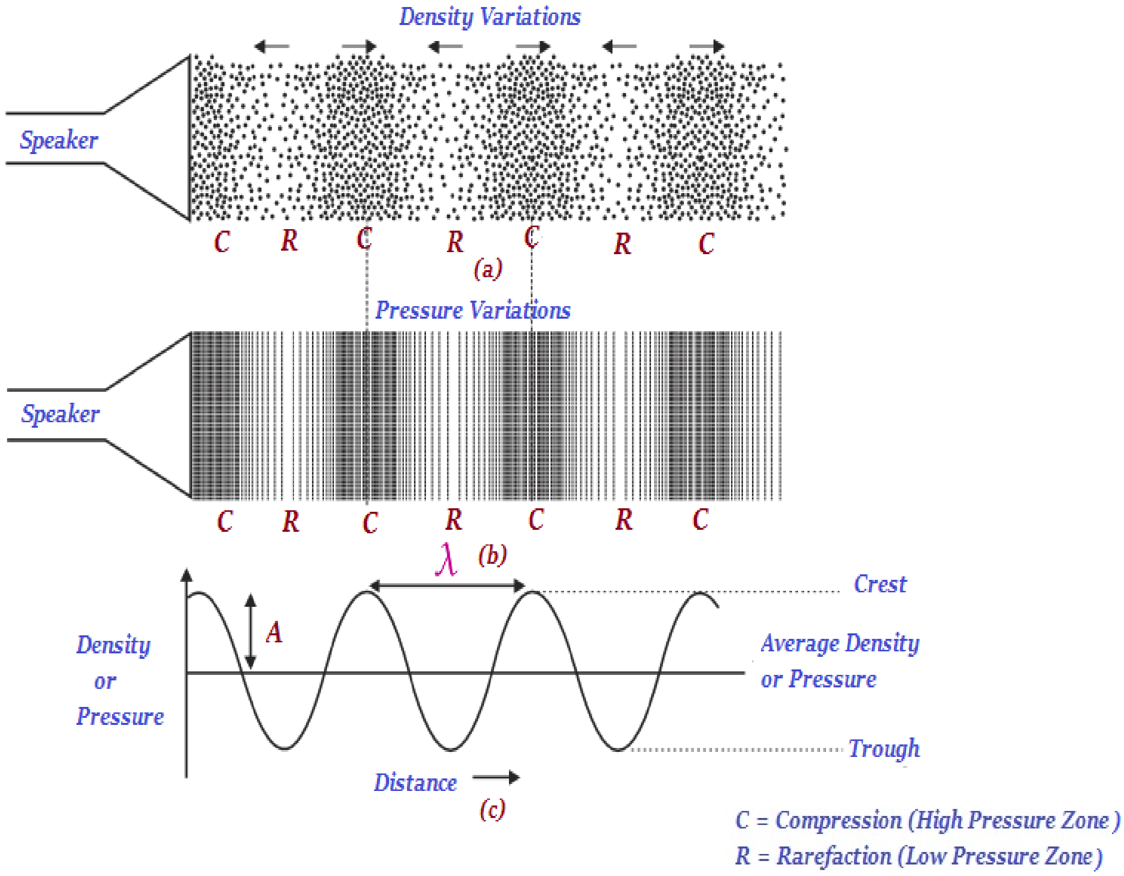
- However, sound cannot travel through a vacuum medium.

- The particles (of gas, liquid, or solid) do not travel all the way from the vibrating object to the ear, but rather when the object vibrates, it sets the particles of the medium around it vibrating and so on and so forth.



- In other words, the particles of the medium do not travel/move forward, but rather the disturbance is carried forward through one vibrating particle to another.

- When vibrating particles move forward, they push and compress the air in front of it and create a region of high pressure known as **compression** (see the image given below).



- Further, when the vibrating particles move backwards, it creates a region of low pressure known as **rarefaction** (R) (see the image given above).

- As the particles move back and forth rapidly, a series of compressions (high pressure zone) and rarefactions (low pressure zone) is created in the air; likewise, the sound wave propagates through the medium.

