IMAMIA PUBLIC HIGH SCHOOL
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EDUCATIONAL TRUST KASHMIR

Light Reflection and Refraction

Reflection of Light: The phenomenon of bouncing back of light into the same medium by the smooth surface is called reflection.

Incident light: Light which falls on the surface is called incident light.

Reflected light: Light which goes back after reflection is called reflected light.

The angle of incidence: The angle between the incident ray and the normal.

An angle of reflection: The angle between the reflected ray and the normal.

Mirror: The surface which can reflect the light is a mirror.

Plane Mirror: If the reflecting surface is a plane then the mirror is plane.

Spherical Mirror: If the reflecting surface is part of the hollow sphere then the mirror is a spherical mirror.
The spherical mirror is of two types:

- **Convex mirror:** In this mirror reflecting surface is convex. It diverges the light so it is also called a diverging mirror.
- **Concave mirror:** In this mirror reflecting surface is concave. It converges the light so it is also called converging mirror.

Parameters of Mirror:

- Center of Curvature: The centre of hollow sphere of which mirror is a part.
- The radius of curvature: The radius of hollow sphere of which mirror is a part.
- Pole: The centre of mirror (middle point) is pole.
- Principal axis: The line joining the pole and center of curvature is called principal axis.
- Aperture: Size of mirror is called aperture of mirror.
- Principal Focus: The point on the principal axis, where all the incident rays parallel to principal axis converge or diverge after reflection through mirror.
- Focal Length: The distance between pole and focus point is focal length.

Special Rays for Formation of Image:

- A ray of light which is parallel to the principal axis of a spherical mirror, after reflection converges or diverges from focus.
- A ray of light passing through or appearing from the center of curvature of spherical mirror is reflected back along the same path.

- A ray of light passing through or appearing from the focus of spherical mirror becomes parallel to the principal axis.
- A ray of light which is incident at the pole of a spherical mirror is reflected back making same angle with principal axis.

Use of Concave Mirror: It is used as a makeup mirror, the reflector in torches, in headlights of cars and searchlights, doctor's head-mirrors, solar furnace, etc.

Sign Conventions of Spherical Mirror

- All the distances are measured from the pole of the mirror as the origin.
- Distances measured in the direction of incident rays are taken as positive.
- Distances measured opposite to the direction of incident rays are taken as negative.
- Distances measured upward and perpendicular to the principal axis are taken as positive.
- Distances measured downward and perpendicular to the principal axis are taken as negative.

  $1f=1v+1u$ …where f, v and u are focal length, image distance, object distance

Linear Magnification: This is the ratio of the height of the image to the height of the object.
$m=h'h$ …where m = magnification, h = height of image, h' = height of object
Use of Convex Mirror: Convex mirror used as rear view mirror in vehicles, as shop security mirrors, etc.

REFRACTION

Refraction of Light: The bending of light at the interface of two different mediums is called Refraction of light.

- If the velocity of light in medium is more, then medium is called optical rarer. Example, air or vacuum is more optical rarer.
- If the velocity of light in medium is less, then medium is called optical denser. Example, glass is more denser than air.

Refractive Index: It represents the amount or extent of bending of light when it passes from one medium to another.
There are two types of refractive index

- Relative refractive index and
- Absolute refractive index.

Refractive index of medium with respect to other medium is called Relative Refractive Index.
Refractive index of medium 1 with respect to medium 2 = Speedoflightinmedium2(V2) Speed of light in medium 1(V1)
Refractive index of medium with respect to air or vacuum is called Absolute Refractive Index.
Absolute refractive index of medium (m) = Speed of light in air(c) / Speed of light in medium (Vm)
Incident ray: It is incoming ray on the refracting surface.

Refracted ray: It is an outgoing ray from the refracting surface.

An angle of incidence (i): It is the angle between incident rays and perpendicular line (normal) at the point of incidence.

An angle of refraction (r): It is the angle between refracted rays and perpendicular line (normal) at the point of incidence.

Law of Refraction: According to this law

- "The incident ray, refracted ray and normal at the point of incidence all lie in the same plane."
- "The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant."
  $\sin i / \sin r$ = constant (μ)

Lens: The transparent refracting medium bounded by two surfaces in which at least one surface is curved is called lens.
Lenses are mainly two type

- Convex lens and
- Concave lens.

Centre of Curvature: The centres of two spheres, of which lens is part is called the centre of curvature.

Radii of Curvature: The radii of spheres, of which lens is part is called radius of curvature.

Principal Axis: The line joining the centres of curvature of two surfaces of lens is called principal axis.

Optical Center: It is a special point on the principal axis. Light incident on the optical centre passes through the lens without deviation.

Principal Focus: The point on the principal axis at which all incident rays parallel to the principal axis converge or appear to diverge after refraction through the lens.

Special Rays for Image Formation by Lens:

- An incident ray, parallel to the principal axis, after refraction passes through (or appears to come from), second focus of the lens.
- An incident ray, passing through the optical center of the lens, goes undeviated from the lens.
- An incident ray, passing through the (first) principal focus of the lens, or directed toward it, becomes parallel to the principal axis after refraction through lens.

Use of Lens: In photographic cameras, magnifying glass, microscope, telescope, the human eye.

1. Light travels in a straight line.

2. Light gets reflected when it falls on polished surfaces; like mirrors.

3. Light suffers refraction when it travels from one medium to another.

4. There is a change in the wave lengths of !light when it moves from one medium into another.

5. The bouncing back of light when it strikes a smooth or polished surface is called reflection of light. Reflection is of two types; Specular or regular and Diffuse or irregular reflection.

6. The angle of incidence is equal to the angle of reflection. Mathematically, we have $\angle i = \angle r$.

7. The image is as far behind the mirror as the object is in front.

8. The image is unmagnified, virtual and erect.

9. The image has right-left reversal.

10. Focal length of a plane mirror is infinity.

11. Power of a plane mirror is zero.

12. If a plane mirror is turned by an angle, the reflected ray turns by 2θ.

13. The least size of a plane mirror to view an object is equal to half the size of the object.

14. Pole (Vertex): The central point of a mirror is called its pole.

15. Centre of curvature: The centre of the sphere of which the mirror is a part is called the centre of curvature. It is denoted by C.

16. Radius of curvature: The radius of the sphere of which the mirror is a part is called the radius of curvature. It is denoted by R.

17. Principal axis: The straight line passing through the pole and the centre of curvature of the mirror is called the principal axis.

18. Principal focus: It is a point on the principal axis at which the rays parallel to the principal axis meet after reflection or seem to come from. For a concave mirror, the focus lies in front of the

mirror and for a convex mirror, it lies behind the mirror.
In short, a concave mirror has a real focus while a convex mirror has a virtual focus.

19. Focal plane : A plane, drawn perpendicular to the principal axis and passing through the principal focus.

20. Focal length : The distance between the pole and the focus is called the focal length. It is represented by f. The focal length is half the radius of curvature.

21. Aperture: The size of the mirror is called its aperture. It is also defined as the effective diameter of the light reflecting area of the mirror.

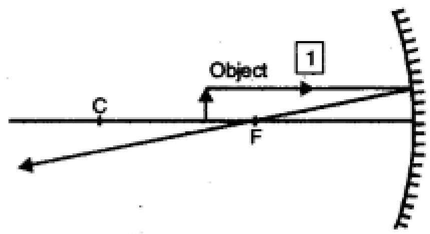
22. Real image : When the rays of light, after reflection from a mirror, actually meet at a point, then the image formed by these rays is said to be real. Real images can be obtained on a screen.

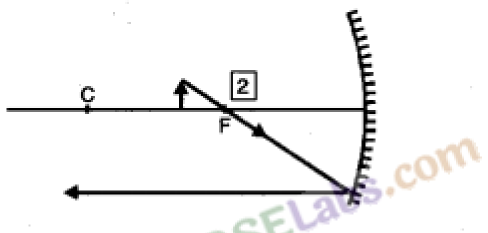
23. Virtual image: When the rays of light, after reflection from a mirror, appear to meet at a point, then the image formed by these rays is said to be virtual. Virtual images can't be obtained on a screen.

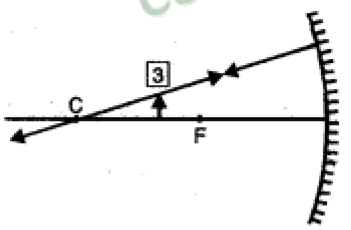
24. The following rays are used while drawing ray diagrams to find the position of an image :

- A ray of light parallel to the principal axis after reflection passes through the focus. (1)
- A ray of light passing through the focus after reflection becomes parallel to the principal axis. (2)
- A ray of light incident on the centre of curvature retraces its path after reflection form the mirror.

(3)







25. For mirrors, the following results hold :
u is – ve, if the object is in front of the mirror.
(Real object)
u is + ve, if the object is behind the mirror.
(Virtual object)
v is – ve, if the image is in front of the mirror.
(Real image)
vis +ve, if the image is behind the mirror.
(Virtual image)
Focal length of a concave mirror is taken as – ve. Focal length of a convex mirror is taken as +ve.

26. When the image formed by a spherical mirror is real, it is also inverted and is on the same side of the mirror as the object. Since both v and u are negative, the magnification is negative.

27. When the image formed by a spherical mirror is virtual, it is also erect and is on the other side of the mirror as the object. In this case, u is – ve and v is + ve , therefore, m is positive.

28. The expression for the mirror formula is 1/u+1/v = 1/f

29. Linear magnification is given by the expression

$$m = \frac{v}{u} = \frac{h_i}{h_o}$$

30. If m is positive, the image is erect w.r.t the object and if m is negative, the image is inverted w.r.t. the object.

31. The position of the image for various positions of the object for a concave mirror is as shown in the table below. The table also shows the use of the mirror for different positions of the object.

S.No.	Position of object	Position of image	Nature of image	Uses
1.	Between the pole and the principal focus	Behind the mirror	Virtual, erect and magnified	Shaving mirror, dentist mirror
2.	At the principal focus	At infinity	Extremely magnified	In torches, head lights
3.	Between focus and the centre of curvature	Beyond centre of curvature	Real, inverted and bigger than object.	In flood lights
4.	At the centre of curvatrue	At the centre of curvature	Real, inverted and equal to the size of the object	Reflecting mirror for projector lamps
5.	Beyond the centre of curvature	Between the principal focus and centre of curvature	Real, inverted and diminished	
6.	At infinity	At the principal focus or in the focal plane	Real, inverted and extremely diminished in size	To collect heat radiations in solar devices

The position of the image for various positions of the object for a convex mirror is as shown in the table below. The table also shows the use of the mirror for different positions of the object.

S.No.	Position of object	Position of image	Nature of image	Uses
1.	At infinity	Appears at the principal focus	Virtual, erect and extremely diminished	Used as a rear view mirror
2.	Between infinity and the pole	Appears between the principal focus and the pole	Virtual, erect and diminished	Used as a rear view mirror

32. The bending of light when it travels from one medium into another is called refraction of light

33.

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in the medium}} = \frac{c}{v}$$

34. As light travels from ,one medium to another, the frequency of light does not change.

35. Light refracts because it has different speeds in different media.

36. The refraction of light obeys the following two laws :

- The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.
- The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This
  constant is called the index of refraction or refractive index.
  Mathematically, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$

37. If ${}_{w}n_{g}$ is the refractive index of glass w.r.t. water, ${}_{a}n_{g}$ be the refractive index of glass w.r.t. air and ${}_{a}n_{w}$ be the refractive index of water w.r.t. air ,then

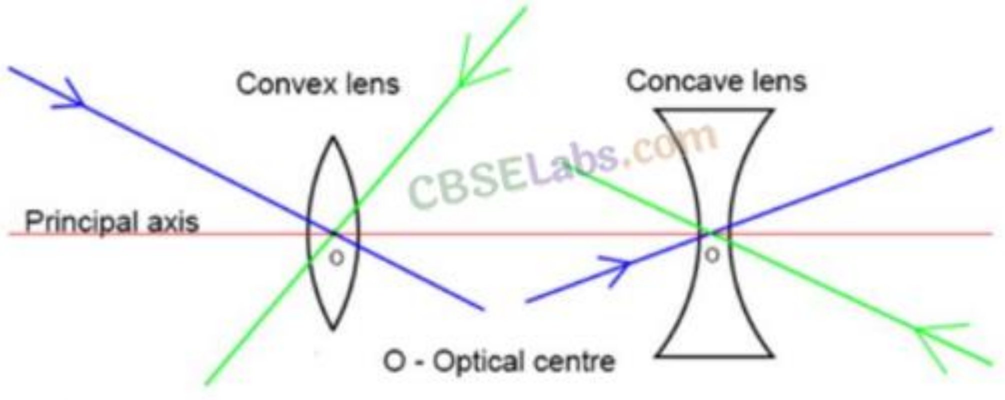
$${}_{w}n_{g} = \frac{{}_{a}n_{g}}{{}_{a}n_{w}}$$

38. The most familiar and widely used optical device is the lens. A lens is an optical system with two refracting surfaces. The simplest lens has two spherical surfaces close enough together that we can neglect the distance between them. Such a lens is called a thin lens. The two common types of lenses are Converging lens or Convex lens, Diverging lens or Concave lens.

