

# **PHYSICS**

## ***REFERENCE STUDY MATERIAL***

*for*

## **CLASS – X**

**CHAPTER WISE CONCEPTS, FORMULAS AND  
NUMERICALS INCLUDING HOTS PROBLEMS**

Prepared by

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Dated:05.09.2013

Dear Shri M.S.Kumarswamy,

It has been brought to my notice the good work done by you with regard to making question bank and worksheets for classes VI to X in Mathematics. I am pleased to look at your good work. Mathematics is one discipline which unfortunately and wrongly perceived as a phobia. May be lack of motivation from teachers and inadequate study habits of students is responsible for this state of affairs. Your work in this regard assumes a great significance. I hope your own students as well as students of other Vidyalayas will benefit by your venture. You may mail the material to all the Kendriya Vidyalayas of the region for their benefit. Keep up the good work.

**May God bless!**

**Yours sincerely,**

  
(Isampal)

Shri M.S.Kumarswamy  
TGT (Maths)  
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Copy to: the principals, Kendriya Vidyalayas, Bangalore Region with instructions to make use of the materials prepared by Mr. M.S.Kumarswamy being forwarded separately.

**DEDICATED  
TO  
MY FATHER**

**LATE SHRI. M. S. MALLAYYA**

# CHAPTER - 10

## LIGHT – REFLECTION AND REFRACTION

### **LIGHT**

An object reflects light that falls on it. This reflected light when received by our eyes, enables us to see things.

### **Reflection of light**

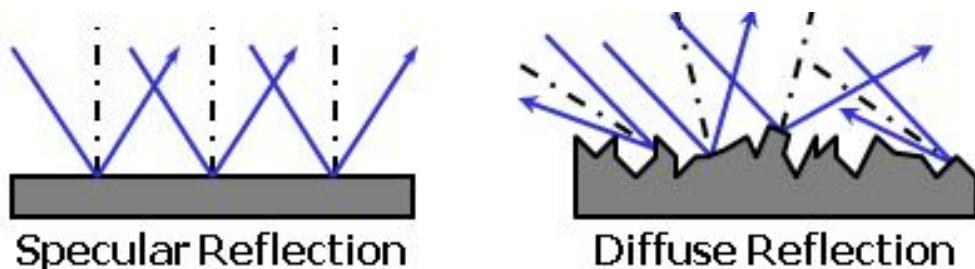
Reflection of light is the phenomenon of bouncing back of light in the same medium on striking the surface of any object.

There are two types of reflection:

1. Regular reflection or Specular Reflection
2. Irregular reflection or Diffuse Reflection

**Regular Reflection:** When the reflecting surface is smooth and well polished, the parallel rays falling on it are reflected parallel to one another, the reflected light goes in one particular direction. This is Regular reflection or Specular reflection see below figure.

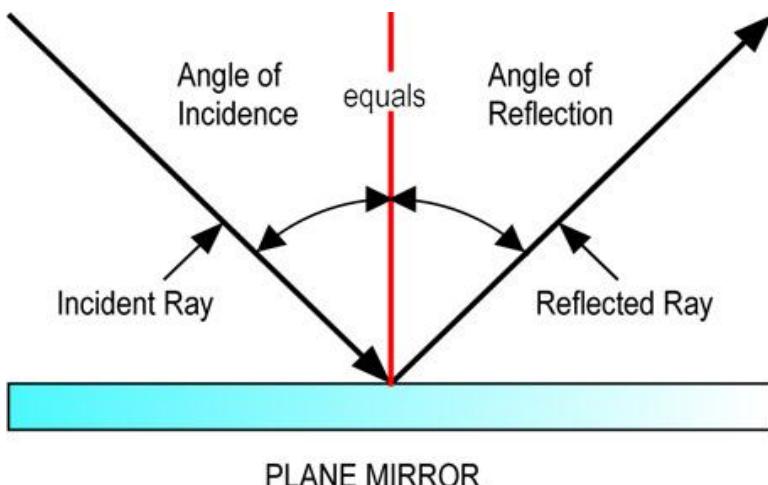
**Irregular reflection:** When the reflecting surface is rough, the parallel rays falling on it reflected in different direction, as shown in below fig. Such a reflection is known as diffuse reflection or irregular reflection.



### **LAWS OF REFLECTION OF LIGHT**

According to the laws of Reflection of light,

- (i) The angle of incidence is equal to the angle of reflection, and
- (ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.



These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces.

## OBJECTS

Anything which gives out light rays either its own or reflected by it is called an object.

**LUMINOUS OBJECTS:** The objects like the sun, other stars, electric bulb, tube-light etc. which emit their own light are called luminous objects.

**NON – LUMINOUS OBJECTS:** The objects which do not emit light themselves but only reflect or scatter the light which falls on them, are called non-luminous objects. A flower, chair, table, book, trees, etc are all non-luminous objects.

## IMAGES

Image is an optical appearance produced when light rays coming from an object are reflected from a mirror (or refracted through lens).

## REAL IMAGE

The image which can be obtained on a screen is called a real image. In a cinema hall, we see the images of actors and actress on the screen. So, the images formed on a cinema screen is an example of real images.

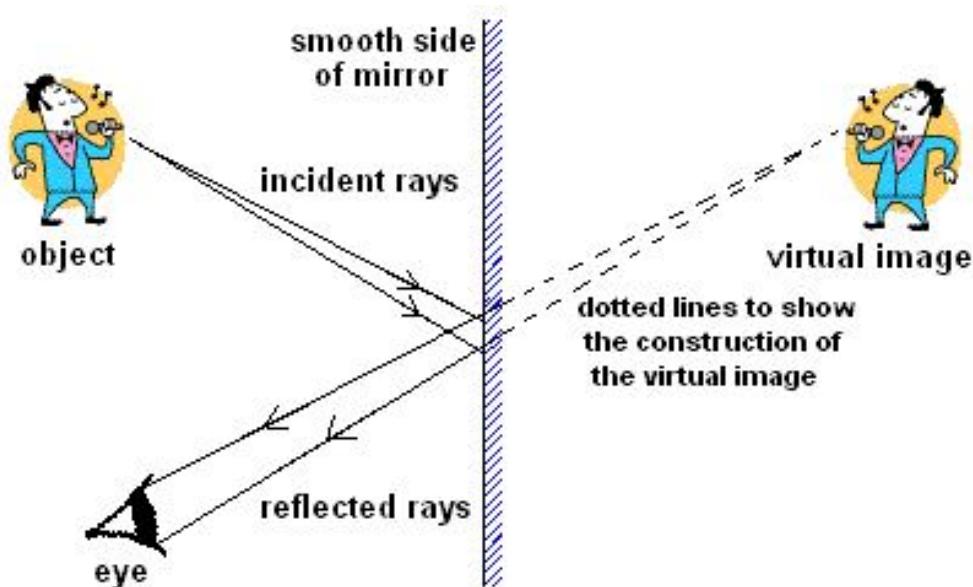
## VIRTUAL IMAGE

The image which cannot be obtained on a screen is called a virtual image. A virtual image can be seen only by looking into a mirror. The image of our face in a plane mirror is an example of virtual image.

## LATERAL INVERSION

When an object is placed in front of a plane mirror, then the right side of object appears to become the left side of image; and the left side of object appears to become the right side of image. This change of sides of an object and its mirror image is called lateral inversion.

The phenomenon of lateral inversion is due to the reflection of light.



## CHARACTERISTICS OF IMAGES FORMED BY PLANE

The characteristics of images formed by plane mirrors are:

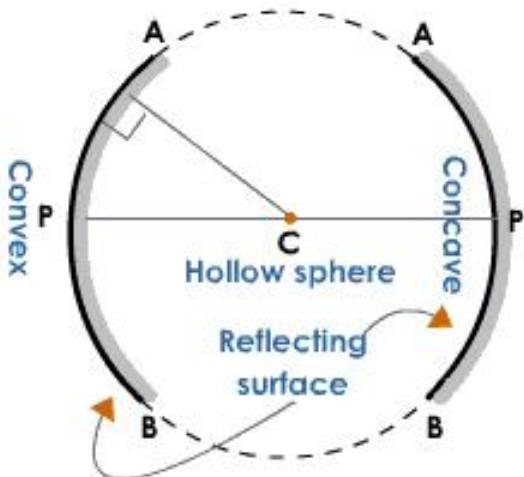
1. The image of real object is always virtual. Such image cannot be taken on a screen.
2. The image formed in a plane mirror is always erect.
3. The size of the image in a plane mirror is always the same as the size of the object.
4. The image formed in a plane mirror is as far behind the mirror, as the object is in front of the mirror.
5. The image formed in a plane mirror is laterally inverted i.e. the left side of the objects becomes the right side of the image and vice-versa.

### **SPHERICAL MIRROR**

A spherical mirror is that mirror whose reflecting surface is the part of a hollow sphere of glass. The spherical mirrors are of two types: Concave mirror and Convex mirror.

**CONCAVE MIRROR:** A concave mirror is that spherical mirror in which the reflection of light takes place at the concave surface (or bent-in surface).

**CONVEX MIRROR:** A convex mirror is that spherical mirror in which the reflection of light takes place at the convex surface (or bulging –out surface).



### **TERMS RELATED TO SPHERICAL MIRRORS**

**Centre of Curvature(C):** The centre of curvature of a spherical mirror is the centre of the hollow sphere of glass of which the spherical mirror is a part. It is represented by letter 'C'.

**Pole(P):** The pole of a spherical mirror is the centre of the mirror. It is represented by letter 'P'.

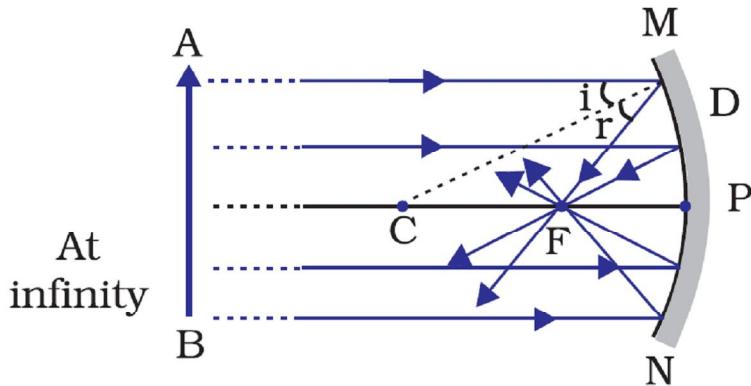
**Radius of Curvature(R):** The radius of curvature of a spherical mirror is the radius of the hollow sphere of glass of which the spherical is a part. It is represented by the letter 'R'.

**Principal axis:** The principal axis of a spherical mirror is the straight line passing through the centre of curvature C and pole P of the spherical mirror, produced on both sides.

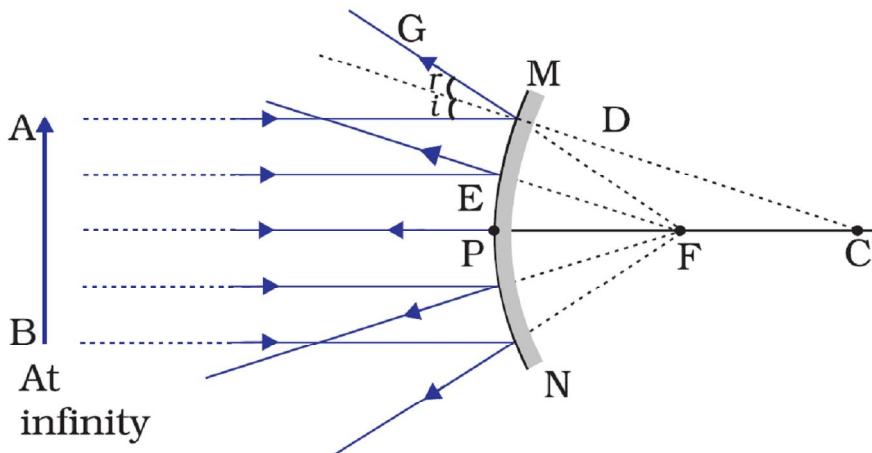
**Aperture:** The aperture of a spherical mirror is the diameter of the reflecting surface of the mirror.