- As shown in the image given above, the lower portion (valley) of the curve is known as **trough** and the upper portion (peak) is known as **crest**.

- The distance between two consecutive compressions or two consecutive rarefactions is known as the **wavelength**.

- Wavelength is usually represented by the Greek letter lambda (**λ**) and its SI unit is meter (m).

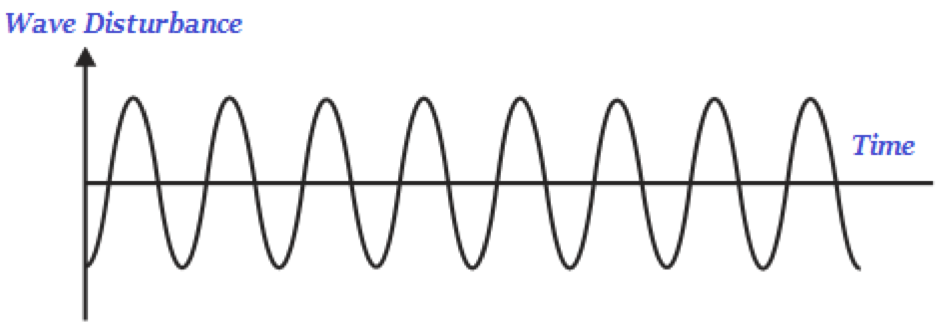
- The number of the compressions or rarefactions that counted per unit time is known as **frequency** of the sound wave.

- Frequency of the sound wave is commonly represented by **v** (Greek letter, nu).

- The SI unit of frequency of the sound wave is hertz (Hz).

- The sensation of a frequency that we sense/listen is usually referred as the **pitch** of a sound.

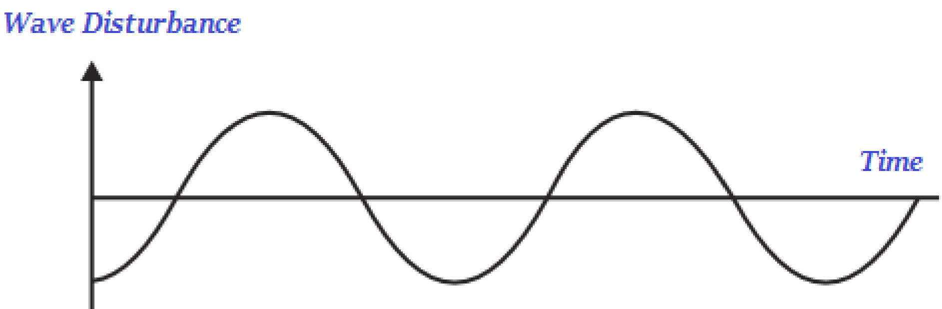
- The faster the vibration of the sound source, the higher is the frequency and so the higher is the pitch (see the image given below).



Wave shape for a high pitched sound

- Likewise, a high pitch sound has more number of compressions and rarefactions passing the fixed point per unit time.

- The lower the vibration of the sound source, the lesser is the frequency and so the lesser is the pitch (see the image given below).



Wave shape for a low pitched sound

- Likewise, a lower pitch sound has less number of compressions and rarefactions passing the fixed point per unit time.

- The magnitude of the maximum disturbance in the given medium on either side of the mean value is known as the **amplitude** of the sound wave.

- Amplitude is commonly represented by the letter **A**.

- The softness or loudness of a sound is fundamentally determined by its amplitude.

- A sound of single frequency is known as **tone**.

- The sound, which is created by mixing of several harmonious frequencies, is known as **note**.

- Note is pleasant in listening.

23. SPEED OF SOUND IN DIFFERENT MEDIA

Introduction

- The speed of sound depends on the type and properties of the medium through which it is traveling.

- The speed of sound in a particular medium depends on temperature and pressure of that medium.

- The speed of sound decreases when it passes from solid to gaseous state of a given medium.

- In any medium, if the temperature increases, the speed of sound also increases and vice versa.