39. It should be noted that, if the above lenses are surrounded by .a material with a refractive index greater than that of the lens, the convex lens gets converted into a concave lens and vice-versa.

40. Any lens that is thicker at its centre than at its edges is a converging lens with positive f, and any lens that is thicker at its edges than at the centre is a diverging lens with negative f.

41. Optical centre : The central point C in the lens is called the optical centre. If a ray is incident towards the optical centre, it passes undeviated .through the lens.

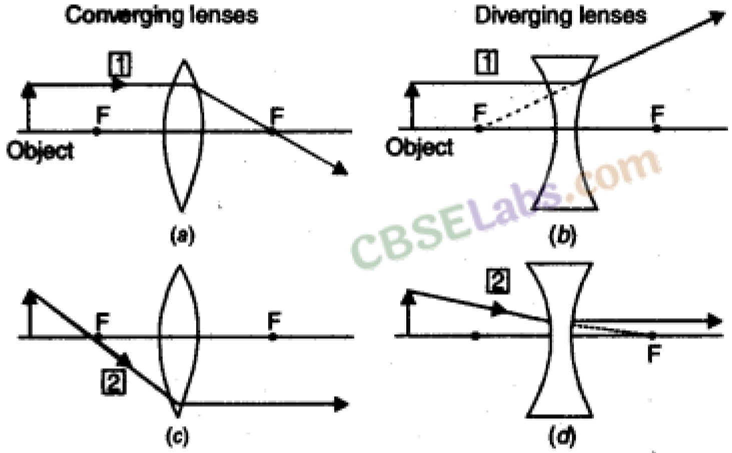


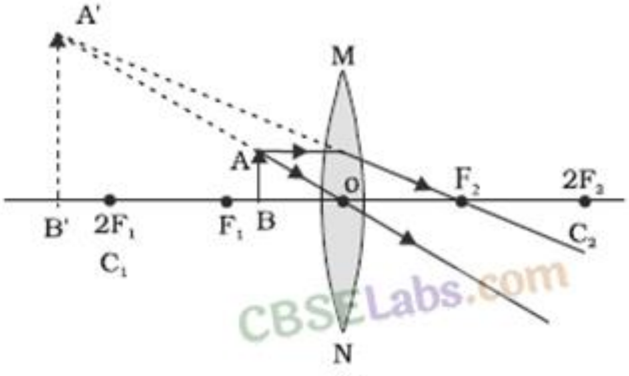
42.Principal axis: Since the lens contains two spherical surfaces, therefore, it has two centres of curvatures.
The line joining these centres and passing through the optical centre is called principal axis.

43. Aperture: The effective width of a lens through which refraction takes place is called the aperture.

44. Focus and Focal Length : If a beam of light moving parallel to the principal axis of a convex lens is incident on it, the rays converge or meet at a point on the principal axis. This point F is called the focus. The distance CF is called the focal length. If a beam of light moving parallel to the principal axis is incident on a concave lens, the beam of light diverges. If these diverged rays are produced backward, they meet at a point F on the principal . axis. The transmitted rays appear to come from this point. This point F is called the focus and distance CF is called the focal length.

45. For drawing the ray diagrams, we note the following :





(f)

- All rays parallel to the principal axis after refraction pass through the principal focus or seem to come from it.
- A ray of light passing through the focus after refraction becomes parallel to the principal axis.
- A ray of light passing through the optical centre of the lens after refraction passes undeviated.

46. A convex and a concave lens can be supposed to be made-up of prisms.

47. Image formation by a concave lens.

S.No.	Position of object	Position of image	Nature of image	Uses
1.	At infinity	Appears at the principal focus on the same side as that of the object	Virtual, erect and extremely diminished	Spectacles for short sightedness
2.	Between infinity and the lens	Appears between the principal focus and the lens	Virtual, erect and diminished	Spectacles for short sightedness

48. Image formation by a convex lens.

S.No.	Position of object	Position of image	Nature of image	Uses
1.	At infinity	At the principal focus or in the focal plane	Real, inverted and extremely diminished in size	Telescopes
2.	Beyond 2F	Between F and 2F	Real, inverted and diminished	In a camera, In eye while reading
3.	At 2F	At 2F	Real, inverted and equal to the size of the object	Photocopier
4.	Between F and 2F	Beyond 2F	Real, inverted and bigger than object	Projector, microscope objective
5.	At the principal focus	At infinity	Real, inverted and extremely magnified	Spotlights
6.	Between the optical centre and the principal focus	On the same side as that of object	Virtual, erect and magnified	Magnifying glass, eye lenses spectacles for short sightedness

49. New Cartesian sign conventions :

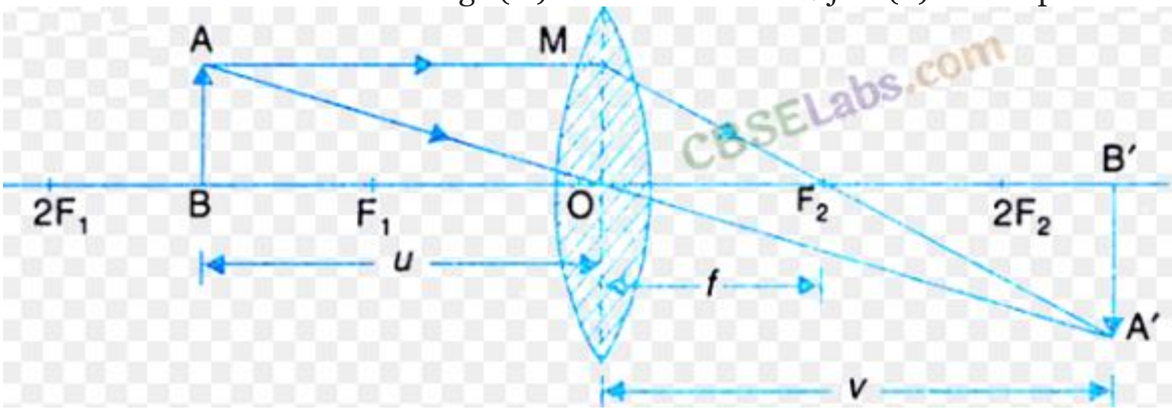
- All distances, object distance (u), image distance (v) and focal length f are measured from the optical centre.
- The distances measured in the direction of incident ray are taken as positive and distances measured against the direction of incident ray are taken as negative.
- All distances (heights) of objects and images above principal axis are taken as positive and those below the principal axis are taken as negative.

50. For the two lenses, the sign conventions take the form

- u is- ve, if the object is in front of the lens. (Real object)
- u is +ve, if the object is virtual.
- v is – ve, if the image is on the same side as that of the object. (Virtual image)
- v is +ve, if the image is real.
- Focal length of a concave lens is taken as – ve.
- Focal length of a convex lens is taken as +ve.

51. Lens formula for convex lens $1/v-1/u = 1/f$

52. The linear magnification produced by a lens is defined as the ratio of the size of the image (h’) to the size of the object (h). It is represented by m i.e.,



53. If the magnification of a lens is negative, then the image formed is inverted and real.

54. If the magnification of a lens is positive, then the image formed is erect and virtual.

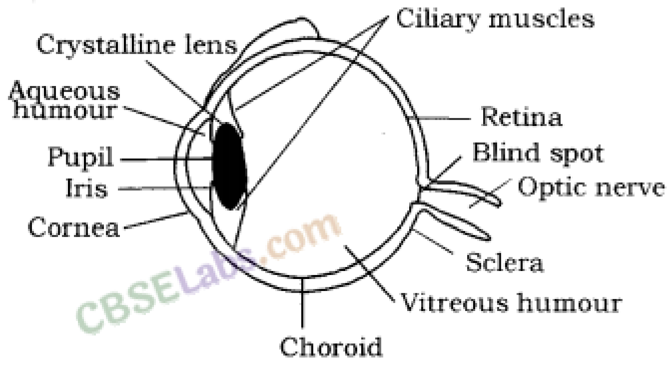
55. Power is defined as the reciprocal of the focal length. Power is measured in dioptre.

Human Eye and Colourful World

Human Eye: working of human eye, Persistence of vision, Power of accommodation of human eye, Defects of vision.

The Human Eye: It is a natural optical instrument which is used to see the objects by human beings. It is like a camera which has a lens and screen system.

Structure of the Human Eye



The various parts of eye and their functions :

- Retina: It is a light sensitive screen inside the eye on which image is formed. It contains rods and cones.
- Cornea: It is a thin membrane which covers the eye trail. It acts like a lens which refracts the light entering the eye.
- Aqueous humour: It is fluid which fills the space between cornea and eye lens.
- Eye lens: It is a convex lens made of transparent and flexible jelly like material. Its curvature can be adjusted with the help of ciliary muscles.
- Pupil: It is a hole in the middle of iris through which light enters the eye. It appears black because light falling on it goes into the eye and does not come back.
- Ciliary muscles: These are the muscles which are attached to eye lens and can modify the shape of eye lens which leads to the variation in focal lengths.
- Iris: It controls the amount of light entering the eye by changing the size of the pupil.
- Optical nerve: These are the nerves which take the image to the brain in the form of electrical signals.

The human eye is roughly spherical in shape with a diameter of about 2.3 cm. It consists of a convex lens made up of living tissues. Hence, human lenses are living organs contrary to the simple optical lenses. The following table lists the main parts of the human eye and their respective functions.

S.No.	**Human Eye Part**	**Functions**
1.	Pupil	Opens and closes in order to regulate and control the amount of light.

2.	Iris	Controls light level similar to the aperture of a camera.
3.	Sclera	Protects the outer coat.
4.	Cornea	A thin membrane which provides 67% of the eye's focusing power.
5.	Crystalline lens	Helps to focus light into the retina.
6.	Conjunctive	Covers the outer surface (visible part) of the eye.
7.	Aqueous humour	Provides power to the cornea.
8.	Vitreous humour	Provides the eye with its form and shape.
9.	Retina	Captures the light rays focussed by the lens and sends impulses to the brain via the optic nerve.
10.	Optic nerve	Transmits electrical signals to the brain.

11.	Ciliary muscles	Contracts and extends in order to change the lens shape for focusing.

How Pupil Works?
For Example, You would have observed that when you come out of the cinema hall after watching the movie in the bright sunlight, your eyes get closed. And when you entered the hall from the bright light, you won't be able to see and after some time you would be able to see. Here, the pupil of an eye provides a variable aperture, whose size is controlled by iris.
(a) When the light is bright: Iris contracts the pupil, so that less light enters the eye.
(b) When the light is dim: Iris expands the pupil, so that more light enters the eye.
Pupil opens completely when iris is relaxed.

Persistence of Vision: It is the time for which the sensation of an object continue in the eye. It is about 1/16th of a second.

Power of Accommodation: The ability of the eye lens to adjust its focal length accordingly as the distances is called power of accommodation.

Ciliary muscles

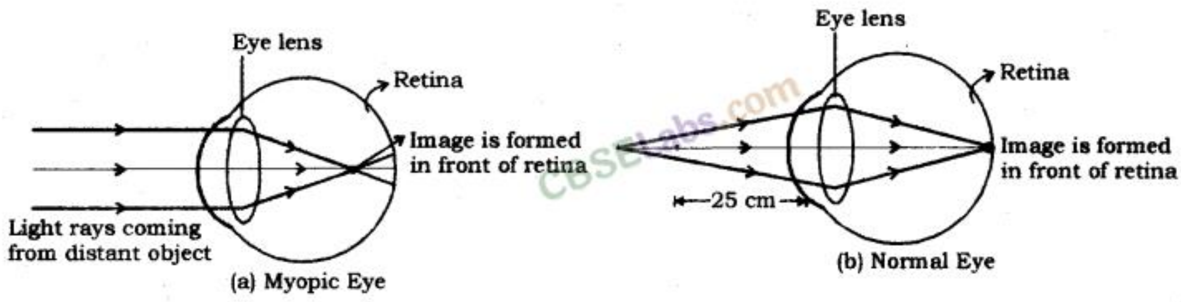
Relaxed	Contract
1. Eye lens become thin.	1. Eye lens become thick.
2. Increases the focal length.	2. Decreases the focal length.
3. Enable us to see distant object clearly.	3. Enable us to see nearby object clearly.