## **PRINCIPAL FOCUS OF A SPHERICAL MIRROR**

The principal focus of a concave mirror is a point on its principal axis to which all the light rays which are parallel and close to the axis, converge after reflection from the concave mirror. A concave mirror has a real focus. The focus of a concave mirror is in front of the mirror. Since a concave mirror converges a parallel beams of light rays, it is also called converging mirror.



The principal focus of a convex mirror is a point on its principal axis from which a beam of light rays, initially parallel to the axis, appears to diverge after being reflected from the convex mirror. A convex mirror has a virtual focus. The focus of a convex mirror is situated behind the mirror. Since a convex mirror diverges a parallel beams of light rays, it is also called diverging mirror.



**Focal Length:** The focal length of a spherical mirror is the distance between its pole and principal focus. It is denoted by the letter 'f'.

### **Relation between Radius of curvature and focal length of a spherical mirror**

The focal length of a spherical mirror is equal to half of its radius of curvature.

$$f = \frac{R}{2}$$

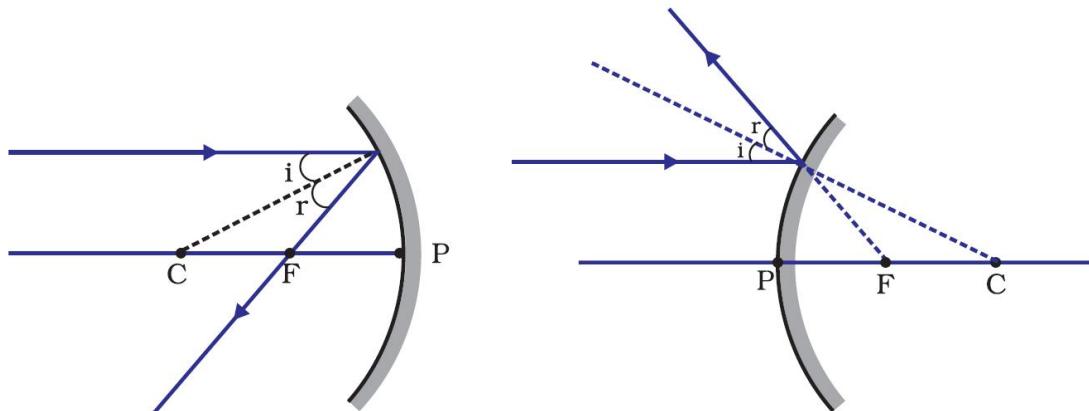
In other words, for spherical mirrors of small apertures, the radius of curvature is found to be equal to twice the focal length.

$$R = 2f$$

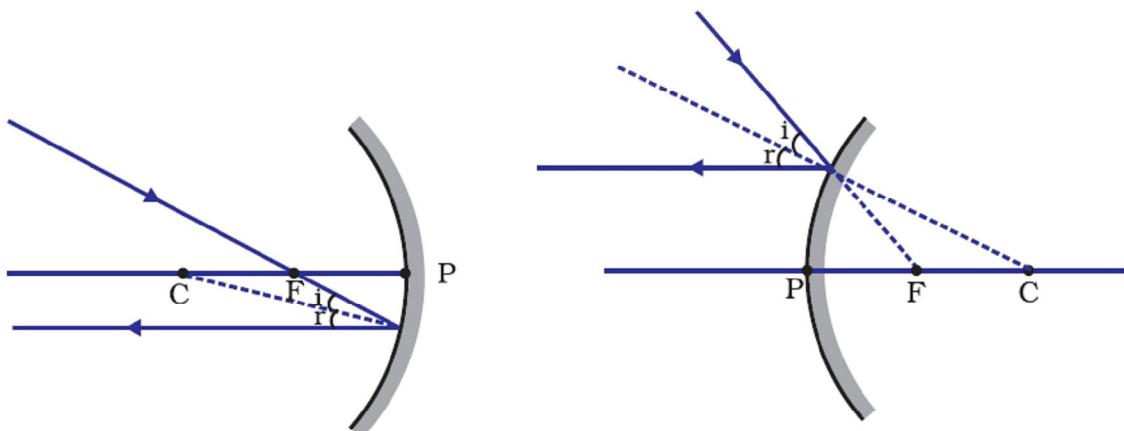
## RULES FOR OBTAINING IMAGES FORMED BY SPHERICAL MIRRORS

The intersection of at least two reflected rays give the position of image of the point object. Any two of the following rays can be considered for locating the image.

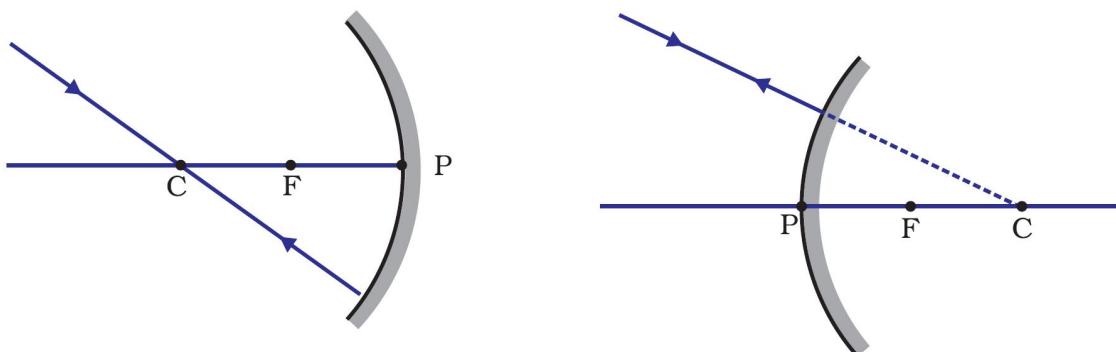
1. A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.



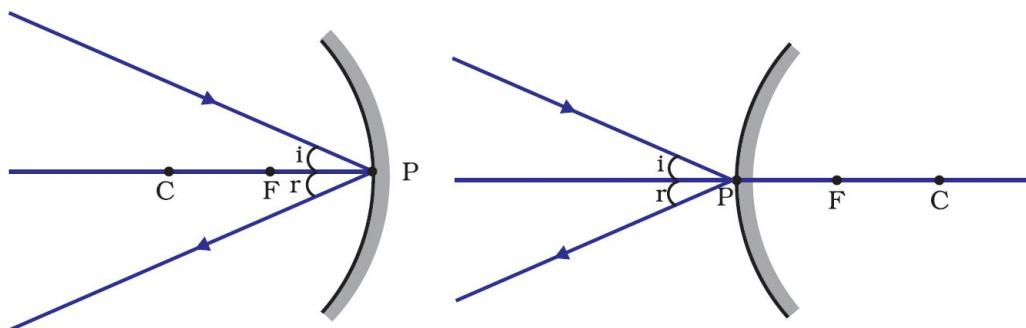
2. A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, after reflection, will emerge parallel to the principal axis.



3. A ray passing through the centre of curvature of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path. The light rays come back along the same path because the incident rays fall on the mirror along the normal to the reflecting surface.



4. A ray incident obliquely to the principal axis, towards a point P (pole of the mirror), on the concave mirror or a convex mirror, is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence (point P), making equal angles with the principal axis.



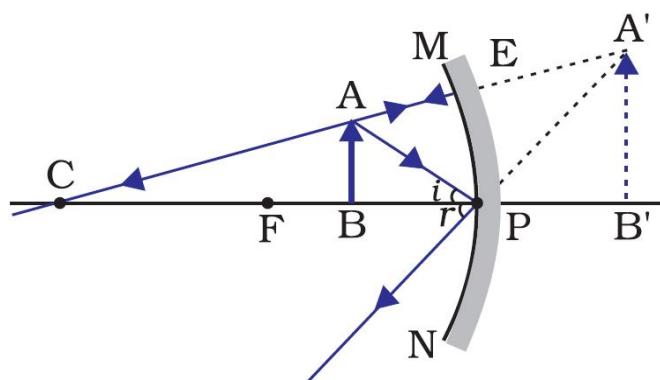
### **FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONCAVE MIRROR**

The type of image formed by a concave mirror depends on the position of object in front of the mirror. There are six positions of the object:

#### **Case–1: Object is in between P and F**

When an object is placed between the pole(P) and focus(F) of a concave mirror, the image formed is

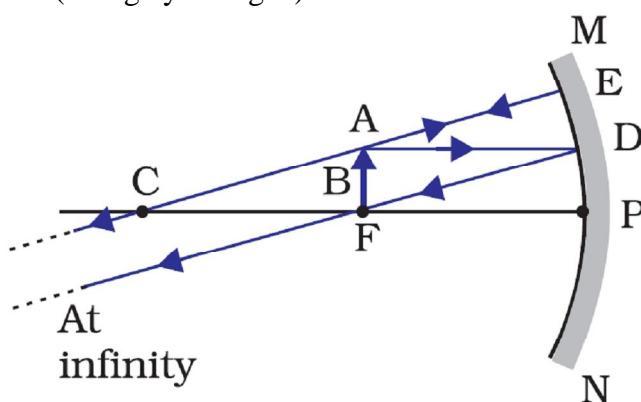
- (i) behind the mirror
- (ii) virtual and erect and
- (iii) larger than the object (or magnified)



#### **Case–2: Object is at the focus(F).**

When an object is placed at the focus of a concave mirror, the image formed is

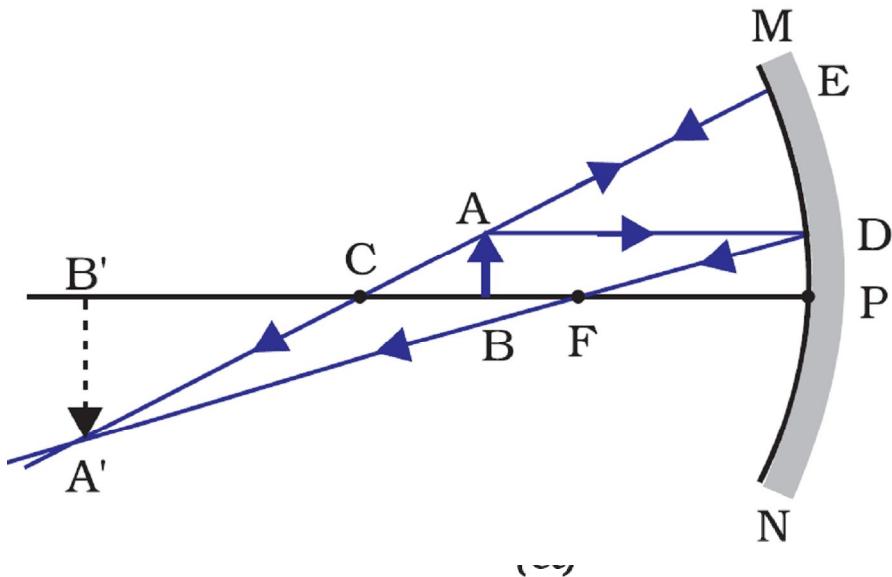
- (i) at infinity
- (ii) real and inverted, and
- (iii) highly magnified (or highly enlarged)