- For example, the speed of sound in air at 0 ºC is 331 m s^{-1} and at 22 ºC it is 344 m s^{-1}.

- **The following table illustrates the speed of sound in different media at 250 C:**

State	Substance	Speed in m/s
Solids	Aluminum	6420
	Nickel	6040
	Steel	5960
	Iron	5950
	Brass	4700
	Glass	3980
Liquid	Sea Water	1531
	Distilled Water	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965

	Air	346
	Oxygen	316
	Sulphur Dioxide	213

Sonic Boom

- When the speed of any object surpasses the speed of sound waves, the speed of respective object is known as **supersonic speed**. For example, the speed of bullets, jet aircrafts, etc.

Jet aircrafts with supersonic speed

- When a sound producing source itself moves with a speed higher than that of the sound, it produces the **shock waves** in air.

- The shock waves carry a large amount of energy, which causes air pressure variation in its immediate environment.

- The shock waves produce a very sharp and loud sound, which is known as **sonic boom**.

Reflection of Sound

- When sound waves strike with a solid wall or even liquid, it gets reflected back.

Echo

- If you shout or clap in a (especially) mountains region, after a while, you will hear the same sound, it is known as **echo**.

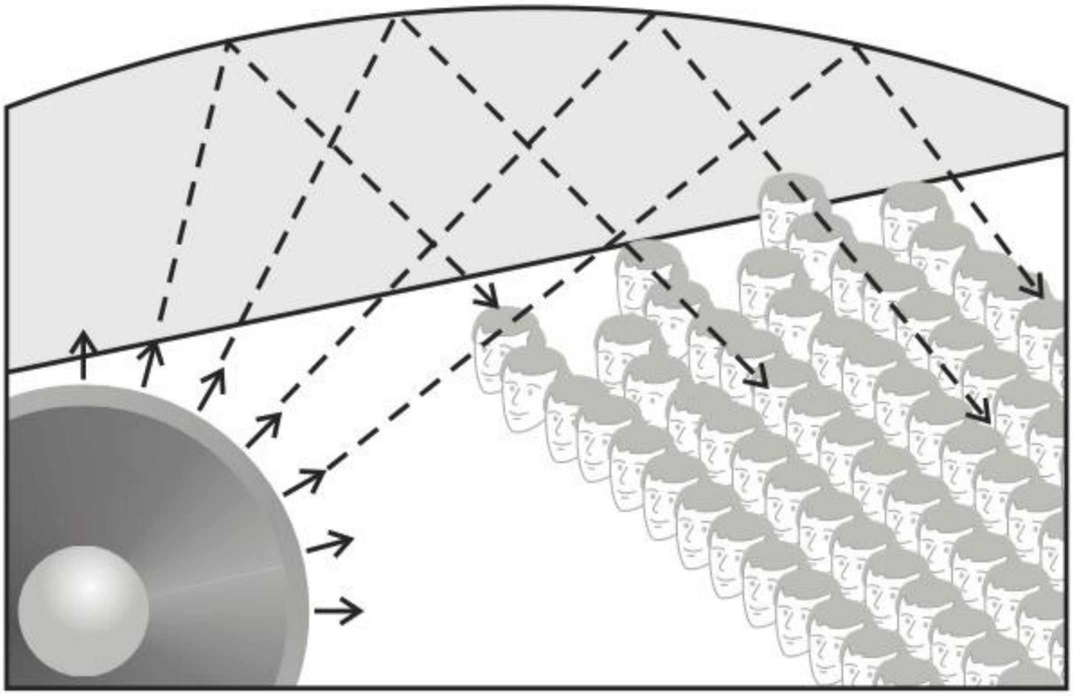
- The sensation of sound continues in our brain for about 0.1 s; therefore, to hear a distinct echo sound, the time interval between the original sound and the reflected sound must be at least 0.1s.

- To hear the distinct echo sound, the minimum distance of the obstacle from the source of sound must be 17.2 m. However, this distance is variable, as depends on temperature.

Reverberation

- The repeated reflection that results in the persistence of sound waves is known as **reverberation**. E.g. in a big hall (especially, an auditorium), the excessive reverberation can be heard.