Near point of the Eye	Far point of the Eye
It is 25 cm for normal eye. The minimum distance at which object can be seen most distinctly without strain.	It is infinity for normal eye. It is the farthest point upto which the eye can see object clearly.

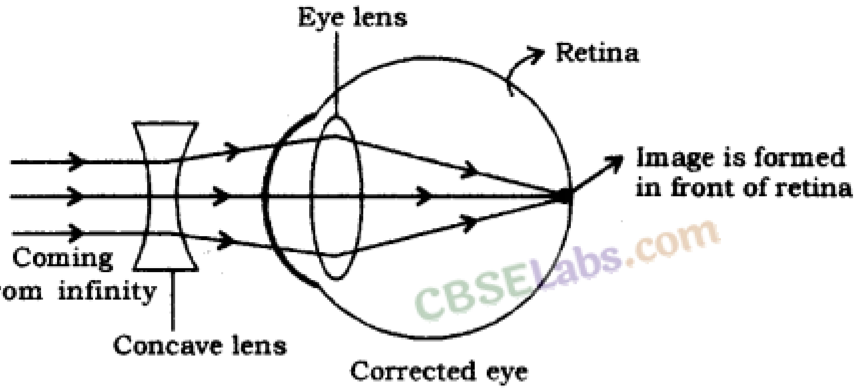
Colour Blindness: A person having defective cone cells is not able to distinguish between the different colours. This defect is known as Colour Blindness.

Defects of Vision and their Correction
Myopia (Short-sightedness): It is a kind of defect in the human eye due to which a person can see near objects clearly but he cannot see the distant objects clearly. Myopia is due to
(i) excessive curvature of the cornea.

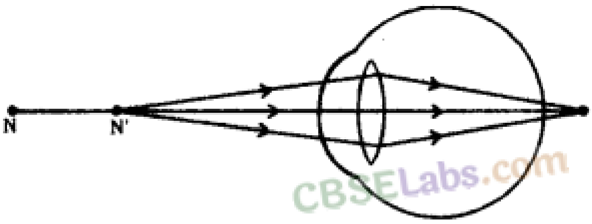
(ii) elongation of eyeball.



Correction: Since a concave lens has an ability to diverge incoming rays, it is used to correct this defect of vision. The image is allowed to format the retina by using a concave lens of suitable power as shown in the given figure.



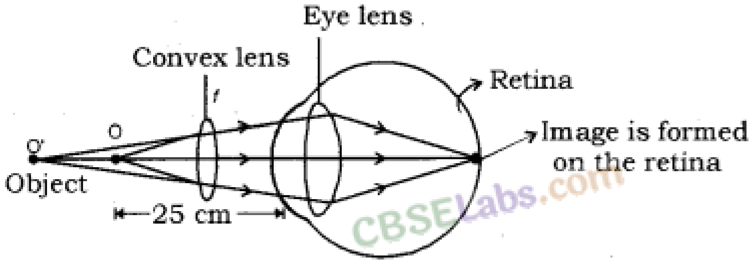
Hypermetropia (Long-sightedness): It is a kind of defect in the human eye due to which, a person can see distant objects properly but cannot see the nearby objects clearly. It happens due to
(i) decrease in the power of eye lens i.e., increase in focal length of eye lens.
(ii) shortening of eyeball.



Hypermetropic eye

A hypermetropic eye has its least distance of distinct vision greater than 25 cm.
Correction: Since a convex lens has the ability to converge incoming rays, it can be used to correct this defect of vision, as you already have seen in the animation. The ray diagram for the

corrective measure for a hypermetropic eye is shown in the given figure.



Power of the correcting convex lens:
The Lens formula, 1v−1u=1f can be used to calculate the focal length and hence, the power of the myopia correcting lens.
In this case,
Object distance, u = ∞
Image distance, v =
person's far point Focal length, f =?
Hence, lens formula becomes

$$\frac{1}{\text{far point}} - \frac{1}{\infty} = \frac{1}{\text{focal length}}$$

$$\frac{1}{\text{far point}} - 0 = \frac{1}{\text{focal length}}$$

In case of a concave lens, the image is formed in front of the lens i.e., on the same side of the object.
Focal length = -Far point
Now, power of the required lens (P) = 1f(inm)

Power of the correcting convex lens: Lens formula, 1v−1u=1f can be used to calculate focal length f and hence, power P of the correcting convex lens, where,
Object distance, u = -25 cm, normal near point
Image distance, v = defective near point
Hence, the lens formula is reduced to
1v+125=1f

Presbyopia: It is a kind of defect in human eye which occurs due to ageing. It happens due to the following reasons
(i) decrease in flexibility of eye lens.
(ii) gradual weakening of ciliary muscles.
In this, a person may suffer from both myopia and hypermetropia.

Correction: By using a bifocal lens with appropriate power. Bifocal lenses consist of both concave and convex lens, upper position consists of the concave lens and lower portion consists of a convex lens.

Astigmatism: It is a kind of defect in human eye due to which a person cannot see (focus) simultaneously horizontal and vertical lines both.

Correction: By using a cylindrical lens.

Cataract: Due to the membrane growth over eye lens, the eye lens becomes hazy or even opaque. This leads to a decrease or loss of vision. This problem is called a cataract. It can be corrected only by surgery.

Refraction of light through a prism, Dispersion of white light by a glass prism, Composition of white light, Recombination of spectrum colours, Rainbow.

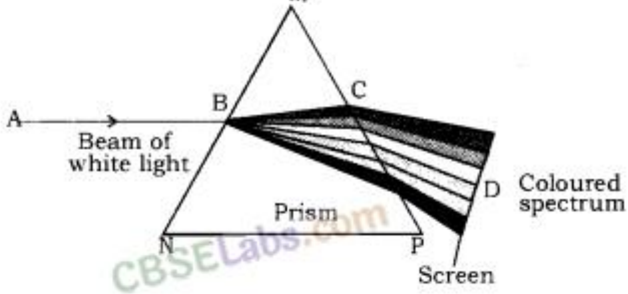
Refraction of light through a prism: When a ray of light is incident on a rectangular glass slab, after refracting through the slab, it gets displaced laterally. As a result, the emergent ray comes out parallel to the incident ray.
Unlike a rectangular slab, the side of a glass prism are inclined at an angle called the angle of prism.

Prism: A prism has two triangular bases and three

Angle of Prism: Angle between two lateral faces is

Angle of Deviation: The angle between the incident deviation.

Dispersion of white light by a glass prism: The phenomenon of splitting of white light into its seven constituent colours when it passes through a glass prism is called dispersion of white light. The various colours seen are Violet, Indigo, Blue, Green, Yellow, Orange and Red. The sequence of colours remembers as VIBGYOR. The band of seven colours is called the spectrum. The different component colour of light bends at a different angle with respect to the incident angle. The violet light bends the least while the red bends most.



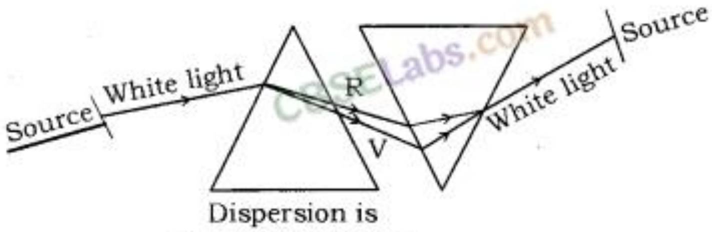
Composition of white light: White light consists of seven colours i.e., violet, indigo, blue, green, yellow, orange and red.

Monochromatic light: Light consisting of single colour or wavelength is called monochromatic light, example; sodium light.

Polychromatic light: Light consisting of more than two colours or wavelengths is called polychromatic light, example; white light.

Recombination of white light: Newton found that when an inverted prism is placed in the path of dispersed light then after passing through the prism, they recombine to form white light.

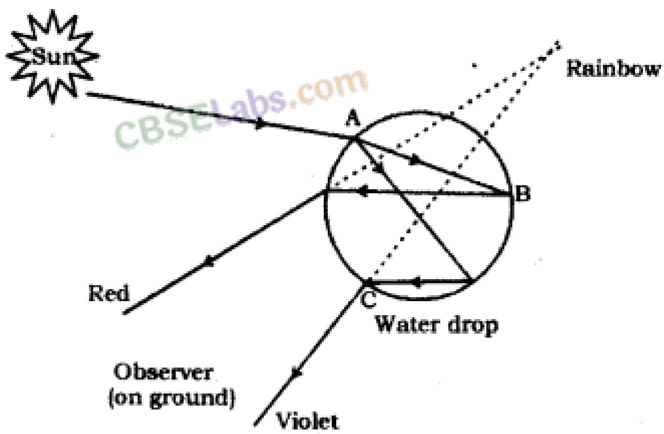
Issac Newton: He was the first, who obtained spectrum of sunlight by using glass prism. He tried to split the spectrum of white light more by using another similar prism, but he could not get any more colours.
He repeated the experiment using second prism in inverted position with respect to the first prism. It allowed all the colours of spectrum to pass through second prism. He found white light emerges on the other side of second prism.



He concluded that Sun is made up of seven visible colour VIBGYOR.

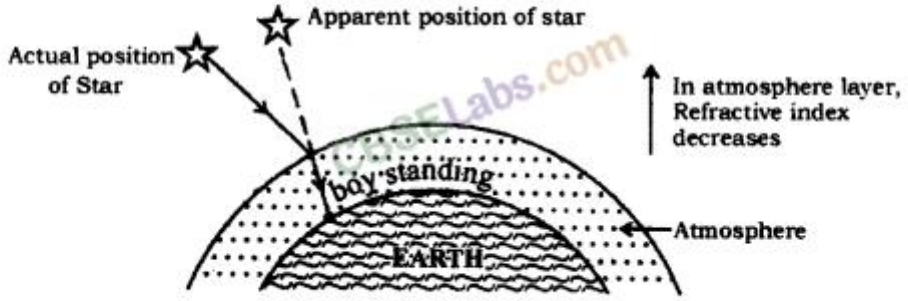
Rainbow: It is the spectrum of sunlight in nature. It is formed due to the dispersion of sunlight by the tiny water droplet, present in the atmosphere.

Formation of the rainbow: The water droplets act like small prism. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's eye.
Red colour appears on top and violet at the bottom of rainbow.
A rainbow is always formed in a direction opposite to that of Sun.
At 'A' – Refraction and dispersion take place.
At 'B' – Internal reflection takes place.
At 'C' – Refraction and dispersion take place.

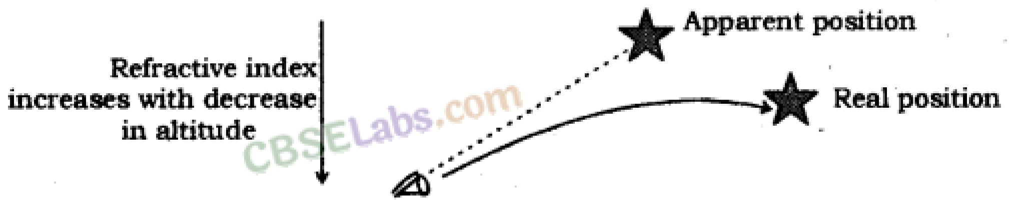


Atmospheric Refraction: The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is called Atmospheric Refraction.

Appearance of Star Position: It is due to atmospheric refraction of star light.
The temperature and density of different layer of atmosphere keeps varying. Hence, we have different medium.
Distant star act as point source of light. When the starlight enter the Earth's atmosphere, it undergoes refraction continuously, due to changing refractive index i.e. from Rarer to denser. It bends towards the normal.
Due to this, the apparent position of the star is different from actual position. The star appear higher than its actual position.