### **Case–3: Object is in between focus(F) and centre of curvature(C)**

When an object is placed between the focus(F) and centre of curvature(C) of a concave mirror, the image formed is

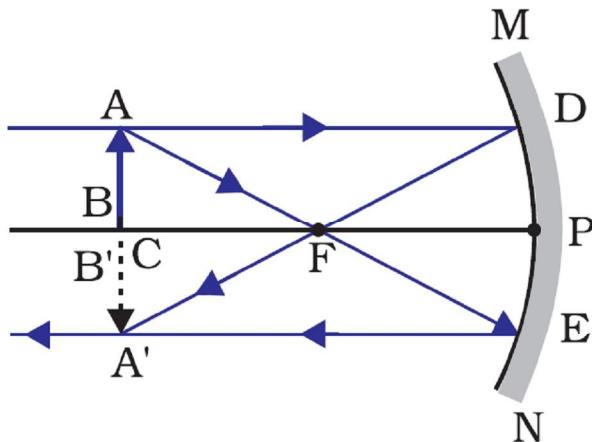
- (i) beyond the centre of curvature
- (ii) real and inverted, and
- (iii) larger than the object (or magnified)



### **Case–4: Object is at the centre of curvature(C)**

When an object is placed at the centre of curvature of a concave mirror, the image formed is

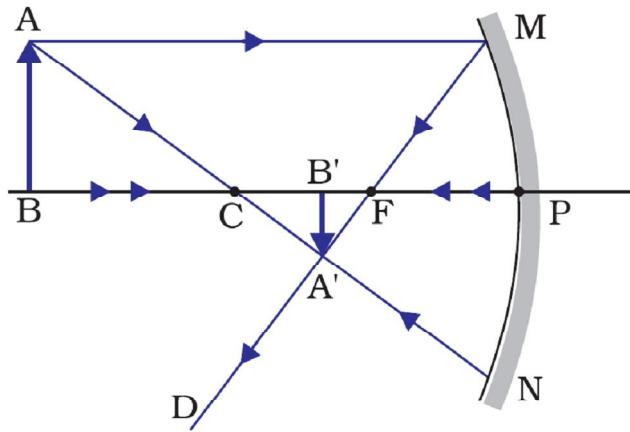
- (i) at the centre of curvature
- (ii) real and inverted, and
- (iii) same size as the object



### **Case–5: Object is beyond the centre of curvature(C)**

When an object is placed beyond the centre of curvature of a concave mirror, the image formed is

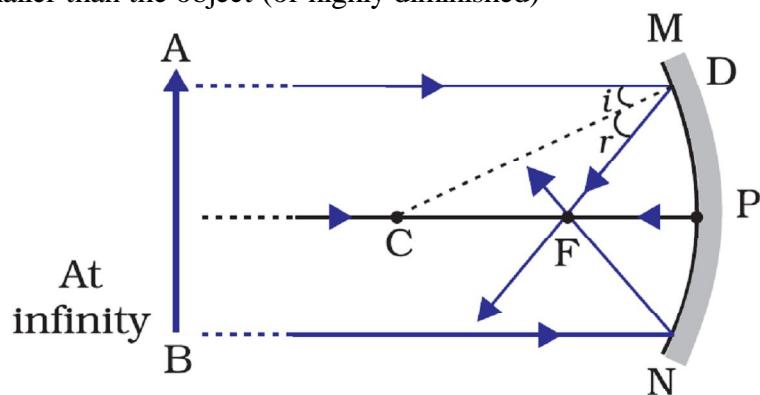
- (i) between the focus and centre of curvature
- (ii) real and inverted, and
- (iii) smaller than the object (or diminished)



#### **Case–6: Object is at infinity.**

When an object is placed at infinity of a concave mirror, the image formed is

- (i) between the focus and centre of curvature
- (ii) real and inverted, and
- (iii) much smaller than the object (or highly diminished)



#### **USES OF CONCAVE MIRRORS**

1. Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
2. Concave mirrors are used as shaving mirrors to see a larger image of the face.
3. The dentists use concave mirrors to see large images of the teeth of patients.
4. Concave mirrors are used as doctor's head mirrors to focus light coming from a lamp on to the body parts of a patient to be examined by the doctor.
5. Concave dishes are used in TV dish antennas to receive TV signals from the distant communications satellite.
6. Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

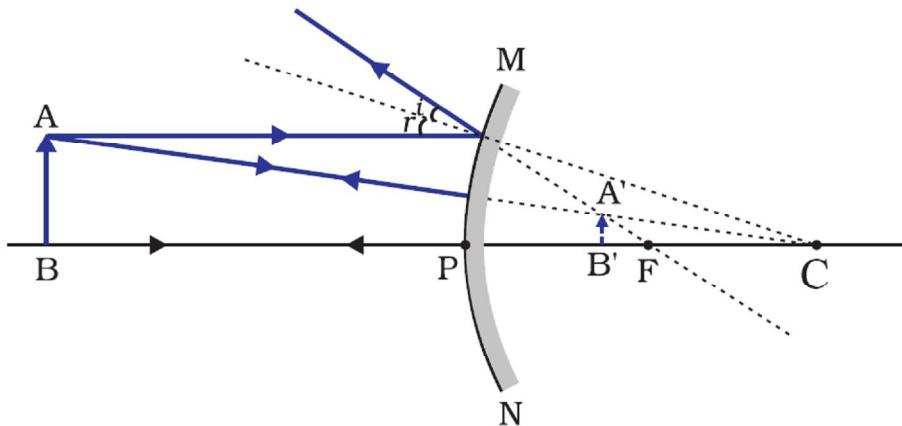
#### **FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONVEX MIRROR**

The type of image formed by a convex mirror depends on the position of object in front of the mirror. There are six positions of the object:

#### **Case–1: Object is placed between P and infinity**

When an object is placed between pole and infinity in front of a convex mirror, the image formed is

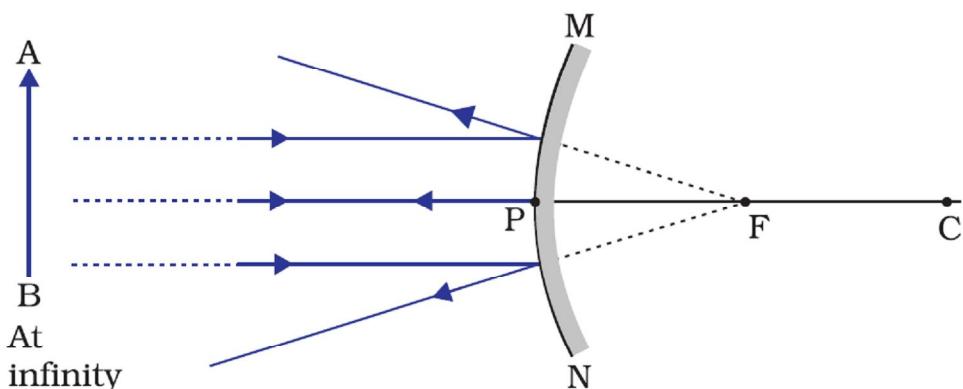
- (i) between the pole and focus
- (ii) virtual and erect, and
- (iii) smaller than the object (or diminished)



### Case–2: Object is at infinity.

When an object is placed at infinity of a convex mirror, the image formed is

- (i) behind the mirror at focus
- (ii) virtual and erect, and
- (iii) much smaller than the object (or highly diminished)



## USES OF CONVEX MIRRORS

Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles. These mirrors are fitted on the sides of the vehicle, enabling the driver to see traffic behind him/her to facilitate safe driving. Convex mirrors are preferred because they always give an erect, though diminished, image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view much larger area than would be possible with a plane mirror.

### INTEXT QUESTIONS PAGE NO. 168

#### **1. Define the principal focus of a concave mirror.**

**Ans.** Light rays that are parallel to the principal axis of a concave mirror converge at a specific point on its principal axis after reflecting from the mirror. This point is known as the principal focus of the concave mirror.

#### **2. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?**

**Ans.** Here  $R = 20 \text{ cm}$

$$\text{We know that } f = \frac{R}{2} \Rightarrow f = \frac{20}{2} = 10 \text{ cm}$$

### **3. Name a mirror that can give an erect and enlarged image of an object.**

**Ans.** When an object is placed between the pole and the principal focus of a concave mirror, the image formed is virtual, erect, and enlarged.

### **4. Why do we prefer a convex mirror as a rear-view mirror in vehicles?**

**Ans.** Convex mirrors give a virtual, erect, and diminished image of the objects placed in front of them. They are preferred as a rear-view mirror in vehicles because they give a wider field of view, which allows the driver to see most of the traffic behind him.

## **MIRROR FORMULA**

In a spherical mirror, the distance of the object from its pole is called the object distance ( $u$ ). The distance of the image from the pole of the mirror is called the image distance ( $v$ ). The distance of the principal focus from the pole is called the focal length ( $f$ ). There is a relationship between these three quantities given by the *mirror formula* which is expressed as

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

## **MAGNIFICATION**

Magnification produced by a spherical mirror gives the relative extent to which the image of an object is magnified with respect to the object size. It is expressed as the ratio of the height of the image to the height of the object. It is usually represented by the letter  $m$ . If  $h_1$  is the height of the object and  $h_2$  is the height of the image, then the magnification  $m$  produced by a spherical mirror is given by

$$m = \frac{\text{height of the image}}{\text{height of the object}} \Rightarrow m = \frac{h_2}{h_1}$$

The magnification  $m$  is also related to the object distance ( $u$ ) and image distance ( $v$ ). It can be expressed as:

$$m = \frac{h_2}{h_1} = -\frac{v}{u}$$

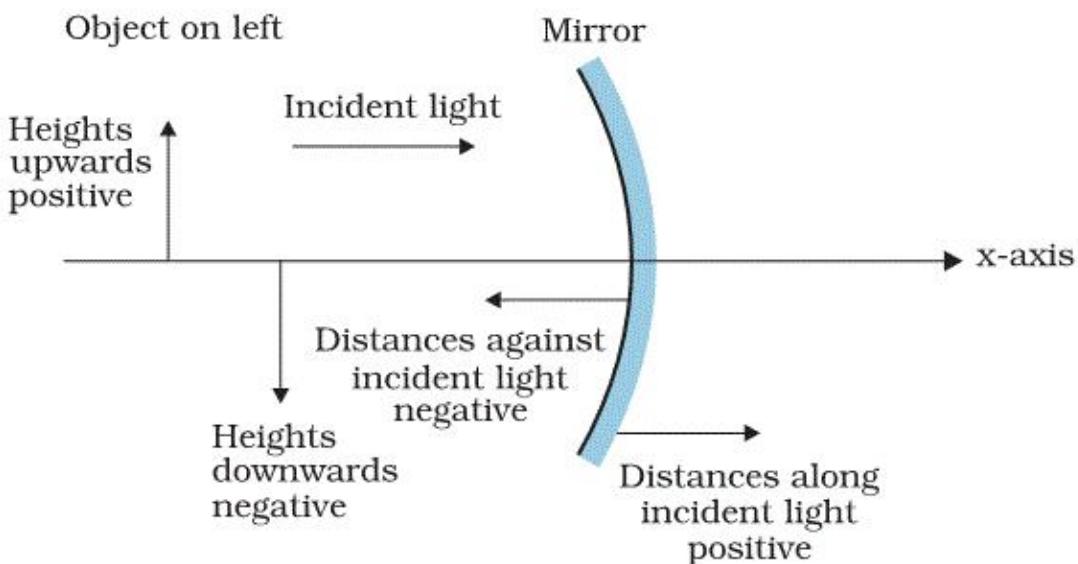
### **Points to be remembered:**

- The height of the object is taken to be positive as the object is usually placed above the principal axis.
- The height of the image should be taken as positive for virtual images. However, it is to be taken as negative for real images.
- When the image is real, it is inverted so  $h_2$  is negative which results  $m$  is -ve. A negative sign in the value of the magnification indicates that the image is real.
- When the image is virtual, it is erect so  $h_2$  is positive which results  $m$  is +ve. A positive sign in the value of the magnification indicates that the image is virtual.