- Usually, the ceilings of concert or movie halls are given curved shape so that the sound waves after reflection reach all the corners of the hall (see the image given below).



Curved ceilling of a Movie Hall

Range of Audible Sound

- The audible range of sound for the human beings varies between 20 Hz to 20000 Hz.
- However, as people grow older their ears gradually become less sensitive to higher the sound frequencies.
- The sounds of frequencies less than 20 Hz are known as **infrasonic sound** or **infrasound**.
- Whales, rhinoceroses, and elephants produce sound in the infrasound range.
- The sound of frequencies higher than 20 kHz are known as **ultrasonic sound** or **ultrasound**.
- Ultrasound technology is used extensively in different industries and for the medical purposes.
- Dolphins, bats, and porpoises produce ultrasound sound.

Hearing Aid

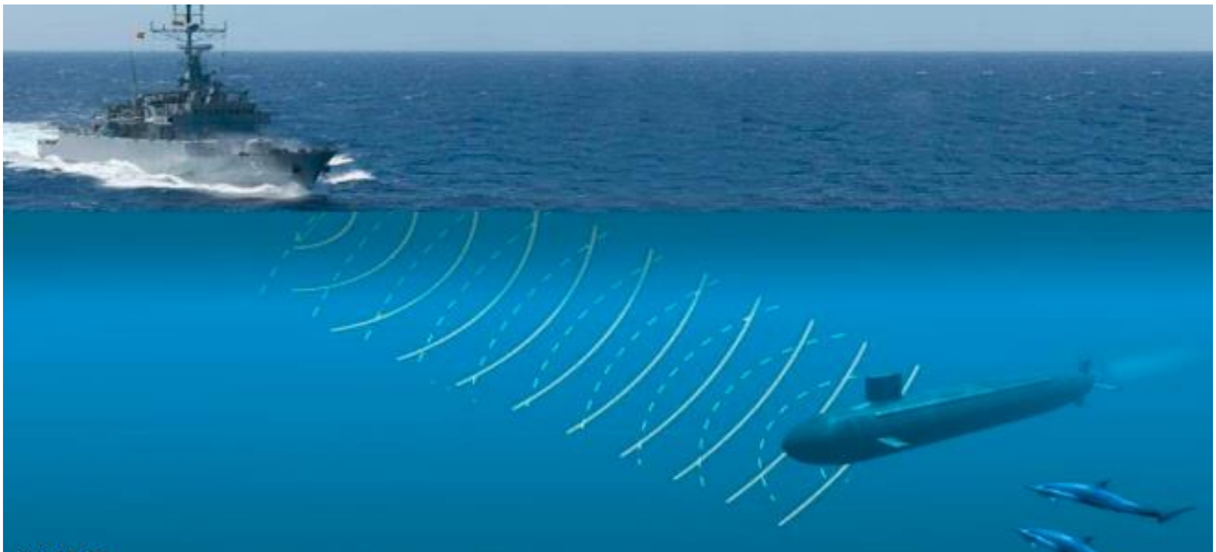
- The hearing aid is an electronic device that help deaf people to listen properly.

Hearing Aid

- A hearing aid is a battery operated device that receives sound through a microphone.

SONAR

- The term SONAR stands for **SOund Navigation And Ranging**.



SONAR

- Sonar is an advanced device that uses ultrasonic waves to measure the direction, distance, and speed of underwater objects (submarines); depth of sea; under water hills; valleys; sunken ships; etc.