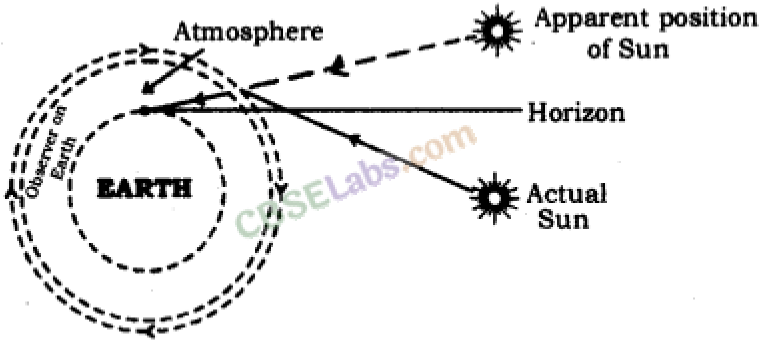
Twinkling of Star: It is also due to atmospheric refraction.
Distant star act like a point source of light. As the beam of starlight keeps deviating from its path, the apparent position of star keeps on changing because physical condition of earth's atmosphere is not stationary.
Hence, the amount of light enters our eyes fluctuate sometimes bright and sometime dim. This is the "Twinkling effect of star".



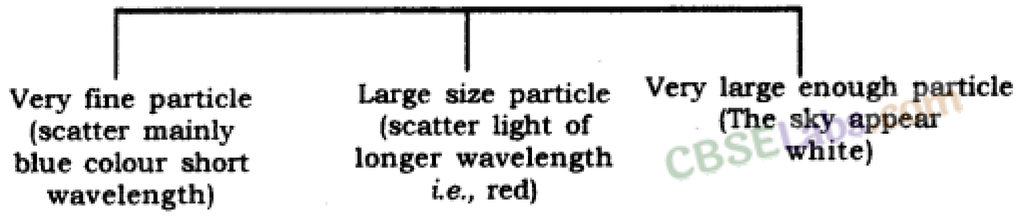
Why planets do not twinkle ?
Planets are closer to earth and are seen as extended source of light i.e. the collection of large number of point sized sources of light. Therefore the total amount of light entering our eyes from all individual point source will nullify the twinkling effect.

Why, the duration of day becomes approximately 4 minutes shorter if there is no atmosphere on earth: Actual sun rise happens when it is below the horizon in the morning. The rays of light from the sun below the horizon reach our eyes because of refraction of light. Similarly, the sun can be seen about few minutes after the actual sun set. Thus the duration of, day time will increase by 4 minutes.
This is due to atmospheric refraction. Because of this sun is visible about 2 minutes earlier than actual sunrise and about 2 minutes after the actual sun set.

Apparent flattering of the Sun's disc at sunset and sunrise is due to atmospheric refraction.



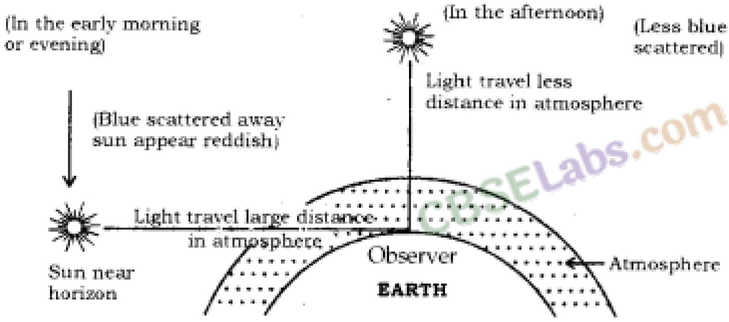
Scattering of light: According to Rayleigh' Law of Scattering, the amount of scattered light $\propto 1\lambda_4$ (λ = wavelength)
Scattering of light decreases with increase in wavelength.
Tyndall Effect: When a beam of light strikes, the minute particle of earth's atmosphere, suspended particles of dust and molecule of air the path of beam become visible. The phenomenon of scattering of light by the colloidal particle gives rise to Tyndall Effect.
It can be observed when sunlight passes through a canopy of a dense forest.
The colour of the scattered light depends on the size of the scattering particles.



Colour of Sunrise and Sunset: While sunset and sunrise, the colour of the sun and its surroundihg appear red. During sunset and sunrise, the sun is near to horizon, and therefore, the sunlight has to travel larger distance in atmosphere. Due to this, most of the blue light (shorter wavelength) is scattered away by the particles. The light of longer wavelength (red colour) reaches our eye. This is why sun appear red in colour.

Why the danger signal or sign is made of red colour?
Red colour scatteres the most when strikes the small particle of fog and smoke because it has the maximum wavelength (visible spectrum). Hence, from large distance also, we can see the red colour clearly.

At noon sun appears white: At noon, the sun is overhead and sunlight would travel shorter distance relatively through the atmosphere. Hence, at noon, the sun appear white as only little of the blue and violet colours are scattered.



Human Eye: It is a wonderful gift of nature to the human body. Human eye is nearly spherical in shape of diameter about 2.5 cm.

Parts of Human Eye:

- **Cornea:** It is the protective and front layer of the eye. It is made by a transparent membrane. Light enters the eye through the cornea.
- **Iris:** Dark and a colourful muscular diaphragm is called iris. It is responsible for colour of the eye.
- **Pupil:** Small circular hole in the centre of iris. It regulates the amount of light entering the eye by adjusting the size of the iris.
- **Ciliary Muscles:** It holds the eye lens at its proper position. It changes the size of eye lens.
- **Eye lens:** The eye lens is a convex lens made by the transparent jelly like material.
- **Retina:** It is the screen of the eye. A real and inverted image form on the retina.
- **Rods and Cones:** These are colour sensitive rods and cones shaped cells. Rods are responsible for the vision in dim light while cones are responsible for colour.
- **Optic Nerve:** It converts information of the image into a corresponding electric signal and passes it to the brain.
- **Blind Spot:** The junction of the optic nerve and retina, where no rods and cones cells are present is called the blind spot. It is insensitive to light.

Near Point: The nearest point from eye at which the eye can see clearly without strain is called near point. For normal eye it is 25 cm.

Far Point: The farthest point, upto which the eye can see the object clearly is called far point. For normal eye it is infinity.

The range of Vision: Distance between near point and far point of eye is called range of vision.

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

Myopia (Near-sightedness): In this defect, the eye is unable to see far off objects clearly but is able to see near objects clearly.
Reason.

- Due to increase in size of eye ball
- Due to excessive curvature of cornea
- Due to increase in power (or decrease in focal length) of eye lens.

Correction: It is corrected by using concave lens of suitable focal length.

Hypermetropia (Far sightedness): In this defect eye is unable to see nearby objects clearly but is able to see far objects clearly.
Reason.

- Due to decrease in size of eye ball
- Due to decrease in power (or increase in focal length) of eye lens.

Correction: It is corrected by using a convex lens of suitable focal length.

Dispersion of Light: Splitting of white light into seven colours is called dispersion. Example, the formation of Rainbow (VIBGYOR). Violet deviates the most but red deviates least.

1. The human eye is one of the most valuable and sensitive sense organs. It enables us to see the wonderful world and the colours around us.

2. The eyeball is approximately spherical in shape with a diameter of about 2.3 cm.

3. Most of the refraction for the light rays entering the eye occurs at the outer surface of the cornea. The crystalline lens merely provides the finer adjustment of focal length required to focus.

4. The human eye has the following parts :

- **Cornea :** The transparent spherical membrane covering the front of the eye.
- **Iris:** The coloured diaphragm between the cornea and lens.
- **Pupil:** The small hole in the iris.
- **Eye lens :** It is a transparent lens made of jelly like material.
- **Ciliary muscles:** These muscles hold the lens in position.
- **Retina:** The back surface of the eye.
- **Blind spot:** The point at which the optic nerve leaves the eye. An image formed at this point is not sent to the brain.
- **Aqueous humour:** A clear liquid region between the cornea and the lens.
- **Vitreous humour:** The space between eye lens and retina is filled with another liquid called vitreous humour.

5. In the eye, the image is formed on the retina by successive refractions at the cornea, the aqueous humour, the lens and the vitreous humour. Electrical signals then travel along the optic nerve to the brain to be interpreted. In good light, the yellow spot is most sensitive to detail and the image is automatically formed there.

6. Accommodation: The ability of the eye to focus both near and distant objects, by adjusting its focal length, is called the accommodation of the eye or the ability of the ciliary muscles to change the focal length of the eye lens is called accommodation.

7. Defects of the Eye : Although the eye is one of the most remarkable organs in the body, it may have several abnormalities, which can often be corrected with eyeglasses, contact lenses, or surgery. The various defects from which an eye can suffer are (i) Hypermetropia or long sightedness, (ii) Myopia or short-sightedness and (iii) Astigmatism, (iv) Presbyopia.

8. Hypermetropia, hyperopia, or long sightedness : A person suffering from this defect can see distant objects I clearly but cannot see nearby objects clearly. In this defect, the near point lies farther away than 25 cm. Hypermetropia (far sightedness — the image of nearby objects is focussed beyond the retina) is corrected by using a convex lens of suitable power. The eye loses its power of accommodation at old age.

9. Hypermetropia is due to the following reasons :

- Either the hyperopic eyeball is too short or
- The ciliary muscle is unable to change the shape of the lens enough to properly focus the image i.e. the focal length of the eye lens increases.

10. Myopia or short sightedness or near sightedness: A person suffering from myopia or short sightedness can see nearby objects clearly but cannot see the far away objects clearly. Myopia (short sightedness — the image of distant objects is focussed before the retina) is corrected by using a concave lens of suitable power.

11. This defect is due to the following reasons :

- Either the eyeball is longer than normal or
- The maximum focal length (due to excessive curvature of the cornea) of the lens is insufficient to produce a clearly formed image on the retina.

12. A person may also have an eye defect known as astigmatism, in which light from a point-source produces a line image on the retina. A person suffering from this defect cannot see in all directions equally well i.e., he cannot see the vertical and horizontal lines simultaneously. This condition arises either when the cornea or the crystalline lens or both are not perfectly spherical. Astigmatism can be corrected with lenses having different curvatures in two mutually perpendicular directions i.e., cylindrical lens.

13. When a person suffers from both, the myopia as well as Hypermetropia, his spectacles for correction have bifocal lenses. The upper half is a concave lens for distant vision and lower half is a convex lens for reading.

14. Presbyopia is that defect of human eye, due to which an old person cannot read and write comfortably. That is why Presbyopia is also called old sight.

15. To correct Presbyopia, an old person has to use spectacles with a convex lens of suitable focal length, or power as explained already.

16. The cause of Hypermetropia is decrease in length of eyeball or increase In focal length of eye lens. But the cause of Presbyopia is only increase in focal length of eye lens. The eyeball, in Presbyopia, has normal length.
the vision of the eye decreases, leading sometimes to total loss of vision. The problem is overcome

by cataract surgery i.e., removal of the eye lens, and its replacement by a lens of suitable focal length.

18. We need two eyes because a human being has a horizontal field of view of about 150° with one eye and of about 180° with two eyes. Thus, two eyes provide us wider horizontal field of view. With one eye, the world looks flat, i.e., two dimensional only. With two eyes, the view is three dimensional, i.e., dimension of depth is added to our view.

19. As our two eyes are separated by a few centimetres, each eye observes a slightly different image. Our brain combines the two views into one and we get to know how close or far away the things seen are.

20. By donating our eyes after we die, one pair of our eyes can give vision to two corneal blind people. Eye donors may belong to any sex or any age group. People suffering from diabetes, hypertension, asthma or any other non- communicable diseases can donate eyes. People who have been using spectacles or those operated for cataract can also donate eyes.

21. The smallest distance, at which the eye can see objects clearly without strain, is called the near point of the eye or the least distance of distinct vision. For a young adult with normal vision, it is about 25 cm.

22. Persistence of vision of the eye: The image of an object persists on the retina for 1/16 second, even after the removal of the object. The sequence of still pictures taken by a movie camera is projected on a screen at a rate of about 24 images or more per second. The successive impressions of images on the screen appear to merge smoothly into one another to give us the feeling of moving images.

23. The large numbers of light sensitive cells contained in the retina of the eye are of two types: rod shaped cells which respond to brightness or intensity of light and cone shaped cells, which respond to colour of light. Thus/cone shaped cells enable us to distinguish between different colours.

24. When a person cannot distinguish between different colours, he is said to be colour blind though his vision may otherwise be normal. Colour blindness is a genetic disorder which occurs by inheritance. So far, there is no cure for colour blindness.

25. Far point: The farthest point upto which a short sighted eye can see clearly is called the far point of the eye. For a normal eye, the far point is infinity.

26. Near point : The nearest point upto which a long sighted eye can see clearly is called the near point of the eye. For a normal human eye, of an adult, the near point is about 25 cm from the eye.