## SIGN CONVENTION FOR SPHERICAL MIRRORS

The following sign convention is used for measuring various distances in the ray diagrams of spherical mirrors:

1. Object is always placed to the left of mirror
2. All distances are measured from the pole of the mirror.
3. Distances measured in the direction of the incident ray are positive and the distances measured in the direction opposite to that of the incident rays are negative.
4. Distances measured above the principal axis are positive and that measured below the principal axis are negative.



### INTEXT QUESTIONS PAGE NO. 171

- 1. Find the focal length of a convex mirror whose radius of curvature is 32 cm.**

**Ans.**

Ans. Here  $R = 32 \text{ cm}$

$$\text{We know that } f = \frac{R}{2} \Rightarrow f = \frac{32}{2} = 16 \text{ cm}$$

Hence, the focal length of the given convex mirror is 16 cm.

- 2. A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?**

**Ans.** Here, magnification,  $m = -3$ ,

object distance,  $u = -10 \text{ cm}$  and

image distance,  $v = ?$

Putting these values in the magnification formula for a mirror, we get

$$\begin{aligned} m &= -\frac{v}{u} \Rightarrow -3 = -\frac{v}{-10} \\ \Rightarrow v &= -30 \text{ cm} \end{aligned}$$

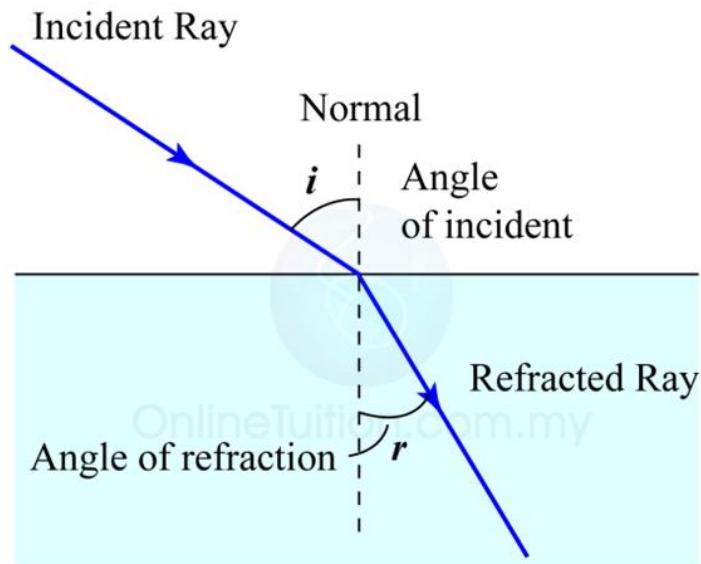
## **NUMERICALS BASED ON CONVEX AND CONCAVE MIRROR**

1. Find the focal length of a convex mirror of radius of curvature 1m.
2. Focal length of a convex mirror is 50 cm. What is its radius of curvature?
3. Radius of curvature of a concave mirror is 25 cm. What is its focal length?
4. A concave mirror produces 10 cm long image of an object of height of 2cm. What is the magnification produced?
5. An object 1 cm high is held near a concave mirror of magnification 10. How tall will be the image?
6. An object 4 cm in size is placed at a distance of 25 cm from a concave mirror of focal length 15 cm. Find the position, nature and height of the image.
7. A converging mirror forms a real image of height 4 cm, of an object of height 1 cm placed 20 cm away from the mirror. Calculate the image distance. What is the focal length of the mirror?
8. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.
9. An arrow 2.5 cm high is placed at a distance of 25 cm from a diverging mirror of focal length 20 cm., Find the nature, position and size of the image formed.
10. The image formed by a convex mirror of focal length 20cm is a quarter of the object. What is the distance of the object from the mirror?
11. Find the size, nature and position of image formed by a concave mirror, when an object of size 1cm is placed at a distance of 15cm. Given focal length of mirror is 10cm.
12. An object 2cm high is placed at a distance of 16cm from a concave mirror, which produces 3cm high inverted image. What is the focal length of the mirror? Also, find the position of the image.
13. An erect image 3 times the size of the object is obtained with a concave mirror of radius of curvature 36cm. What is the position of the object?
14. A 2.5cm candle is placed 12 cm away from a convex mirror of focal length 30cm. Give the location of the image and the magnification.
15. An object is placed in front of a concave mirror of focal length 20cm. The image formed is 3 times the size of the object. Calculate two possible distances of the object from the mirror.
16. The image formed by a convex mirror is virtual, erect and smaller in size. Illustrate with figure.

- 17.** A concave mirror produces a real image 10mm tall, of an object 2.5mm tall placed at 5cm from the mirror. Calculate focal length of the mirror and the position of the image.
- 18.** An object is placed at a large distance in front of a convex mirror of radius of curvature 40cm. How far is the image behind the mirror?
- 19.** An object is placed 15cm from a convex mirror of radius of curvature 90cm. Calculate position of the image and its magnification.
- 20.** The image formed by a convex mirror of focal length 30cm is a quarter of the object. What is the distance of the object from the mirror?
- 21.** When an object is placed at a distance of 60cm from a convex mirror, the magnification produced is  $1/2$ . Where should the object be placed to get a magnification of  $1/3$ ?
- 22.** An object is placed 18cm front of a mirror. If the image is formed at 4cm to the right of the mirror. Calculate its focal length. Is the mirror convex or concave? What is the nature of the image? What is the radius of curvature of the mirror?
- 23.** A convex mirror used for rear view on an automobile has a radius of curvature of 3m. If a bus is located at 5m from this mirror, find the position, nature and magnification of the image.
- 24.** An object 3cm high is held at a distance of 50cm from a diverging mirror of focal length 25cm. Find the nature, position and size of the image formed.
- 25.** A converging mirror of focal length 20cm forms an image which is two times the size of the object. Calculate two possible distances of the object from the mirror.
- 26.** The linear magnification of a convex mirror of focal length 15cm is  $1/3$ . What is the distance of the object from the focus of the mirror?
- 27.** The focal length of a convex mirror is 12.5 cm. How far is its centre of curvature (i) from the pole (ii) from the focus.
- 28.** Find the focal length of a concave mirror that produces four times larger real image of an object held at 5cm from the mirror.
- 29.** An object is held at 30cm in front of a convex mirror of focal length 15cm. At what distance from the convex mirror should a plane mirror be held so that images in the two images coincide with each other?
- 30.** Draw any three ray diagrams to show how the size and nature of image of an object change when it moves from centre of curvature of concave mirror towards the pole of the mirror.

## **REFRACTION OF LIGHT**

The change in direction of light when it passes from one medium to another obliquely, is called refraction of light. In other words, the bending of light when it goes from one medium to another obliquely is called refraction of light. The refraction takes place when light enters from air to water (see below figure).



The speed of light is different in different substances. The refraction of light is due to the change in the speed of light on going from one medium to another. Thus, when light goes from one medium to another, its speed changes. And this change in speed of light causes the refraction of light.

## **MEDIUM**

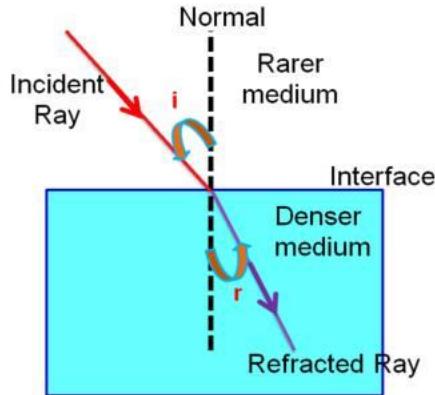
A transparent substance in which light travels is known as a medium. Medium can be divided into two types:

1. **Optically rarer medium:** A medium in which the speed of light is more is known as optically rarer medium (or less dense medium)
2. **Optically denser medium:** A medium in which the speed of light is less is known as optically denser medium (or more dense medium)

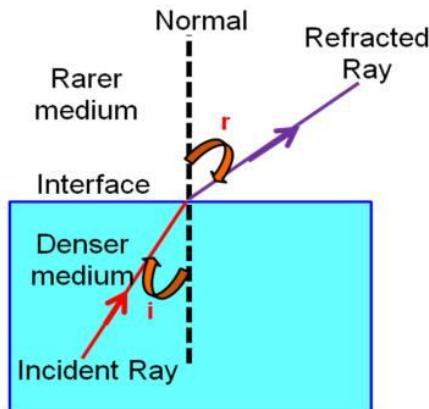
Glass is an optically denser medium than air and water.

## **RULES OF REFRACTION :**

**Rule-1 :** When a light ray travels from a rarer medium to a denser medium, the light ray bends towards the normal.



**Rule-2 :** When a light ray travels from a denser medium to a rarer medium, the light ray bends away from the normal



## LAWS OF REFRACTION

According to laws of refraction of light.

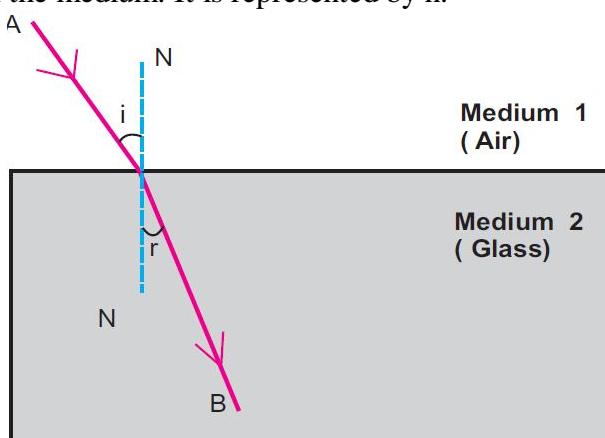
(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

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

If  $i$  is the angle of incidence and  $r$  is the angle of refraction, then,  $\frac{\sin i}{\sin r} = \text{constant}$ . This constant value is called the refractive index of the second medium with respect to the first.

## REFRACTIVE INDEX

The refractive index of a medium is defined as the ratio of speed of light in vacuum to the speed of light in the medium. It is represented by  $n$ .



➤ Refractive index of a medium,  $n = \frac{\text{speed of light in vacuum/air}}{\text{speed of light in medium}} = \frac{c}{v}$

Both  $c$  and  $v$  are in m/s

➤ Relative refractive index of medium 2 w.r.t. medium 1 is  ${}^1n_2 = \frac{n_2}{n_1} = \frac{v_1}{v_2}$

➤ Both  $v_1, v_2$  are in m/s,  $n_2, n_1$  have no units

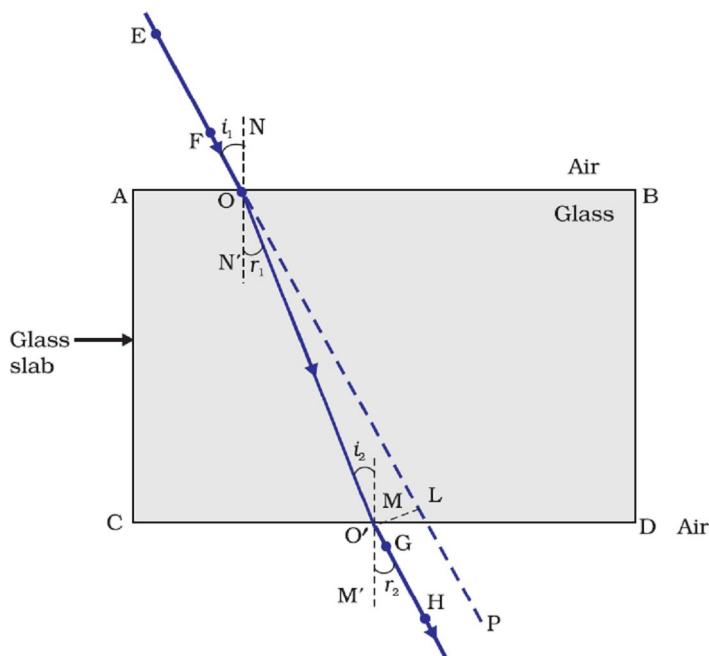
$${}^1n_2 = \frac{1}{{}^2n_1}$$

- Snell's law of refraction: When light travels from medium 1 to medium 2, then
$$n_2 = \frac{n_1}{n_2} = \frac{\sin i}{\sin r}$$
- $n_w = \frac{\text{real depth}(x)}{\text{apparent depth}(a)}$   
Both x and y are in metre or in cm.
- Velocity of light in vacuum/air is  $c = 3 \times 10^8$  m/s.