24. THE SOLAR SYSTEM

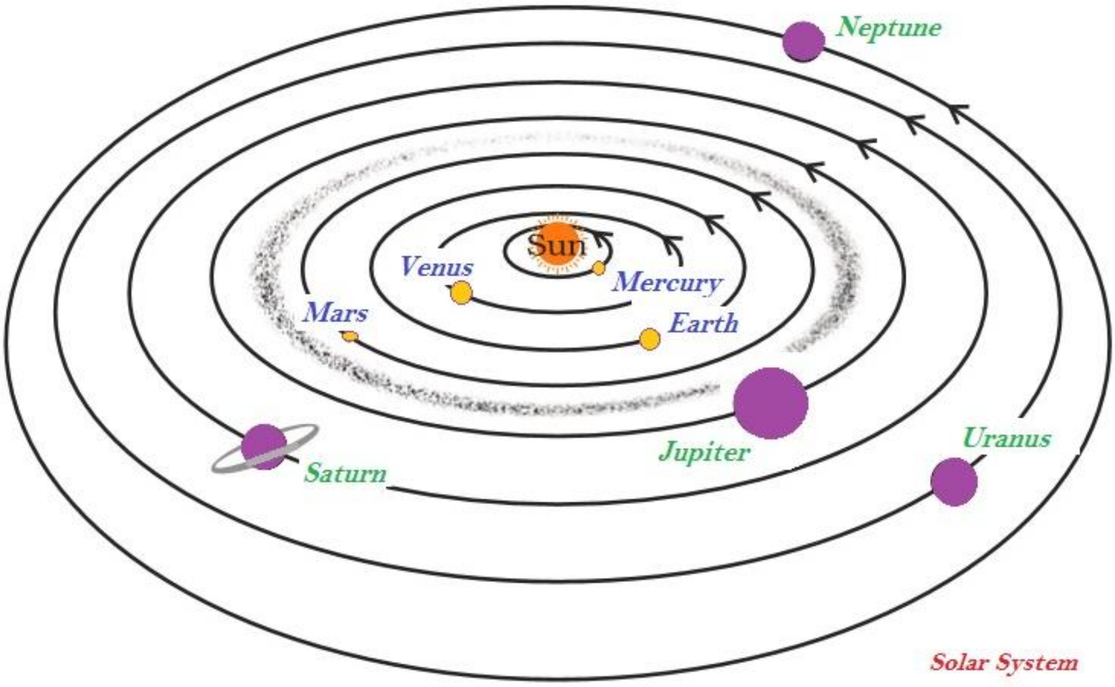
- The Sun and all the celestial bodies which revolve around it (the sun) are known as the **solar system**.

- The solar system consists of a large number of bodies including planets, comets, asteroids, and meteors.

- There are eight planets; they are arranged in their order of distance from the Sun as: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune (see the image given below).

- The first four planets, Mercury, Venus, Earth and Mars, are known as '**inner planets**.'

- Jupiter, Saturn, Uranus and Neptune are much farther off from the sun and known as '**outer planet**.'



The Sun

- The Sun is the nearest star from the earth.