27. Least cfistance of distinct vision: The minimum distance upto which an eye can see clearly is called the legist distance of distinct vision ; it is normally denoted by D. The least distance of distinct vision is equal to the distance between the eye and its near point. For a normal human eye, this distance is around 25 cm.

28. The distance between far point and near point of the eye is called range of vision of the eye.

29. When white light passes through a prism, the violet light bends most and the red light bends the least. Dispersion of light is the phenomenon of splitting of white light into its constituent seven colours on passing through a glass prism. The band of seven colours so obtained is called visible spectrum.

30. The seven colours of white light are violet, indigo, blue, green, yellow, orange and red. It is remembered by the acronym VIBGYOR.

31. Isaac Newton was the first to use a prism to obtain a spectrum of sunlight.

32. Spectrum is the band of distinct colours we obtain when white light is split by a prism.

33. Cause of dispersion : Every colour has its own characteristic wavelength/frequency. Different colours move with same speed in air/vacuum. But their speeds in refracting media like glass are different. Therefore, refractive index of the medium for different colours is different. As a result, different colours undergo different deviations on passing through the prism. Hence, different colours emerge from the prism along different directions.

34. The speed of light in vacuum is same for all wavelengths, but the speed in a material substance is different for different wavelengths.

35. In any medium other than air/vacuum red light travels the fastest and violet light travels the slowest.

36. The most familiar form of electromagnetic radiation may be defined as that part of the spectrum that the human eye can detect. Light is produced by the rearrangement of electrons in atoms and molecules. The various wavelengths of visible light are classified with colours ranging from violet ($\lambda = 4 \times 10^{-7}$ m) to red ($\lambda = 7 \times 10^{-7}$ m). The eye's sensitivity is a function of wavelength, the sensitivity being a maximum at a wavelength of about $\lambda = 5.6 \times 10^{-7}$ m (yellow-green).

37. When we pass white light through two ideptical prisms held side by side with their refracting edges in opposite directions; the first prism disperses white light into seven colours and the second prism recombines the seven colours into white light. Thus, light emerging from 2nd prism is white.

38. A rainbow is formed due to dispersion of light by tiny droplets of water which act as prisms.

39. Atmospheric refraction is the cause of twinkling of stars, advance sunrise and delayed sunset.

40. Scattering of light causes the blue colour of sky and the reddening of the Sun at sunrise and sunset.

Electricity

CHAPTER: 03 **CLASS:10TH**

Electric charge :- Electric Charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. There are two types of charges positive and negative charge (commonly carried by protons and electrons respectively). The proton has a charge of +e, and the electron has a charge of –e.

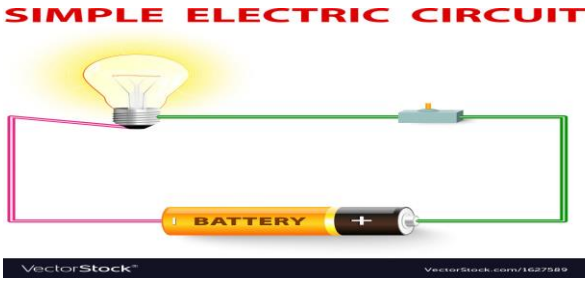
Charge: Like mass, the charge is the fundamental property of matter. There are two types of charge
(i) Positive charge.
(ii) Negative charge

Electricity: Electric current, electric circuit, voltage or electric potential, resistance and (Ohm's law).

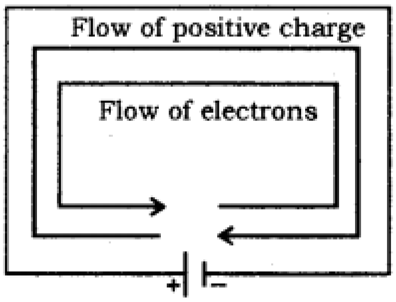
Electric Current: The flow of electric charge is known as Electric Current, Electric current is carried by moving electrons through a conductor.
By convention, electric current flows in the opposite direction to the movement of electrons.

Electric Circuit: Electric circuit is a continuous and closed path of electric current.

It is a closed path along which an electric current flow.



Expression of Electric Current: Electric current is denoted by the letter 'I'. Electric current is expressed by the rate of flow of electric charges. Rate of flow means, the amount of charge flowing through a particular area in unit time.



Conventional flow of electric charge.

If a net electric charge (Q) flows through a cross-section of a conductor in time t, then,

$$\text{Electric current (I)} = \frac{\text{Net charge (Q)}}{\text{Time } (t)} \quad \text{or,} \quad \boxed{I = \frac{Q}{t}}$$

Where I is electric current, Q is a net charge and t is a time in second.

S.I. Unit of Electric Charge and Current: S.I. unit of electric charge is coulomb (C).
One coulomb is nearly equal to 6×10^{18} electrons. S.I. unit of electric current is ampere (A).
Ampere is the flow of electric charge through a surface at the rate of one coulomb per second. This means, if 1 coulomb of electric charge flows through a cross section for 1 second, it would be equal to 1 ampere.
Therefore, 1 A = 1 C/1 s

Small Quantity of Electric Current: Small quantity of electric current is expressed in milliampere and microampere. Milliampere is written as mA and microampere as pA.
1 mA (milliampere) = 10^{-3} A
1 pA (microampere) = 10^{-6} A

Ammeter: An apparatus to measure electric current in a circuit..

Positive and Negative Charge: The charge acquired by a glass rod when rubbed with silk is called a positive charge and the charge acquired by an ebonite rod when rubbed with wool is called negative charge.

Properties of Electric Charge:
(i) Unlike charges attract each other and like charges repel each other.
(ii) The.force between two charges varies directly as the product of two charges and inversely as the square of the distance (r) between both charges (q_1 and q_2).

$$F \propto \frac{q_1 \times q_2}{r_2} \quad \Rightarrow \quad F = K\frac{q_1 \times q_2}{r_2}$$

K = constant

S.I. unit of charge is coulomb (C).
1 coulomb = 1 ampere × 1 second.
1C = 1A × 1s
Thus, the quantity of charge which flows through a circuit when one ampere of current flows through it in one second is known as a 1-coulomb charge.

Electric Potential and Potential Difference:

Electric Potential: The amount of electric potential energy at a point is called electric potential.
Potential Difference: The difference in the amount of electric potential energy between two points in an electric circuit is called electric potential difference.
Electric potential difference is known as voltage, which is equal to the amount of work done to move the unit charge between two points against static electric field.
Therefore, Voltage = Work done on Charge
Voltage or electric potential difference is denoted by V'. Therefore, V = WQ
Where, W = Work done and Q = Charge
S.I. Unit of Electric Potential Difference (Voltage)
S.I. unit of electric potential difference is volt and denoted by 'V' This is named in honour of Italian Physicist Alessandro Volta.

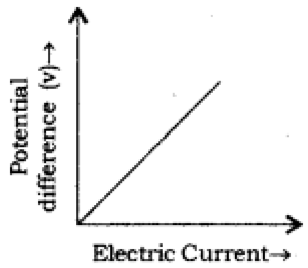
Since joule is the unit of work and Coulomb is the unit of charge, 1 volt of electric potential difference is equal to the 1 joule of work to be done to move a charge of 1 coulomb from one point to another in an electric circuit. Therefore
1V = 1Joule/1Coulomb = 1J/1C
$1V = 1JC^{-1}$

Voltmeter: An apparatus to measure the potential difference or electric potential difference between two points in an electric circuit.

Galvanometer: It is a device to detect current in an electric circuit.

<u>Ohm's Law</u>: Ohm's Law states that the potential difference between two points is directly proportional to the electric current, at a constant temperature.
This means potential difference V varies as electric current.
$V \propto I$
V = RI
I = VR
R = V/I
Where, R is constant for the given conductor at a given temperature and is called resistance.
Resistance: Resistance is the property of conductor which resists the flow of electric current through it.
S.I. unit of resistance is ohm. Ohm is denoted by Greek letter 'Q'

1 Ohm: 1 ohm (Q) of resistance (R) is equal to the flow 1A of current through a conductor between two points having a potential difference equal to 1V.
This means; 1Ω = 1V.1A
From the expression of Ohm's Law, it is obvious that electric current through a resistor is inversely proportional to resistance. This means electric current will decrease with an increase in resistance and vice versa. The graph of V (potential difference) versus I (electric current) is always a straight line.



Graph of Potential Difference (V) Vs Electric Current (I)
Voltage, i.e. Potential difference (V) = ?
We know, from Ohm's Law that,
R = VI
15 Ω = V15A
V = 225V

Resistance: Resistance is a property of conductor due to which it resists the flow of electric current through it. A component that is used to resist the flow of electric current in a circuit is called a resistor.
In practical application, resistors are used to increase or decrease the electric current.

Variable Resistance: The component of an electric circuit which is used to regulate the current, without changing the voltage from the source, is called variable resistance.

Rheostat: This is a device which is used in a circuit to provide variable resistance.

Cause of Resistance in a Conductor: Flow of electrons in a conductor is electric current. The positive particles of conductor create hindrance to flow of electrons, because of attraction between them, this hindrance is the cause of resistance in the flow of electricity.

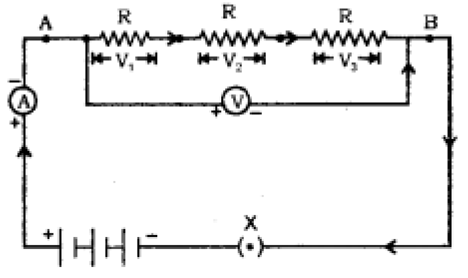
Factors on Which Resistance of a Conductor Depends: Resistance in a conductor depends on nature, length and area of cross section of the conductor.
(i) Nature of Material: Some materials create least hindrance and hence, are called good conductors. Silver is the best conductor of electricity. While some other materials create more hindrance in the flow of electric current, i.e. flow of electrons through them. Such materials are called bad conductors. Bad conductor are also known as insulators. Hard plastic is the one of the best insulators of electricity.

(ii) Length of Conductor: Resistance (R) is directly proportional to the length of the conductor. This means, resistance increases with increase in length of the conductor. This is the cause that long electric wires create more resistance to the electric current. Thus, Resistance (R) ∝ length of conductor (l)
or, $R \propto l$ ...(i)

(iii) Area of Cross Section: Resistance R is inversely proportional to the area of cross section (A) of the conductor. This means R will decrease with an increase in the area of conductor and vice versa. More area of conductor facilitates the flow of electric current through more area and thus, decreases the resistance. This is the cause that thick copper wire creates less resistance to the electric current.
Thus, resistance (R) ∝ 1/Area of cross section of conductor (A)

or, $R \propto lA$ ....(ii)
From equations (i) and (ii)
$R \propto lA$
$R = \rho\ lA$
Where, ρ (rho) is the proportionality constant. It is called the electrical resistivity of the material of conductor.
From equation (iii) $RA = \rho l \Rightarrow \rho = RAl$ ..(iv)
The S.I. of Resistivity: Since, the S.I. unit of R is Q, S.I. unit of area is m^2 and S.I. unit of length is m. Hence, unit of resistivity (ρ) = $\Omega \times m_2 m = \Omega m$
Thus, S.I. unit of resistivity (ρ) is Ωm.
Resistivity: It is defined as the resistance offered by a cube of a material of side 1m when current flows perpendicular to its opposite faces. It's S.I. unit is ohm-meter (Ωm).
Resistivity, $\rho = RA/L$
Resistivity is also known as specific resistance.
Resistivity depends on the nature of the material of the conductor.
Materials having a resistivity in the range of 10^{-8} Ωm to 10^{-6} Ωm are considered as very good conductors. Silver has resistivity equal to 1.60 × 10-8 Ωm and copper has resistivity equal to 1.62 × 10^{-8} Ωm.
Rubber and glass are very good insulators. They have a resistivity in the order of 10^{-12} Ωm to 10^{-8} Ωm.
The resistivity of materials varies with temperature.
Combination of resistors (Series and Parallel combination), the heating effect of electric current and electric power.
Combination of Resistors
(i) Series combination
(ii) Parallel combination.

1. **Resistors in Series:** A number of resistors are said to be in series if these are joined end to end and the same current (i.e., total) current flows through each one of them when a potential difference is applied across the combination.
   When resistors are joined from end to end, it is called in series. In this case, the total resistance of the system is equal to the sum of the resistance of all the resistors in the system.