## **TWO REFRACTIONS THROUGH A RECTANGULAR GLASS SLAB**

On passing through a rectangular glass slab, a ray of light suffers two refractions, one while going from air to glass and the other while going from glass to air. Light emerges from rectangular slab in a direction parallel to that in which it entered the glass slab. However the final emergent ray is slightly shifted sideways from the direction of original incident ray by a distance x called lateral shift.

The perpendicular distance between the original path of incident ray and the emergent ray coming out of the glass slab is called lateral displacement of the emergent ray of light. Lateral displacement depends mainly on three factors: angle of incidence, thickness of glass slab and refractive index of glass slab. Actually lateral displacement is directly proportional to (i) angle of incidence (ii) thickness of glass slab (iii) refractive index of glass slab. Higher the values of these factors, greater will be the lateral displacement. The angle which the emergent ray makes with the normal is called the angle of emergence.



## **CONDITION FOR NO REFRACTION**

Refraction will not take place under the following two conditions:

1. When light is incident normally on a boundary.

A ray of light traveling in medium 1 falls normally. Therefore angle of incidence,  $I = 0^\circ$ .

According to Snell's law.

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

$$\text{or } \sin r = \frac{n_1}{n_2} \sin i = \frac{n_1}{n_2} \sin 0^\circ = \frac{n_1}{n_2} \times 0 = 0$$

$$\text{or } r = 0$$

Thus, there is no deviation in the ray at the boundary. Hence, no refraction occurs when light is incident normally on a boundary of two media.

**2. When the refractive indices of two media are equal.**

When refractive index of medium 1 is equal to refractive index of medium 2 i.e.

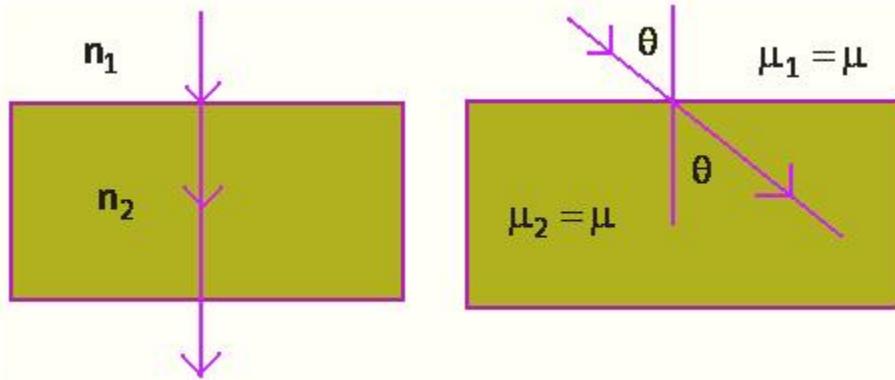
$n_1 = n_2$ , then according to Snell's law

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = 1$$

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

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

Hence no refraction occurs at the boundary that separates two media of equal refractive indices.



**INTEXT QUESTIONS – PAGE No. 176**

**1. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?**

The light ray bends towards the normal. When a ray of light travels from an optically rarer medium to an optically denser medium, it gets bent towards the normal. Since water is optically denser than air, a ray of light travelling from air into the water will bend towards the normal.

**2. Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is  $3 \times 10^8$  m/s.**

Refractive index of a medium  $n_m$  is given by,

$$n_m = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

Speed of light in vacuum,  $c = 3 \times 10^8$  m/s

Refractive index of glass,  $n_g = 1.50$

$$\text{Speed of light in the glass, } v = \frac{c}{n_g} = \frac{3 \times 10^8}{1.50} = 2 \times 10^8 \text{ m/s}$$

- 3. Find out, from Table 10.3, the medium having highest optical density. Also find the medium with lowest optical density.**

Highest optical density = Diamond

Lowest optical density = Air

Optical density of a medium is directly related with the refractive index of that medium. A medium which has the highest refractive index will have the highest optical density and vice-versa.

It can be observed from table 10.3 that diamond and air respectively have the highest and lowest refractive index. Therefore, diamond has the highest optical density and air has the lowest optical density.

- 4. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table 10.3.**

Speed of light in a medium is given by the relation for refractive index ( $n_m$ ). The relation is given as

$$n_m = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

$$v = \frac{c}{n_m} \Rightarrow v \propto \frac{1}{n_m}$$

It can be inferred from the relation that light will travel the slowest in the material which has the highest refractive index and travel the fastest in the material which has the lowest refractive index.

It can be observed from table 10.3 that the refractive indices of kerosene, turpentine, and water are 1.44, 1.47, and 1.33 respectively. Therefore, light travels the fastest in water.

- 5. The refractive index of diamond is 2.42. What is the meaning of this statement?**

Refractive index of a medium  $n_m$  is related to the speed of light in that medium  $v$  by the relation:

$$n_m = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

Where,  $c$  is the speed of light in vacuum/air

The refractive index of diamond is 2.42. This suggests that the speed of light in diamond will reduce by a factor 2.42 compared to its speed in air.

## **NUMERICALS**

1. Light travels through water with a speed of  $2.25 \times 10^8$  m/s. What is the refractive index of water?
2. Light travels from rarer medium 1 to a denser medium 2. The angle of incident and refraction are respectively  $45^\circ$  and  $30^\circ$ . Calculate the (i) refractive index of second medium with respect to the first medium and (ii) refractive index of medium 1 with respect to the medium 2.
3. A pond of depth 20cm is filled with water of refractive index  $4/3$ . Calculate apparent depth of the tank when viewed normally.
4. How much time will light take to cross 2mm thick glass pane if refractive index of glasses is  $3/2$ ?

5. Calculate speed of light in water of refractive index 4/3.
6. A ray of light passes from air to glass ( $n = 1.5$ ) at an angle of  $30^\circ$ . Calculate the angle of refraction.
7. A ray of light is incident on a glass slab at an angle of  $45^\circ$ . If refractive index of glass be 1.6, what is the angle of refraction?
8. The refractive index of diamond is 2.47 and that of glass is 1.51. How much faster does light travel in glass than in diamond?
9. The refractive index of glycerine is 1.46. What is the speed of light in air if its speed in glycerine is  $2.05 \times 10^8$  m/s?
10. The refractive index of glass is 1.6 and that of diamond is 2.4. Calculate (i) refractive index of diamond with respect to glass and (ii) refractive index of glass with respect to diamond.
11. A ray of light is travelling from glass to air. The angle of incidence in glass is  $30^\circ$  and angle of refraction in air is  $60^\circ$ . What is the refractive index of glass w.r.t air?
12. A ray of light is travelling from air to water. What is the angle of incidence in air, if angle of refraction in water is  $45^\circ$ ? Take refractive index of water = 1.32
13. A water tank appears to be 4 m deep when viewed from the top. If refractive index of water is 4/3, what is the actual depth of the tank?
14. What is the real depth of a swimming pool when its bottom appears to be raised by 1m? Given refractive index of water is 4/3.
15. A jar 15 cm long is filled with a transparent liquid. When viewed from the top, its bottom appears to be 12cm below. What is the refractive index of the liquid?

### **SPHERICAL LENSES**

A lens is any transparent material (e.g. glass) of an appropriate shape that can take parallel rays of incident light and either converge the rays to a point or diverge the rays from a point.

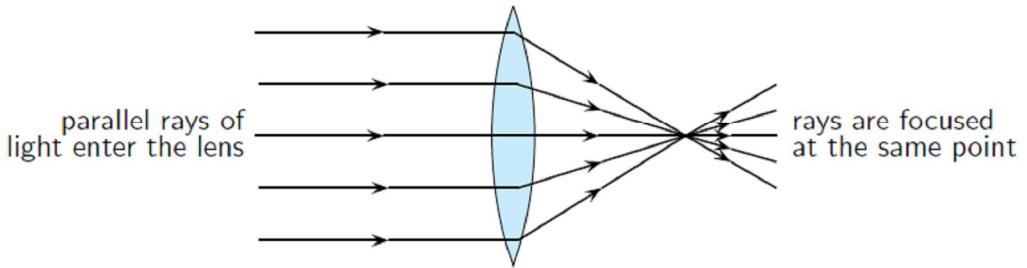
A transparent material bound by two surfaces, of which one or both surfaces are spherical, forms a lens.

Some lenses will focus light rays to a single point. These lenses are called converging or concave lenses. Other lenses spread out the light rays so that it looks like they all come from the same point. These lenses are called diverging or convex lenses. Lenses change the direction of light rays by refraction. They are designed so that the image appears in a certain place or as a certain size. Lenses are used in eyeglasses, cameras, microscopes, and telescopes.

### **CONVEX LENS**

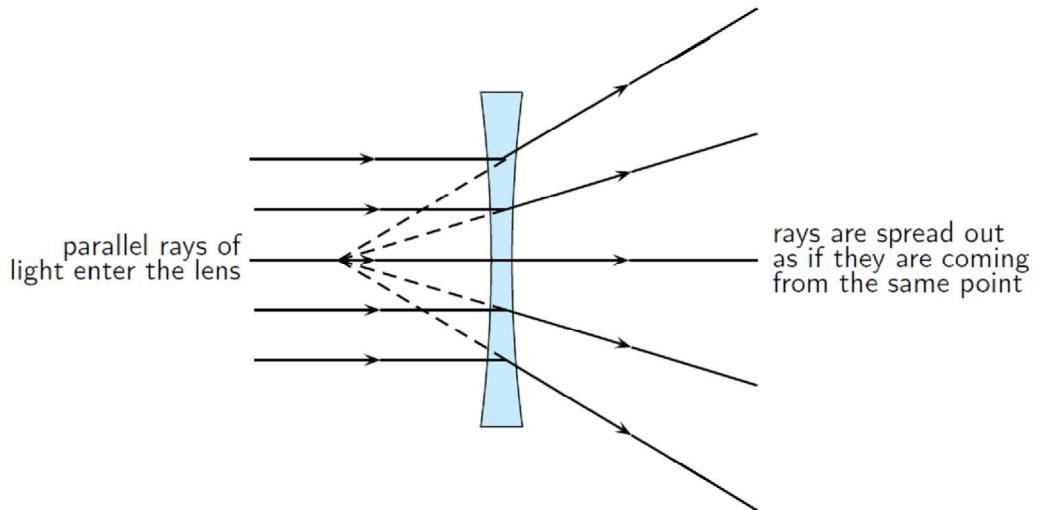
A lens may have two spherical surfaces, bulging outwards. Such a lens is called a double convex lens. It is simply called a convex lens. It is thicker at the middle as

compared to the edges. Convex lens converges light rays. Hence it is called converging lens.