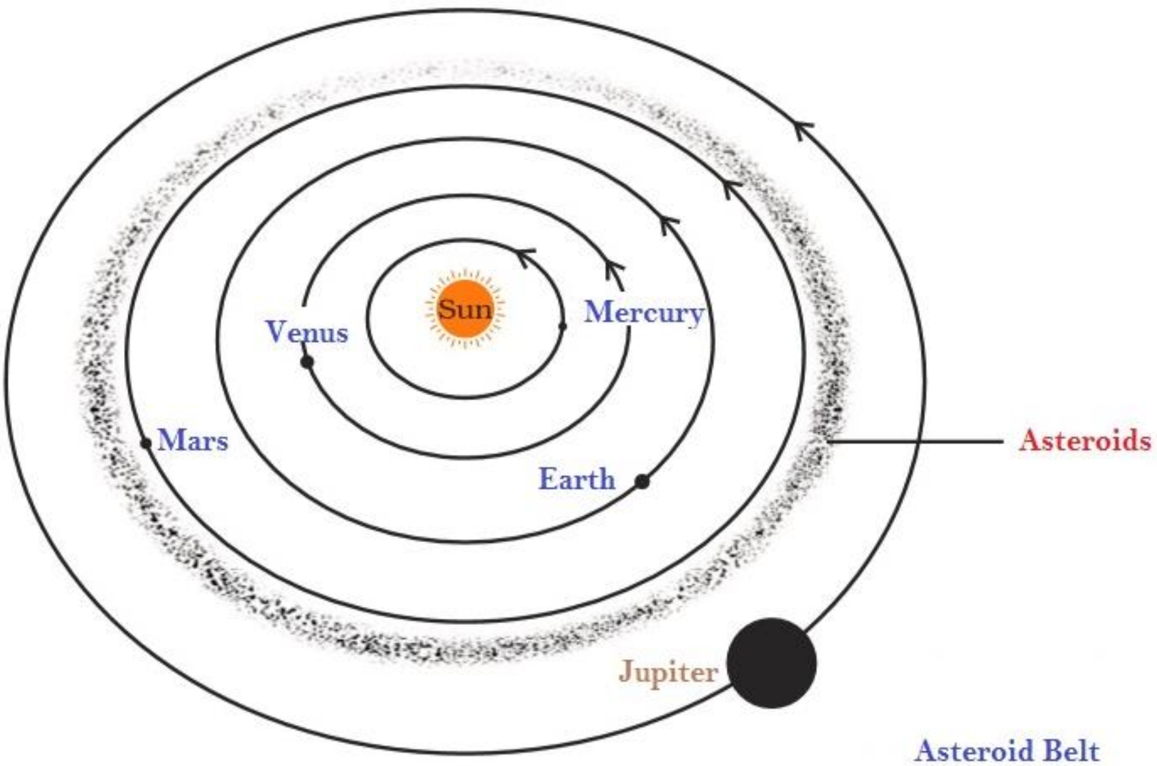
- The Sun is about 150,000,000 kilometers (150 million km) away from the Earth.

- The Sun is the source of almost all energy available on the Earth.
- After sun, Alpha Centauri, is the nearest star from the earth.
- Light year is the distance travelled by light in one year.
- The speed of light is about 300,000 km per second.