   Let, three resistors R_1, R_2, and R_3 get connected in series.
   Potential difference across A and B = V
   Potential difference across R_1, R_2 and R_3 = V_1, V_2 and V_3
   Current flowing through the combination = I
   We, know that
   $V = V_1 + V_2 + V_3$ .... (i)
   According to Ohm's Law :
   $V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$ ..... (ii)
   Let, total resistance = Rs
   Then, $V = IR_s$ ...(iii)

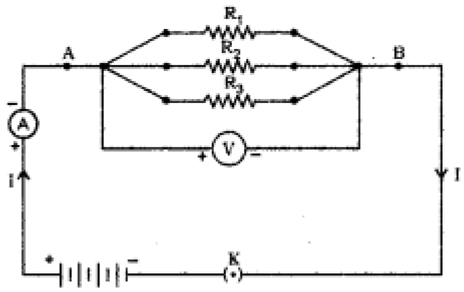
From equations (i) and (ii) and (iii)

$IR_s = IR_1 + IR_2 + IR_3$

$\mathbf{R_s = R_1 + R_2 + R_3}$

When the resistors are connected in series, the current flowing through each resistor is the same and is equal to the total current and the equivalent (resultant) resistance is equal to the sum of the individual resistances and is greater than any individual resistance.

2. **Resistors in Parallel:** A number of resistances are said to be connected in parallel if one end of each resistor is connected to one point and the other end is connected to another point so that the potential difference across each resistor is same and is equal to the applied potential difference b/w the two points.
When resistors are joined in parallel, the reciprocal of the total resistance of the system is equal to the sum of reciprocal of the resistance of resistors.



Let three resistors R_1, R_2 and R_3 connected in parallel.
Potential difference across point A and B = V
Total current flowing between point A and B = I
Currents flowing through resistors R_1, R_2 and R_3 = I_1, I_2 and I_3 respectively.
We, know that,

$\mathbf{I=I_1 +I_2 +I_3}$ **...............(i)**

Since, the potential difference across R_1, R_2, and R_3 is the same = V

according to ohms law

$$I_1 = \frac{V}{R_1},\ I_2 \frac{V}{R_2} \text{ and, } I_3 = \frac{V}{R_3} \quad ....(ii)$$

Let, Total Resistance = R_p

$$\text{Thus, } I = \frac{V}{R_p} \quad ...(iii)$$

From equations (*i*), (*ii*) and (*iii*)

$$\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \Rightarrow \quad \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad ...(iv)$$

In parallel combination, the potential difference across each resistor is the same and is equal to the total potential difference.
The total current through the circuit can be calculated by adding the electric current through individual resistors.
I total = 6A + 48A + 30A + 12A + 24A = 120A + ...

In parallel combination the equivalent resistance is lesser than the least of all the resistances.

Heating Effect of Electric Current: When electric current is supplied to a purely resistive conductor, the energy of electric current is dissipated entirely in the form of heat and as a result, resistor gets heated. The heating of resistor because of dissipation of electrical energy is commonly known as Heating Effect of Electric Current. Some examples are as follows : When electric energy is supplied to an electric bulb, the filament gets heated because of which, it gives light. The heating of electric bulb happens because of heating effect of electric current.

Cause of Heating Effect of Electric Current: Electric current generates heat to overcome the resistance offered by the conductor through which it passes. Higher the resistance, the electric current will generate higher amount of heat. Thus, generation of heat by electric current while passing through a conductor is an inevitable consequence. This heating effect is used in many appliances, such as electric iron, electric heater, electric geyser, etc.

Joule's Law Of Heating: Let, an electric current, I is flowing through a resistor having resistance = R.
The potential difference through the resistor is = V.
The charge, Q flows through the circuit for the time, t
Thus, work done in moving of charge (Q) of potential difference (V),
$W = V \times Q$
Since this charge, Q flows through the circuit for time t
Therefore, power input (P) to the circuit can be given by the following equation :
$P = WT$
$P = V \times Qt$ .....(i)
We know, electric current, $I = Qt$
Substituting $Qt = I$ in equation (i), we get,
$P = VI$ ...(ii)
i.e., $P = VI$
Since, the electric energy is supplied for time ?, thus, after multiplying both sides of equation (ii) by time t, we get,
$P \times t = VI \times t = VIt$ ......(iii)
i.e., $P = VIt$
Thus, for steady current I, the heat produced (H) in time t is equal to VIt
$H = VIt$ i.e., **$H = VIt$**
We know, according to Ohm's Law,
$V = IR$
By substituting this value of V in equation (iii), we get,
$H = IR \times It$
$H = I^2Rt$ ......(iv)
The expression (iv) is known as Joule's Law of Heating, which states that heat produced in a resistor is directly proportional to the square of current given to the resistor, directly proportional to the resistance for a given current and directly proportional to the time for which the current is flowing through the resistor.
Electric Bulb: In an electric bulb, the filament of bulb gives light because of the heating effect of electricity. The filament of bulb is generally, made of tungsten metal, having melting point equal to 3380°C.

Electric Iron: The element of electric iron is made of alloys having high melting poir^ Electric heater and geyser work on the same mechanism.

Electric Fuse: Electric fuse is used to protect the electric appliances from high voltage if any. Electric fuse is made of metal or alloy of metals, such as aluminum, copper, iron, lead, etc. In the case of flow of higher voltage than specified, fuse wire melts and protect the electric appliances.
Fuse of 1A, 2A, 3A, 5A, 10A, etc., used for domestic purpose.
Suppose, if an electric heater consumes 1000W at 220 V.
Then electric current in circuit
I = PV
I = 1000W220V = 4.5 A
Thus, in this case of 5A should be used to protect the electric heater in the flow of higher voltage.

Electric Power
S.I. unit of electric power is watt (W).
1W = 1 volt × 1 ampere = 1V × 1A
I kilowatt or 1kW = 1000 W
Consumption of electricity (electric energy) is generally measured in kilowatt.
Unit of electric energy is kilowatt-hour (kWh).
1 kWh = 1000 watt × 1 hour = 1 unit = 1000 W × 3600 s
1 kWh = 3.6×10^6 watt second = 3.6×10^6 J

Conductor: The material which can allow the flow of electrons through itself is called the conductor. It has a large number of free electrons. It offers low opposition in the flow of current.

Insulator: The material which does not allow the flow of electrons through itself is called insulator. It has less or no free electrons. It offers high opposition in the flow of current.

Electric Current: The amount of flow charge through any cross-sectional area of a conductor in unity time is called Electric Current.
It is represented by 'I'
I = QT
Unit of Electric Current: It is CS^{-1} (coulomb per second) or Ampere (A). Electric Current is a scalar quantity. It is measured by an ammeter.

Direction: The direction of conventional current (or practical current) is opposite to the flow of electrons.

Electric potential: Electric Potential at any point in the electric field is defined as the amount of work done to bring the unit positive charge from infinity (from outside the electric field) to that point.
V =WQ, S.I. unit of Electric Potential is JC^{-1} or volt (V). It is a scalar quantity. The +ve charge flows from higher to lower potential. The -ve charge flows from lower to a higher potential. The difference of electric potential between any two points in the electric field is called Electric Potential difference. It is known as a voltage which is equal to the work done per unit charge between two points against the static electric field.
$V_{AB} = V_A - V_B = W_{AB}Q$
Electric Potential difference is measured by a voltmeter.

Ohm's Law: According to this law

"Under the constant physical condition the potential difference across the conductor is directly proportional to the current flowing through the conductor."

$V \propto I$

$V = IR$ ...[Where R is proportionality constant called resistance of conductor]

⇒ I = VR

R depends upon nature, geometry and physical condition of the conductor.

The heat generated by electric current: The potential difference between two points in an electrical field is equal to the work done in moving a unit charge from one point to another.

Then, work is done, $W = VQ$ and $Q = I \times t$

$W = V \times I \times t$

From Ohm's Law, we know that

$V = IR$

$W = IR \times I \times t = I^2.Rt$

Since heat produced by the electric current is equal to work done, W

$H = W$

⇒ H (heat) = I^2Rt Joule.

Resistance: Ratio of the applied voltage to the current flowing in the conductor is called resistance of the conductor.

⇒ R = VI

S.I. Unit of resistance is VA^{-1} or ohm (Ω).

Resistance is the opposition offered by the conductor in the flow of current.

Practically it is

$R \propto L$ (L is the length of a conductor)

$R \propto 1/A$ (A is the area of a conductor)

So, $R \propto L/A$

$R = \rho L/A$ ...[Where p is proportionality constant called specific resistance of conductor

It only depend upon nature (material) and temperature of conductor.

Specific resistance or Resistivity = $\rho = RA/L$

It's S.I. Unit is Qm

Combination of resistance:

- In this combination the current across every component is same but potential across every component is different.
- If resistance R_1, R_2 and R_3 are connected in series with a battery of Potential V, then equivalence resistance of the combination
  $R = R_1 + R_2 + R_3$

The parallel combination of resistance:

- In this combination the current across every component is different. But potential across every component is the same.
- If resistance R_1, R_2 and R_3 are connected in parallel with a battery of Potential V, then equivalence resistance of combination
  1R=1R1+1R2+1R3

Electric Energy is amount of work done to maintain the continuous flow of electric current in the circuit.
Its S.I. unit is joule (J).

Electric power (P): The electric work done per unit time. The rate at which work is done by an electric current is called as electric power

Electric Power =(Electric work done) (Time taken)
or P = W/t W= VIt
Therefore, P = VIt /t or **P = VI**
The power of an electric circuit is said to be one watt if one amoere of current flows in it against a potential difference of one volt.
V=IR, P= (IR)I
Thus **$P= I^2R$**
I = V/R , P = V (V/R)
Thus **$P = V^2/R$**
Electric power is also defined as the electric energy consumed per unit time.
S.I. unit of electric power is Watt. When one joule of energy is used for one second, electric power is equal to one watt. A bigger unit of power is called a **kilowatt (kW).**
Derivation of formula for electric power:
We know that electric work done, W = V × I × t or P = VIt /t
P = VI
Electric power in watts = Volts × ampere
Also V = IR ...[According to Ohm's Law]
So P = IR × I
$P = I^2R$
We know that I = VR
$P = (VR)^2 \times R = V_2R$ Watt
The maximum value of electric current that can pass through an electric appliance without damaging electric appliance is called current rating of electric appliance.

Magnetic Effects of Electric Current

Magnet: Magnet is an object that attracts objects made of iron, cobalt and Nickle. Magnet comes to rest in North – South direction, when suspended freely.

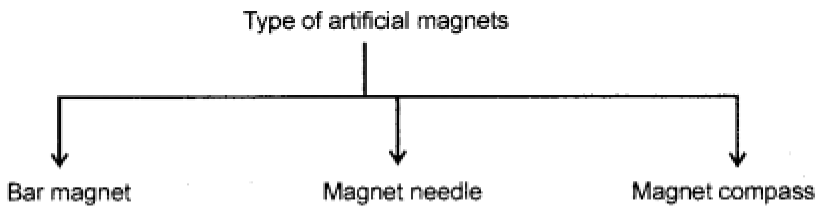
Use of Magnets: Magnets are used

- In refrigerators.
- In radio and stereo speakers.
- In audio and video cassette players.
- In toys and;
- On hard discs and floppies of computers.

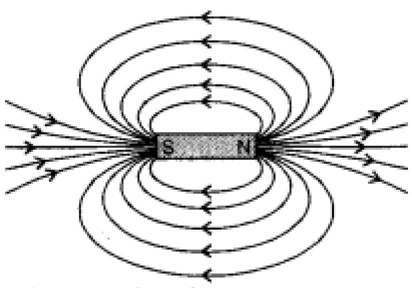
Properties of Magnet

- A free suspended magnet always points towards the north and south direction.
- The pole of a magnet which points toward north direction is called north pole or north-seeking.
- The pole of a magnet which points toward south direction is called south pole or south seeking.
- A magnetic field lines are directed from north-pole to south-pole **outside** the magnet.
- Magnetic field lines are closed and continuous curves.
- The magnetic field lines are crowed near the pole, where the magnetic field is strong and are far apart near middle of the magnet where magnetic field is weak.
- Like poles of magnets repel each other while unlike poles of magnets attract each other.

Magnetic field: The area around a magnet where a magnetic force is experienced is called the magnetic field. It is a quantity that has both direction and magnitude, (i.e., Vector quantity).



Magnetic field and field lines: The influence of force surrounding a magnet is called magnetic field. In the magnetic field, the force exerted by a magnet can be detected using a compass or any other magnet.
The magnetic field is represented by magnetic field lines.