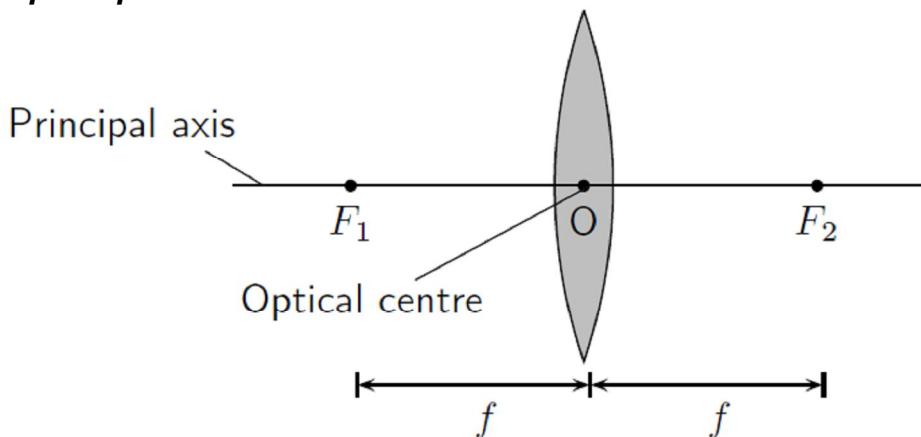
### CONCAVE LENS

A double concave lens is bounded by two spherical surfaces, curved inwards. It is thicker at the edges than at the middle. Such lenses diverge light rays and are called diverging lenses. A double concave lens is simply called a concave lens.



### TERMS RELATED TO SPHERICAL LENS

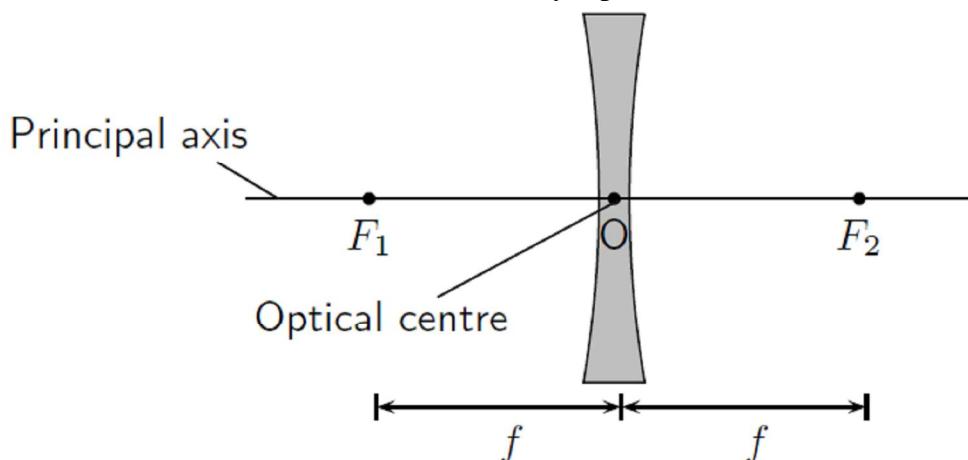
**Principal Axis:** The principal axis is the line which runs horizontally straight through the optical centre of the lens. It is also sometimes called the optic axis. In other words, an imaginary straight line passing through the two centres of the curvature of a lens is called its **principal axis**.



**Optical Centre:** The optical centre (O) of a convex lens is usually the centre point of the lens. The direction of all light rays which pass through the optical centre, remains unchanged.

**Centre of Curvature:** A lens has two spherical surfaces. Each of these surfaces forms a part of a sphere. The centers of these spheres are called **centres of curvature**

**of the lens.** The centre of curvature of a lens is usually represented by the letter C. Since there are two centre's of curvature, we may represent them as  $C_1$  and  $C_2$ .



**Aperture:** The effective diameter of the circular outline of a spherical lens is called its **aperture**. Lenses whose aperture is much less than its radius of curvature are called thin lenses with small aperture.

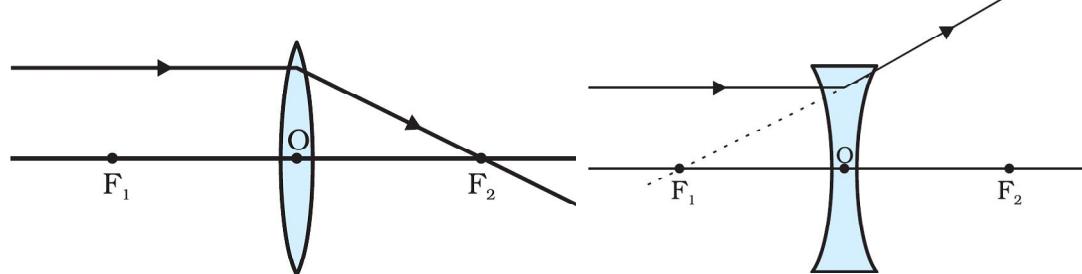
**Focus:** The focus or focal point of the lens is the position on the principal axis where all light rays that run parallel to the principal axis through the lens converge (come together) at a point. Since light can pass through the lens either from right to left or left to right, there is a focal point on each side of the lens ( $F_1$  and  $F_2$ ), at the same distance from the optical centre in each direction. (Note: the plural form of the word focus is foci.)

**Focal Length:** The focal length ( $f$ ) is the distance between the optical centre and the focal point.

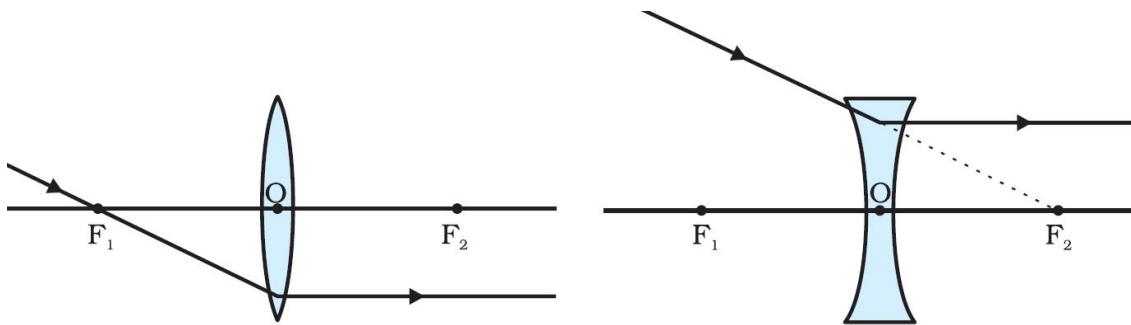
### **RULES FOR OBTAINING IMAGES FORMED BY SPHERICAL LENSES**

The intersection of at least two reflected rays give the position of image of the point object. Any two of the following rays can be considered for locating the image.

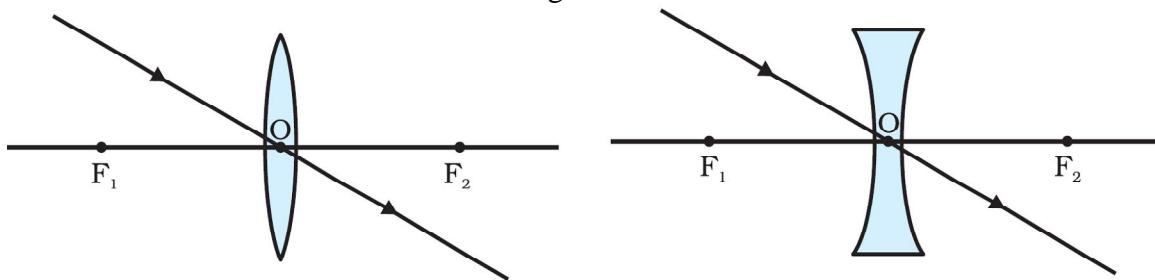
1. A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens, as shown in below figure. In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens, as shown in below figure



2. A ray of light passing through a principal focus, after refraction from a convex lens, will emerge parallel to the principal axis. This is shown in below figure. A ray of light appearing to meet at the principal focus of a concave lens, after refraction, will emerge parallel to the principal axis. This is shown in below figure.



3. A ray of light passing through the optical centre of a lens will emerge without any deviation. This is illustrated in below figure.



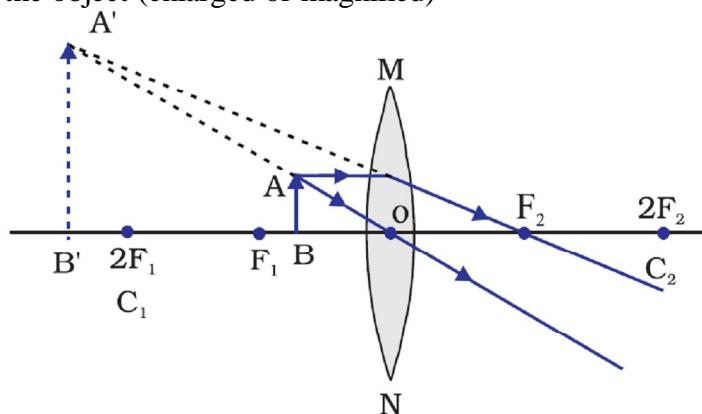
### **FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONVEX LENS**

The type of image formed by a convex lens depends on the position of object in front of the lens. There are six positions of the object:

#### **Case–1: Object is in between optical centre(O) and focus (F<sub>1</sub>)**

When the object is placed between optical centre(O) and focus( $F_1$ ), the image formed is (i) behind the object (on the left side of lens)

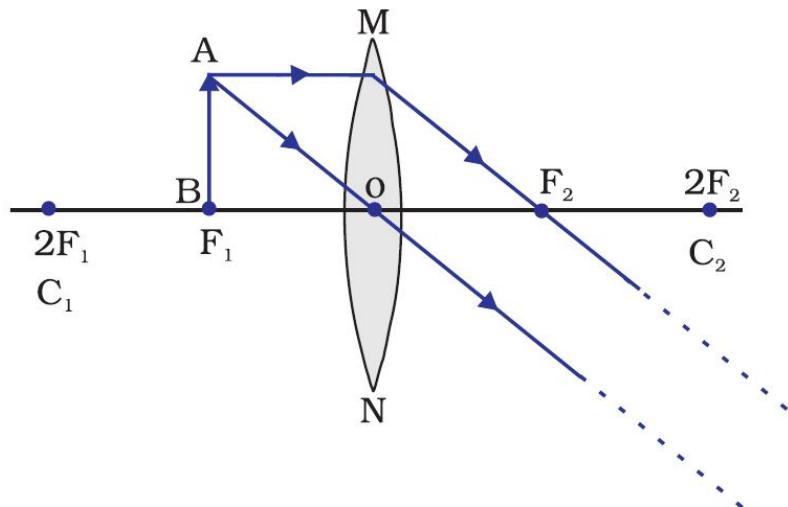
- (ii) virtual and erect, and
- (iii) larger than the object (enlarged or magnified)