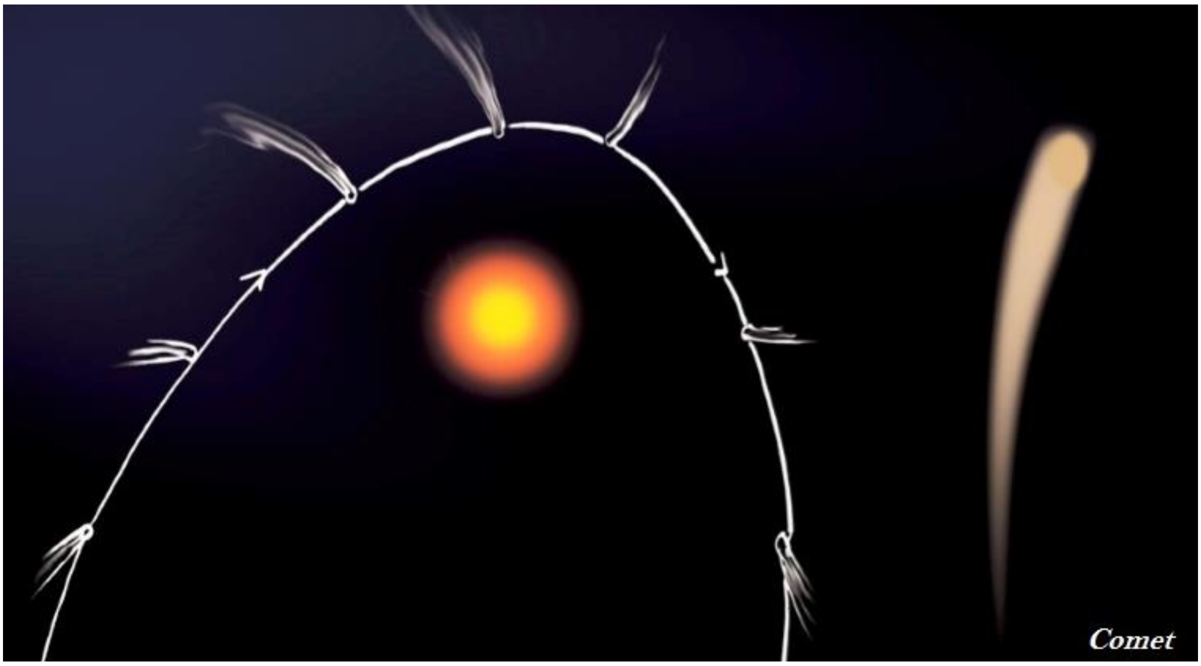
The Planets

- There are eight planets that keep changing their positions with respect to the stars.
- The planets have definite paths in which they revolve around the Sun.
- The path of the planet is known as an **orbit** (see the image given above).
- The time taken by a planet to complete one revolution is known as its period of **revolution**.
- The time period of revolution increases with the distance of the planet increases from the sun.
- All planet also rotates on its own axis, which is known as its rotation period.
- A celestial body revolving around the planet is known as **satellite** or **moon**.
- The planet mercury is smallest and nearest to the Sun.
- Mercury has no satellite of its own.
- Venus is the nearest planet to the earth.
- Venus is the brightest planet.
- Venus appears in the eastern sky before sunrise and appears in the western sky after sunset; therefore, it is also known as morning or an evening star.
- Venus has no moon/satellite.
- Venus rotates from east to west.
- From space, earth appears blue-green due to reflection of light from water and landmass accordingly.

- The Earth has one moon.
- Mars appears somewhat reddish and, hence, known as the red planet.
- Mars has two natural satellites.
- Jupiter is the largest planet of the solar system.
- Jupiter is about 318 times heavier than that of the Earth.
- Saturn appears yellowish in color.
- Saturn has rings around it.
- Saturn is the least dense among all the planets (even water is denser than Saturn).
- Like Venus, Uranus also rotates from east to west.
- The most significant feature of Uranus is that it has highly tilted rotational axis.
- There is a large gap between the orbits of Mars and Jupiter; it is filled with some objects known as '**asteroids**' and this region is known as asteroid belt (see the image given below).



- A Comet appears usually as a bright head with a long tail and the length of the tail grows in size as it approaches towards the sun (see image given below).



- Halley’s comet appears after (nearly) every 76 years; last seen in 1986.

- A **meteor** is typically a small object that occasionally enters the earth’s atmosphere.

- Meteors are commonly known as **shooting stars**.

- Some meteors are very large and they reach the Earth before they evaporate completely.

- The meteor that reaches the Earth is known as **meteorite**.