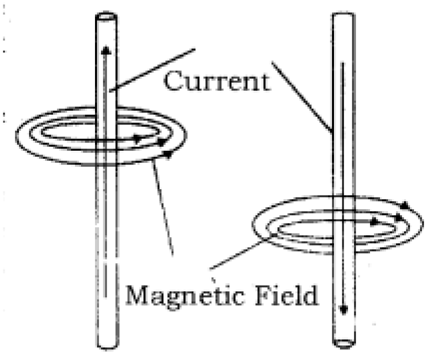
The imaginary lines of magnetic field around a magnet are called field line or field line of magnet. When iron fillings are allowed to settle around a bar magnet, they get arranged in a pattern which makes the magnetic field lines. Field line of a magnet can also be detected using a compass. Magnetic field is a vector quantity, i.e. it has both direction and magnitude.

Direction of field line: Outside the magnet, the direction of magnetic field line is taken from North pole to South Pole. Inside the magnet, the direction of magnetic field line is taken from South pole to North pole.

Strength of magnetic field: The closeness of field lines shows the relative strength of magnetic field, i.e. closer lines show stronger magnetic field and vice – versa. Crowded field lines near the poles of magnet show more strength.

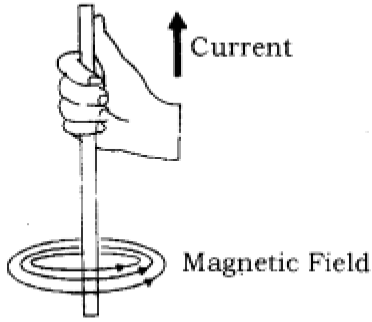
Properties of magnetic field lines
(i) They do not intersect each other.
(ii) It is taken by convention that magnetic field lines emerge from North pole and merge at the South pole. Inside the magnet, their direction is from South pole to North pole. Therefore magnetic field lines are closed curves.

Magnetic field lines due to current a current carrying straight conductor
A current carrying straight conductor has magnetic field in the form of concentric circles, around it. Magnetic field of current carrying straight conductor can be shown by magnetic field lines. The direction of magnetic field through a current carrying conductor depends upon the direction of flow electric current.

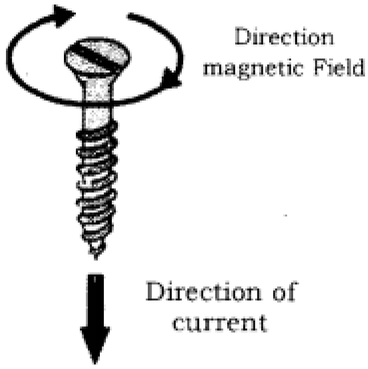


Let a current carrying conductor be suspended vertically and the electric current is flowing from south to north. In this case, the direction of magnetic field will be anticlockwise. If the current is flowing from north to south, the direction of magnetic field will be clockwise.
The direction of magnetic field, in relation to direction of electric current through a straight conductor can be depicted by using the Right Hand Thumb Rule. It is also known as Maxwell's Corkscrew Rule.

Right-Hand Thumb Rule: If a current carrying conductor is held by right hand, keeping the thumb straight and if the direction of electric current is in the direction of thumb, then the direction of wrapping of other fingers will show the direction of magnetic field.



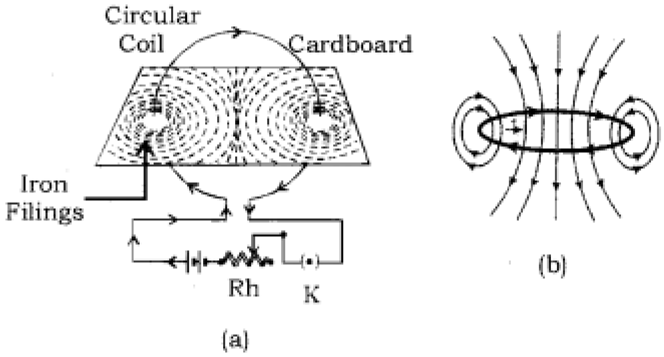
Maxwell's Corkscrew rule: As per Maxwell's Corkscrew Rule, if the direction of forward movement of screw shows the direction of the current, then the direction of rotation of screw shows the direction of magnetic field.



Properties of magnetic field

- The magnitude of magnetic field increases with increase in electric current and decreases with decrease in electric current.
- The magnitude of magnetic field produced by electric current decreases with increase in distance and vice – versa. The size of concentric circles of magnetic field lines increases with distance from the conductor, which shows that magnetic field decreases with distance.
- Magnetic field lines are always parallel to each other.
- No two field lines cross each other.

Magnetic field lines due to a current through a circular loop
In case of a circular current carrying conductor, the magnetic field is produced in the same manner as it is in case of a straight current carrying conductor.



In case of a circular current carrying conductor, the magnetic field lines would be in the form of iron concentric circles around every part of the Films periphery of the conductor. Since, magnetic field lines tend to remain closer when near to the conductor, so the magnetic field would be stronger near the periphery of the loop. On the other hand, the magnetic field lines would be distant from each other when we move towards the centre of the current carrying loop. Finally, at the centre, the arcs of big circles would appear as a straight line.

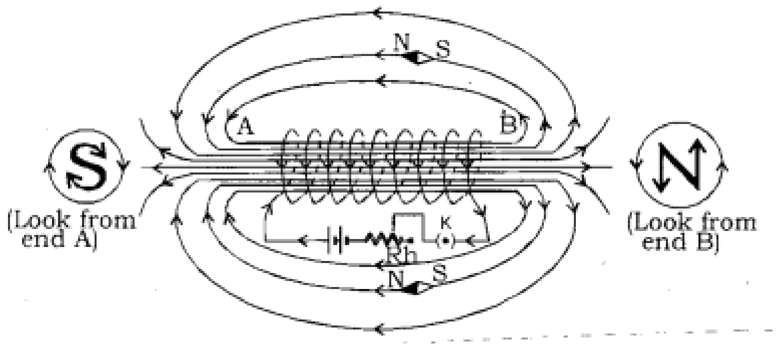
The direction of the magnetic field can be identified using Right Hand Thumb's Rule. Let us assume that the current is moving in anti-clockwise direction in the loop. In that case, the magnetic field would be in clockwise direction, at the top of the loop. Moreover, it would be in an anti-clockwise direction at the bottom of the loop.

Clock Face Rule: A current carrying loop works like a disc magnet. The polarity of this magnet can be easily understood with the help of Clock Face Rule. If the current is flowing in anti – clockwise direction, then the face of the loop shows north pole. On the other hand, if the current is flowing in clockwise direction, then the face of the loop shows south pole.

Magnetic field and number of turns of coil: Magnitude of magnetic field gets summed up with increase in the number of turns of coil. If there are 'n' turns of coil, magnitude of magnetic field will be 'n' times of magnetic field in case of a single turn of coil.

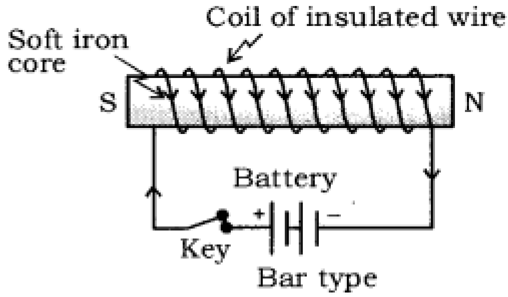
The strength of the magnetic field at the centre of the loop(coil) depends on :
(i) The radius of the coil: The strength of the magnetic field is inversely proportional to the radius of the coil. If the radius increases, the magnetic strength at the centre decreases
(ii) The number of turns in the coil : As the number of turns in the coil increase, the magnetic strength at the centre increases, because the current in each circular turn is having the same direction, thus, the field due to each turn adds up.
(iii) The strength of the current flowing in the coil: As the strength of the current increases, the strength of three magnetic fields also increases.

Magnetic field due to a current in a Solenoid: Solenoid is the coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. A current carrying solenoid produces similar pattern of magnetic field as a bar magnet. One end of solenoid behaves as the north pole and another end behaves as the south pole.

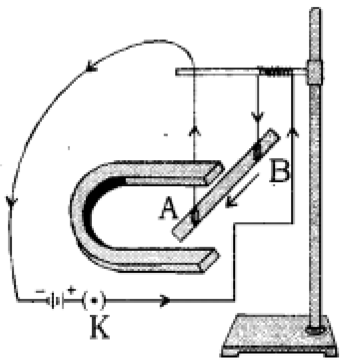


Magnetic field lines are parallel inside the solenoid, similar to a bar magnet, which shows that magnetic field is same at all points inside the solenoid.
Magnetic field produced by a solenoid is similar to a bar magnet.
The strength of magnetic field is proportional to the number of turns and magnitude of current.
By producing a strong magnetic field inside the solenoid, magnetic materials can be magnetized.
Magnet formed by producing magnetic field inside a solenoid is called electromagnet.

Electromagnet, Fleming's Left-Hand Rule, Electric motor, Electromagnetic induction, Fleming's right hand rule, Electric generator and domestic electic circuits.
Electromagnet: An electromagnet consists of a long coil of insulated copper wire wrapped on a soft iron.
Magnet formed by producing magnetic field inside a solenoid is called electromagnet.

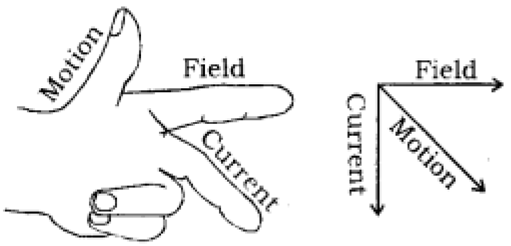


Force on a current carrying conductor in a magnetic field: A current carrying conductor exerts a force when a magnet is placed in its vicinity. Similarly, a magnet also exerts equal and opposite force on the current carrying conductor. This was suggested by Marie Ampere, a French Physicist and considered as founder of science of electromagnetism.



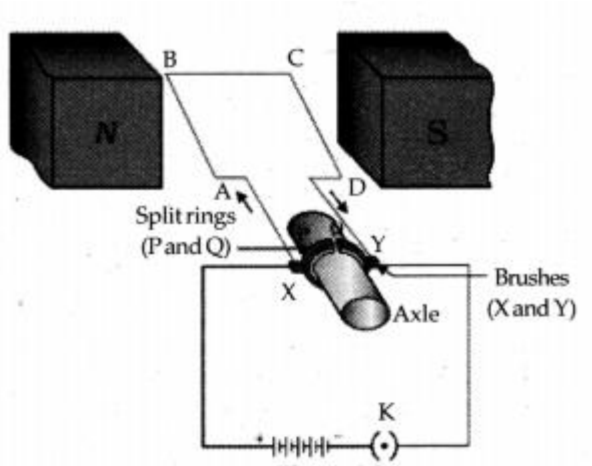
The direction of force over the conductor gets reversed with the change in direction of flow of electric current. It is observed that the magnitude of force is highest when the direction of current is at right angles to the magnetic field.

Fleming's Left-Hand Rule: If the direction of electric current is perpendicular to the magnetic field, the direction of force is also perpendicular to both of them. The Fleming's Left Hand Rule states that if the left hand is stretched in a way that the index finger, the middle finger and the thumb are in mutually perpendicular directions, then the index finger and middle finger of a stretched left hand show the direction of magnetic field and direction of electric current respectively and the thumb shows the direction of motion or force acting on the conductor. The directions of electric current, magnetic field and force are similar to three mutually perpendicular axes, i.e. x, y, and z-axes.
Many devices, such as electric motor, electric generator, loudspeaker, etc. work on Fleming's Left Hand Rule.



Electric motor: A device that converts electrical energy to mechanical energy. It is of two types : AC and DC Motor.
Electrical energy is converted into mechanical energy by using and electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming's Left Hand Rule.

Principle of Electric Motor: When a rectangular coil is placed in a magnetic field and a current is passed through it, force acts on the coil, which rotates it continuously. With the rotation of the coil, the shaft attached to it also rotates.



Electric Motor

Construction: It consists of the following parts :

- Armature: It is a rectangular coil (ABCD) which is suspended between the two poles of a magnetic field.
  The electric supply to the coil is connected with a commutator.
- Commutator or Split – ring: Commutator is a device which reverses the direction of flow of electric current through a circuit. It is two halves of the same metallic ring.
- Magnet: Magnetic field is supplied by a permanent magnet NS.
- Sliding contacts or Brushes Q which are fixed.
- Battery: These are consists of few cells.