#### **Case–2: Object is at the focus (F<sub>1</sub>)**

When the object is placed at the focus( $F_1$ ), the image formed is

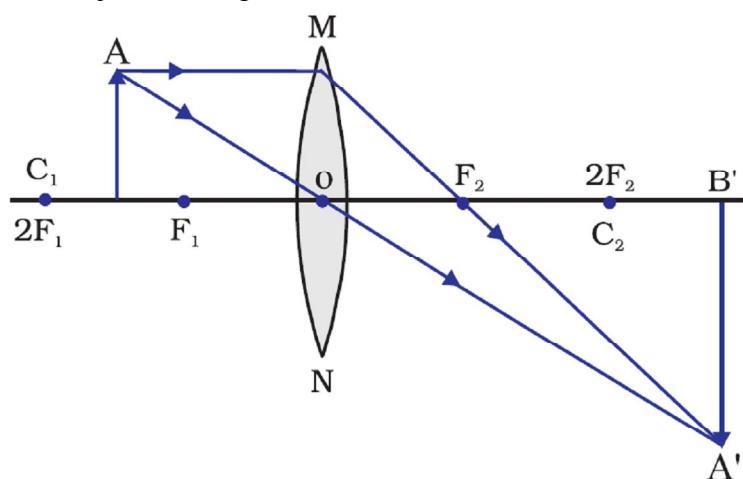
- (i) at infinity
- (ii) real and inverted, and
- (iii) highly enlarged



### Case 3: Object is in between $F_1$ and $2F_1$

When the object is placed between  $F_1$  and  $2F_1$  in front of a convex lens, the image formed is

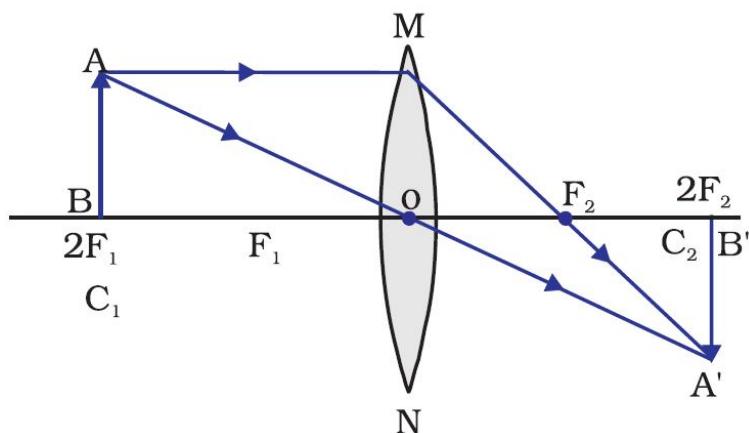
- (i) beyond  $2F_2$ ,
- (ii) real and inverted, and
- (iii) larger than the object (or magnified).



### Case 4: Object is at $2F_1$

When the object is placed at a distance  $2f$  in front of convex lens, the image formed is

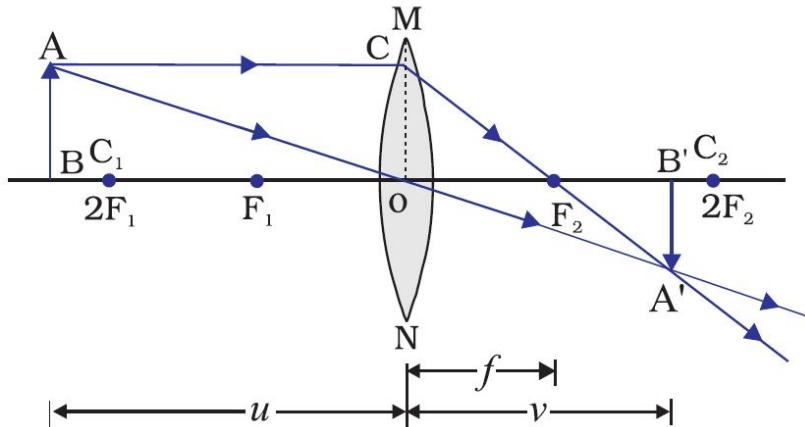
- (i) at  $2F_2$  on the other side of the lens,
- (ii) real and inverted, and
- (iii) of the same size as the object.



### Case-5: Object is at beyond $2F_1$

When the object is placed beyond  $2F_1$  in front of the convex lens, the image formed is

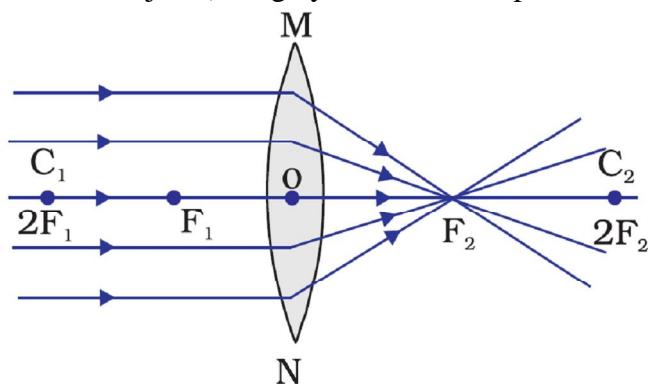
- real and inverted, and
- smaller than the object (or diminished)



### Case-6: Object is at infinity

When the object is placed at the infinity, the image formed is

- at the focus  $F_2$ .
- real and inverted, and
- much smaller than the object (or highly diminished or point sized)



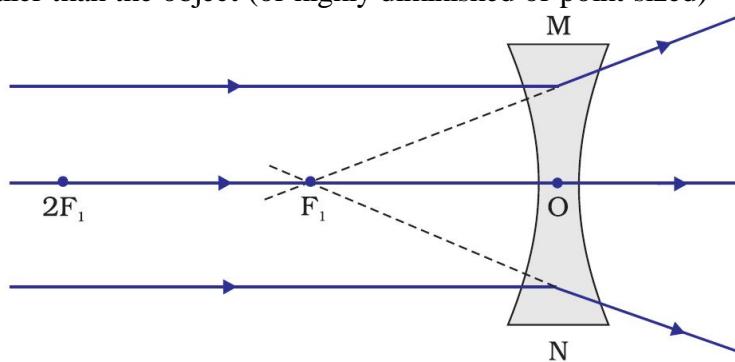
## FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONCAVE LENS

The type of image formed by a concave lens depends on the position of object in front of the lens. There are two positions of the object:

### Case-1: Object is at infinity

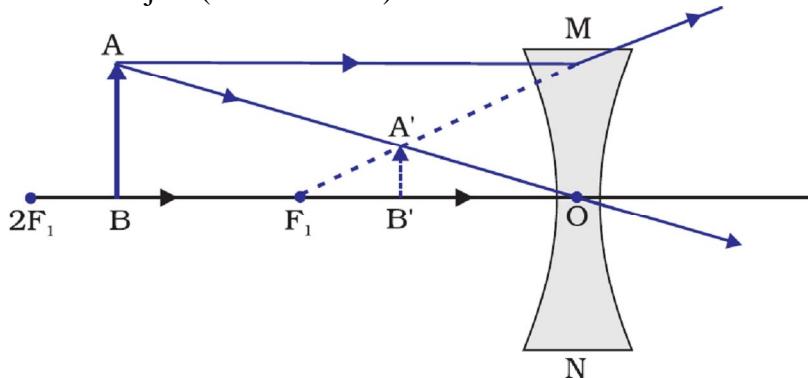
When the object is placed at the infinity, the image formed is

- at the focus  $F_1$ .
- virtual and erect, and
- much smaller than the object (or highly diminished or point sized)



### Case–2: Object is in between optical centre(O) and infinity

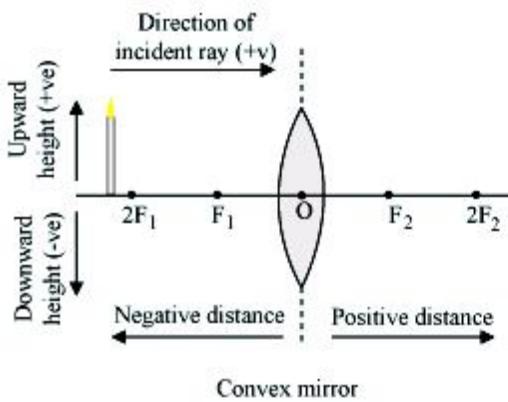
When the object is placed in between optical centre(O) and infinity, the image formed is  
 (i) between optical centre(O) and focus  $F_1$ .  
 (ii) virtual and erect, and  
 (iii) smaller than the object (or diminished)



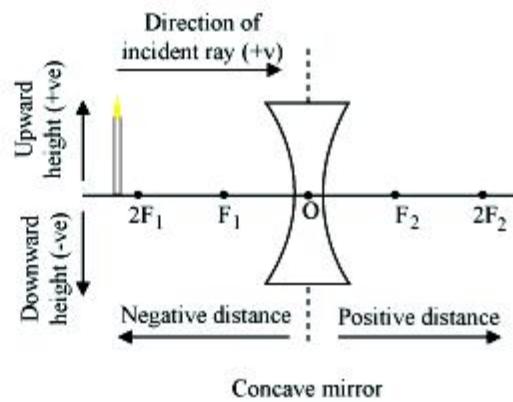
### SIGN CONVENTION FOR SPHERICAL LENSES

While using the lens formula we must make use of proper sign convention while taking the values of object (u), image distance (v), focal length (f), object height (h) and image height (h'). The sign conventions are as follows:

1. All distances are measured from the optical centre of the lens.
2. The distances measured in the same direction as the incident light are taken positive.
3. The distances measured in the direction opposite to the direction of incident light are taken negative.
4. Heights measured upwards and perpendicular to the principal axis are taken positive.
5. Heights measured downwards and perpendicular to the principal axis are taken negative.



Convex mirror



Concave mirror

Consequences of new Cartesian sign convention:

- The focal length of a convex lens is positive and that of a concave lens is negative.
- Object distance u is always negative.
- The distance of real image is positive and that of virtual image is negative.
- The object height h is always positive. Height h' of virtual erect image is positive and that of real inverted image is negative.
- The linear magnification,  $m = h'/h$  is positive for a virtual image and negative for a real image.

## **LENS FORMULA**

Lens formula gives the relationship between object distance ( $u$ ), image-distance ( $v$ ) and the focal length ( $f$ ). The lens formula is expressed as

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

where ‘ $u$ ’ is the distance of the object from the optical centre (O), ‘ $v$ ’ is the distance of the image from the optical centre (O) and ‘ $f$ ’ is the distance of the principal focus from the optical centre (O).

## **MAGNIFICATION**

The magnification produced by a lens, similar to that for spherical mirrors, is defined as the ratio of the height of the image and the height of the object. It is represented by the letter  $m$ . If  $h$  is the height of the object and  $h'$  is the height of the image given by a lens, then the magnification produced by the lens is given by,

$$m = \frac{\text{Height of the Image}}{\text{Height of the object}} = \frac{h'}{h}$$

Magnification produced by a lens is also related to the object-distance  $u$ , and the image-distance  $v$ . This relationship is given by

$$\text{Magnification (m)} = \frac{h'}{h} = \frac{v}{u}$$

## **Points to be remembered**

- If the magnification ‘ $m$ ’ has a positive value, the image is virtual and erect. And if the magnification ‘ $m$ ’ has a negative value, the image will real and inverted.
- A convex lens can form virtual images as well as real images, therefore, the magnification produced by a convex lens can be either positive or negative.
- A convex lens can form images which are smaller than the object, equal to the object or bigger than the object, therefore magnification ‘ $m$ ’ produced by a convex lens can be less than 1, equal to 1 or more than 1.
- A concave lens, however, forms only virtual images, so the magnification produced by a concave lens is always positive.
- A concave lens forms image which are always smaller than the object, so the magnification ‘ $m$ ’ produced by a concave lens is always less than 1.

## **NUMERICALS BASED ON CONVEX LENS**

1. A convex lens of focal length 10cm is placed at a distance of 12cm from a wall. How far from the lens should an object be placed so as to form its real image on the wall?
2. If an object of 7cm height is placed at a distance of 12cm from a convex lens of focal length 8cm, find the position, nature and height of the image.