25. STARS AND THE SOLAR SYSTEM

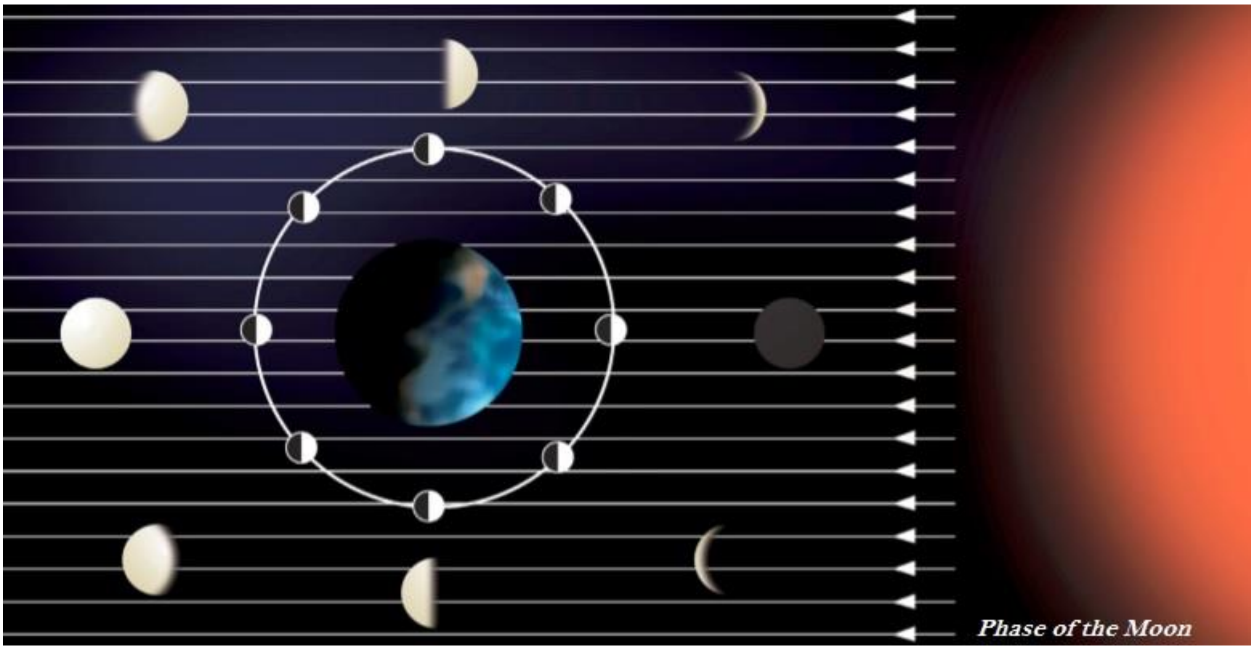
Introduction

- The stars, the planets, the moon, and many other objects in the sky are known as **celestial objects**.

The Moon

- The moon is visible in different shape at different point of time; it happens because of the sunlight falling on it and subsequently gets reflected towards the earth.

- The various shapes of the bright part of the moon as seen at different point of time are known as **phases of the moon** (as shown in the image given below).



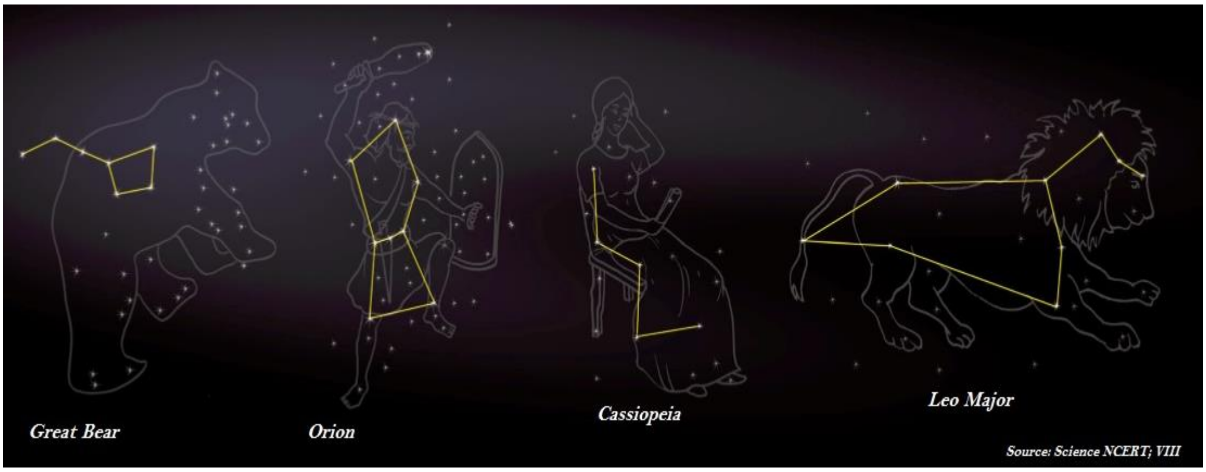
- For the first time, the American astronaut, Neil Armstrong, landed on the moon on July 21, 1969.

- The moon's surface is dusty and barren and have many craters of different sizes (as shown in the image given below).

- The moon has a large number of steep and high mountains.
- The moon has no atmosphere.

The Stars

- From the earth, stars are millions of times farther away than the Sun.
- The stars forming a group that has a distinguishable shape is known as **constellation**.
- The shapes of many of the constellations resemble with familiar objects (as shown in the image given below).



- **Orion** is a recognized constellation that can be seen during winter in the late evenings.

- It also has seven or eight bright stars (see the image given above) and known as the **Hunter**.

- The three middle stars are recognized as the belt of the hunter and the four bright stars appear to be arranged in the shape of a quadrilateral.