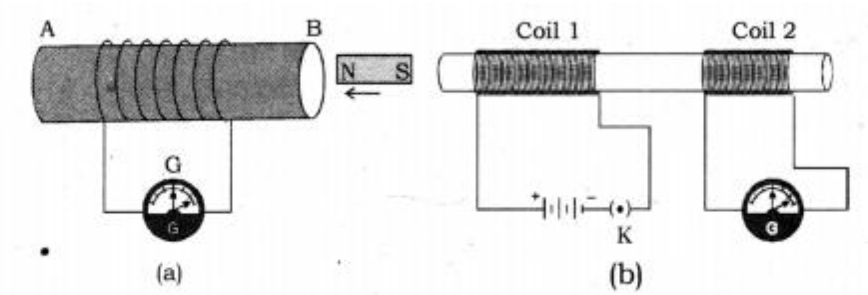
Working: When an electric current is supplied to the coil of the electric motor, it gets deflected because of magnetic field. As it reaches the halfway, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of the current, reverses the direction of forces acting on the coil. The change in direction of force pushes the coil, and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

In commercial motor, electromagnet instead of permanent magnet and armature is used. Armature is a soft iron core with large number of conducting wire turns over it. Large number of turns of conducting wire enhances the magnetic field produced by armature.

Uses of motors :

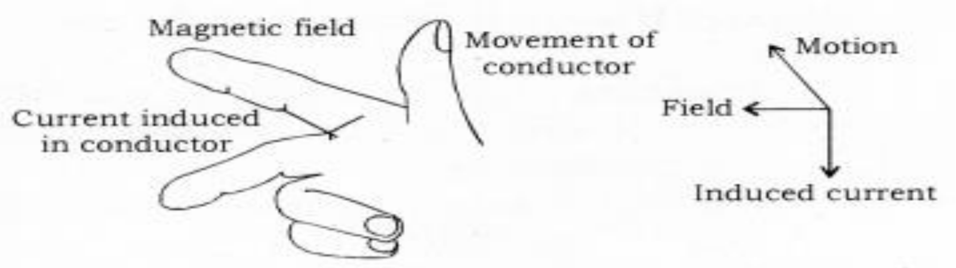
- Used in electric fans.
- Used for pumping water.
- Used in various toys.

Electromagnetic Induction: Michael Faraday, an English Physicist is supposed to have studied the generation of electric current using a magnetic field and a conductor.
Electricity production as a result of magnetism (induced current) is called Electromagnetic Induction.



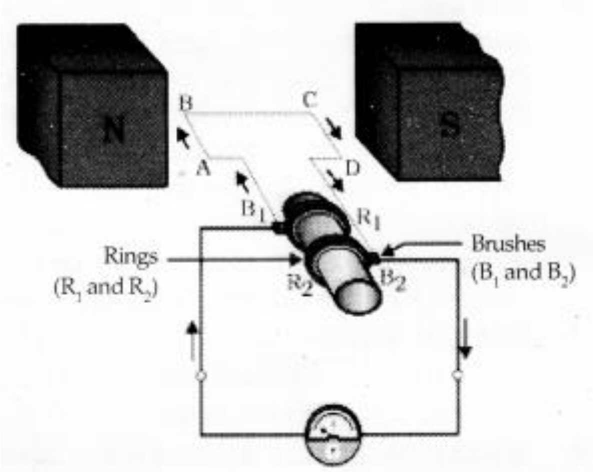
When a conductor is set to move inside a magnetic field or a magnetic field is set to be changing around a conductor, electric current is induced in the conductor. This is just opposite to the exertion of force by a current carrying conductor inside a magnetic field. In other words, when a conductor is brought in relative motion vis – a – vis a magnetic field, a potential difference is induced in it. This is known as electromagnetic induction.

Fleming's Right-Hand Rule: Electromagnetic induction can be explained with the help of Fleming's Right Hand Rule. If the right hand is structured in a way that the index (fore ginger) finger, middle finger and thumb are in mutually perpendicular directions, then the thumb shows direction of induced current in the conductor, in conductor The directions of movement of conductor, magnetic field and induced current can be compared to three mutually perpendicular axes, i.e. x, y and z axes.



The mutually perpendicular directions also point to an important fact that when the magnetic field and movement of conductor are perpendicular, the magnitude of induced current would be maximum.
Electromagnetic induction is used in the conversion of kinetic energy into electrical energy.

Electric Generator: A device that converts mechanical energy into electrical energy is called an electric generator.
Electric generators are of two types: AC generator and a DC generator. Principle of electric generator: Electric motor works on the basis of electromagnetic induction.

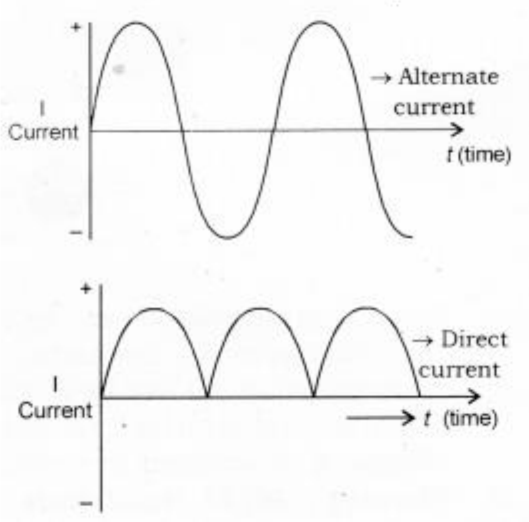


Construction and Working: The structure of an electric generator is similar to that of an electric motor. In case of an electric generator, a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in a way that it can move around an axle. When the armature moves within the magnetic field, an electric current is induced. The direction of induced current changes, when the armature crosses the halfway mark of its rotation.

Thus, the direction of current changes once in every rotation. Due to this, the electric generator usually produces alternate current, i.e. A.C. To convert an A.C generator into a D.C generator, a split ring commutator is used. This helps in producing direct current.
Electrical generator is used to convert mechanical energy into electrical energy.

A.C and D.C Current
A.C – Alternate Current: Current in which direction is changed periodically is called Alternate Current. In India, most of the power stations generate alternate current. The direction of current changes after every 1/100 second in India, i.e. the frequency of A.C in India is 50 Hz. A.C is

transmitted up to a long distance without much loss of energy is advantage of A.C over D.C.



D.C – Direct Current: Current that flows in one direction only is called Direct current. Electrochemical cells produce direct current.
Advantages of A.C over D.C

- Cost of generator of A.C is much less than that of D.C.
- A.C can be easily converted to D.C.
- A.C can be controlled by the use of choke which involves less loss of power where as, D.C can be controlled using resistances which involves high energy loss.
- AC can be transmitted over long distances without much loss of energy.
- AC machines are stout and durable and do not need much maintenance.

Disadvantages of AC

- AC cannot be used for the electrolysis process or showing electromagnetism as it reverses its polarity.
- AC is more dangerous than DC.

Domestic Electric Circuits: We receive electric supply through mains supported through the poles or cables. In our houses, we receive AC electric power of 220 V with a frequency of 50 Hz. The 3 wires are as follows

- Live wire – (Red insulated, Positive)
- Neutral wire – (Black insulated, Negative)
- Earth wire – (Green insulated) for safety measure to ensure that any leakage of current to a metallic body does not give any serious shock to a user.

Short Circuit: Short-circuiting is caused by the touching of live wires and neutral wire and sudden a large current flows.
It happens due to

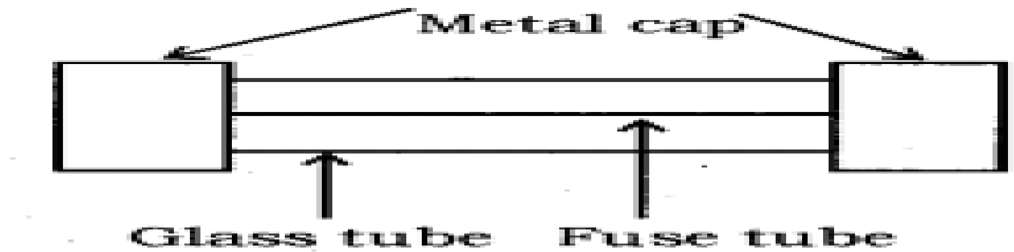
- damage pf insulation in power lines.

- a fault in an electrical appliance.

Overloading of an Electric Circuit: The overheating of electrical wire in any circuit due to the flow of a large current through it is called overloading of the electrical circuit.
A sudden large amount of current flows through the wire, which causes overheating of wire and may cause fire also.

Electric Fuse: It is a protective device used for protecting the circuit from short-circuiting and overloading. It is a piece of thin wire of material having a low melting point and high resistance.

- Fuse is always connected to live wire.
- Fuse is always connected in series to the electric circuit.
- Fuse is always connected to the beginning of an electric circuit.
- Fuse works on the heating effect.



Magnetic field: The area around a magnet in which other magnet feels force of attraction or repulsion is called Magnetic field.

Magnetic field lines: The closed curved imaginary lines in the magnetic field which indicate the direction of motion of north pole in the magnetic field if a magnet is free to do so.

Properties of magnetic field lines.

- Magnetic Field lines originate from the north pole of a magnet and end at its south pole.
- Magnetic Field lines are denser near the poles but rarer at other places.
- The Magnetic Field lines do not intersect one another.

Oersted's experiment: According to this experiment "A current carrying wire creates a magnetic field around it. The direction of magnetic field depends on the direction of current in conductor."

- Magnetic field pattern due to straight current carrying conductor are concentric circles whose center lie on the wire.
- The direction of magnetic field due to straight current carrying conductor can be determined by Right hand thumb rule.

Right hand thumb rule: According to this rule "if current carrying conductor is held in the right hand in such a way that thumb indicate the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor."

Magnetic field pattern due to current carrying loop: The Magnetic field lines are circular near the current-carrying loop. As we move away from the loop, field lines form bigger and bigger circles. At the center of the circular loop, the magnetic field lines are straight.

The solenoid is an insulated and tightly wound long circular wire having large number of turns whose radius is small in comparison to its length. Magnetic field produced by a solenoid is similar to the magnetic field produced by a bar magnet.

Current carrying solenoid is called an electromagnet.

Properties of magnetic lines of force or magnetic field lines.

- These lines originate from the north pole and end at the south pole.
- The magnetic field lines of a magnet form a continuous closed loop.
- Two magnetic lines of force do not intersect each other.
- The tangent at any point on the magnetic line gives the direction of the magnetic field at the point.

Fleming's left hand rule: According to this rule, "if the thumb, forefinger and middle finger of the left hand are stretched perpendicular to each other and if the fore-finger gives the direction of magnetic field, middle finger gives the direction of current, then the thumb will give the direction of motion or the force acting on the current-carrying conductor."

Principle of an electric motor: A motor works on the principle that when a rectangular coil is placed in a magnetic field and current passes through it, a force acts on the coil which rotates it continuously.
When the coil rotates, the shaft attached to it also rotates. In this way the electrical energy supplied to the motor is converted into the mechanical energy of rotation.

Principle of an electric generator: It is based on the principle of electromagnetic induction. It states that "an induced current is produced in a coil placed in a region where the magnetic field changes with time." The direction of induced current is given by Fleming's right-hand rule. An electric generator converts mechanical energy into electrical energy.

Electromagnetic induction: The phenomenon of setting up of an electric current or an induced e.mi. by changing the magnetic lines of force by a moving conductor is called electromagnetic induction.

Maxwell's right hand thumb rule: The direction of the current is given by Maxwell's right-hand thumb rule, "If the current carrying conductor is gripped with the right hand in such a way that the thumb gives the direction of the current, then the direction of the fingers gives the direction of the magnetic field produced around the conductor.

Fleming's left-hand rule: The direction of motion of a conductor in a magnetic field is given by Fleming's left-hand rule. According to this rule, if the thumb, forefinger and middle finger of the left hand are stretched perpendicular to each other and if fore-finger gives the direction of the magnetic field and the middle finger gives the direction of current then, the thumb will give the direction of the motion of the conductor carrying the current.

Fleming's right-hand rule: The direction of the induced current is given by Fleming's right-hand rule. According to this rule if the thumb, forefinger and middle finger of the right hand are stretched perpendicular to each other and if the fore-finger gives the direction of the magnetic field and the thumb gives the direction of motion, then the middle finger will give the direction of the induced current in the conductor.