3. An object 4 cm high is placed at a distance of 10cm from a convex lens of focal length 20cm. Find the position, nature and size of the image.
4. A small object is so placed in front of a convex lens of 5 cm focal length that a virtual image is formed at a distance of 25cm. Find the magnification.
5. Find the position and nature of the image of an object 5cm high and 10cm in front of a convex lens of focal length 6cm.
6. Calculate the focal length of a convex lens, which produces a virtual image at a distance of 50cm of an object placed 20cm in front of it.
7. An object is placed at a distance of 100 cm from a converging lens of focal length 40cm. What is the nature and position of the image?
8. A convex lens produces an inverted image magnified three times of an object at a distance of 15 cm from it. Calculate focal length of the lens.
9. An object placed 4cm in front of a converging lens produces a real image 12cm from the lens. What is the magnification of the image? What is the focal length of the lens? Also draw the ray diagram to show the formation of the image.
10. A lens of focal length 20cm is used to produce a ten times magnified image of a film slide on a screen. How far must the slide be placed from the lens?
11. Determine how far an object must be placed in front of a converging lens of focal length 10cm in order to produce an erect image of linear magnification 4.
12. A convex lens of focal length 6cm is held 4cm from a newspaper, which has print 0.5cm high. By calculation, determine the size and nature of the image produced.
13. A convex lens of focal length 0.10m is used to form a magnified image of an object of height 5mm placed at a distance of 0.08m from the lens. Find the position, nature and size of the image.
14. An erect image 2cm high is formed 12cm from a lens, the object being 0.5cm high. Find the focal length of the lens.
15. The filament of a lamp is 80 cm from a screen and a converging lens forms an image of it on a screen, magnified three times. Find the distance of the lens from the filament and the focal length of the lens.
16. An object 2cm tall is placed on the axis of a convex lens of focal length 5cm at a distance of 10cm from the optical centre of the lens. Find the nature, position and size of the image formed. Which case of image formation by convex lenses is illustrated by this example?

- 17.** A converging lens of focal length 5cm is placed at a distance of 20cm from a screen. How far from the lens should an object be placed so as to form its real image on the screen?
- 18.** An object 5cm high is held 25cm away from a converging lens of focal length 10cm. Find the position, size and nature of the image formed. Also draw the ray diagram.
- 19.** At what distance should an object be placed from a convex lens of focal length 18cm to obtain an image at 24cm from it on the other side? What will be the magnification produced in this case?
- 20.** The magnification produced by a spherical lens is +2.5. What is the nature of image and lens?
- 21.** What is the nature of the image formed by a convex lens if the magnification produced by a convex lens is +3?
- 22.** What is the nature of the image formed by a convex lens if the magnification produced by a convex lens is -0.5?
- 23.** What is the position of image when an object is placed at a distance of 10cm from a convex lens of focal length 10cm?
- 24.** Describe the nature of the image formed when an object is placed at a distance of 30cm from a convex lens of focal length 15cm.
- 25.** At what distance from a converging lens of focal length 12cm must an object be placed in order that an image of magnification 1 will be produced?

### **NUMERICALS BASED ON CONCAVE LENS**

- 1.** A concave lens produces an image 20cm from the lens of an object placed 30cm from the lens. Calculate the focal length of the lens.
- 2.** The magnification of a spherical lens is +0.5. What is the nature of lens and image?
- 3.** If an object is placed at a distance of 50cm from a concave lens of focal length 20cm, find the position, nature and height of the image.
- 4.** An object is placed at a distance of 4 cm from a concave lens of focal length 12cm. Find the position and nature of the image.
- 5.** An object is placed at a distance of 50cm from a concave lens produces a virtual image at a distance of 10 cm in front of the lens. Draw a diagram to show the formation of image. Calculate focal length of the lens and magnification produced.

- 6.** A 50 cm tall object is at a very large distance from a diverging lens. A virtual, erect and diminished image of the object is formed at a distance of 20 cm in front of the lens. How much is the focal length of the lens?
- 7.** A concave lens of focal length 15cm forms an image 10cm from the lens. How far is the object placed from the lens? Draw the ray diagram.
- 8.** An object 60cm from a lens gives a virtual image at a distance of 20cm in front of the lens. What is the focal length of the lens? Is the lens converging or diverging? Give reasons for your answer.
- 9.** A concave lens of 20 cm focal length forms an image 15cm from the lens. Compute the object distance.
- 10.** A concave lens has focal length 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also find the magnification produced by the lens.
- 11.** Calculate the image distance for an object of height 12 mm at a distance of 0.20 m from a concave lens of focal length 0.30m and state the nature and size of the image.
- 12.** A concave lens has focal length of 20cm. At what distance from the lens a 5cm tall object be placed so that it forms an image at 15cm from the lens? Also calculate the size of the image formed.
- 13.** An object is placed 20cm from (a) a converging lens and (b) a diverging lens of focal length 15cm. Calculate the image position and magnification in each case.
- 14.** A 2.0 cm tall object is placed 40cm from a diverging lens of focal length 15 cm. Find the position and size of the image.
- 15.** Find the position and size of the virtual image formed when an object 2 cm tall is placed 20cm from (a) diverging lens of focal length 40cm and (b) converging lens of focal length 40 cm.
- 16.** The magnification produced by a spherical lens is +0.75. What is the nature of image and lens?
- 17.** The magnification produced by a spherical lens and a spherical mirror is +0.8. What is the nature of lens and mirror?
- 18.** The magnification produced by a spherical lens and a spherical mirror is +2.0. What is the nature of lens and mirror?
- 19.** The lens A produces a magnification of -0.6 whereas lens b produces magnification of +0.6. What is the nature of lens A and B.

- 20.** An object is 2m from a lens which forms an erect image one-fourth (exactly) the size of the object. Determine the focal length of the lens. What type of the lens is this?

### **POWER OF A LENS**

The power of a lens is defined as the reciprocal of its focal length. It is represented by the letter  $P$ . The power  $P$  of a lens of focal length  $f$  is given by

$$P = \frac{1}{f}$$

The SI unit of power of a lens is ‘dioptre’. It is denoted by the letter D. If  $f$  is expressed in metres, then, power is expressed in dioptres. Thus, 1 dioptre is the power of a lens whose focal length is 1 metre.  $1D = 1\text{m}^{-1}$ . The *power of a convex lens is positive and that of a concave lens is negative*.

Many optical instruments consist of a number of lenses. They are combined to increase the magnification and sharpness of the image. The net power ( $P$ ) of the lenses placed in contact is given by the algebraic sum of the individual powers  $P_1$ ,  $P_2$ ,  $P_3$ , ... as  $P = P_1 + P_2 + P_3 + \dots$

### **NUMERICALS ON POWER OF LENS**

- 1.** A concave lens produces an image 20cm from the lens of an object placed 30cm from the lens. Calculate the power of the lens.
- 2.** A convex lens is of focal length 10 cm. What is its power?
- 3.** A person having a myopia eye uses a concave lens of focal length 50cm. What is the power of the lens?
- 4.** A thin lens has a focal length of -25cm. What is the power of the lens and what is its nature?
- 5.** A lens has a power of -2.5 D. What is the focal length and nature of the lens?
- 6.** Find the power of a concave lens of focal length 2 m.
- 7.** A convex lens forms a real and inverted image of needle at a distance of 50cm from the lens. If the image is of the same size as the needle, where is the needle placed in front of the lens? Also, find the power of the lens.
- 8.** Two thin lenses of power +3.5 D and -2.5 D are placed in contact. Find the power and focal length of the lens combination.
- 9.** A doctor has prescribed a corrective lens of power -1.5 D. Find the focal length of the lens. Is the prescribed lens is diverging or converging?
- 10.** A concave lens of focal length 25 cm and a convex lens of focal length 20 cm are placed in contact with each other. What is the power of this combination? Also, calculate focal length of the combination.

- 11.** A convex lens of focal length 20 cm is placed in contact with a concave lens of focal length 10cm. What is the focal length and power of the combination?
- 12.** An object is placed at a distance of 50cm from a concave lens of focal length 30cm. Find the nature and position of the image.
- 13.** An object of height 2 cm is placed at a distance of 15cm in front of a concave lens of power -10D. Find the size of the image.
- 14.** A convergent lens of power 8D is combined with a divergent lens of power -10D. Calculate focal length of the combination.
- 15.** A concave lens is kept in contact with a convex lens of focal length 20cm. The combination works as a converging lens of focal length 100cm. Calculate power of concave lens.
- 16.** Find the focal length and nature of lens which should be placed in contact with a lens of focal length 10 cm so that the power of the combination becomes 5D.
- 17.** A convex lens of power 3D is held in contact with a concave lens of power - 1 D. A parallel beam of light is made to fall on the combination. At what distance from the combination will the beam get focussed?
- 18.** A convex lens of focal length 25cm and a concave lens of focal length 10cm are placed in close contact with one another.
- What is the power of the combination?
  - What is the focal length of the combination?
  - Is this combination converging or diverging?
- 19.** The power of a combination of two lenses X and Y is 5D. If the focal length of lens X be 15 cm, then
- calculate the focal length of lens Y.
  - State the nature of the lens Y.
- 20.** Two lenses A and B have focal lengths of +20cm and - 10 cm, respectively.
- What is the nature of lens A and lens B?
  - What is the power of lens A and lens B?
- What is the power of the combination if lenses A and B are held close together?

### **INTEXT QUESTIONS PAGE No. 184**

#### **1. Define 1 dioptre of power of a lens.**

Power of lens is defined as the reciprocal of its focal length. If P is the power of a lens of focal length F in metres, then

The S.I. unit of power of a lens is Dioptre. It is denoted by D.

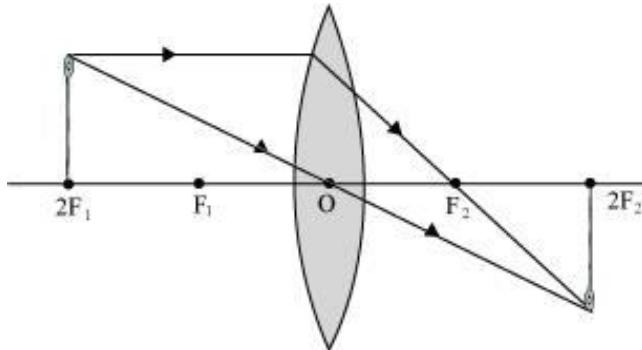
$$P = \frac{1}{f(\text{in metres})}$$

1 dioptre is defined as the power of a lens of focal length 1 metre.

Hence,  $1 \text{ D} = 1 \text{ m}^{-1}$

- 2. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.**

When an object is placed at the centre of curvature,  $2F_1$ , of a convex lens, its image is formed at the centre of curvature,  $2F_2$ , on the other side of the lens. The image formed is inverted and of the same size as the object, as shown in the given figure.



It is given that the image of the needle is formed at a distance of 50 cm from the convex lens. Hence, the needle is placed in front of the lens at a distance of 50cm.

$$\text{Object distance, } u = -50 \text{ cm}$$

$$\text{Image distance, } v = 50 \text{ cm}$$

$$\text{Focal length} = f$$

According to the lens formula,

$$\begin{aligned}\frac{1}{v} - \frac{1}{u} &= \frac{1}{f} \\ \frac{1}{f} &= \frac{1}{50} - \frac{1}{-50} = \frac{1}{50} + \frac{1}{50} = \frac{1}{25} \\ f &= 25\text{cm} = 0.25\text{m}\end{aligned}$$

$$\text{Power of the lens, } P = \frac{1}{f(\text{in metres})} = \frac{1}{0.25} = +4D$$

Hence, the power of the given lens is +4 D.

- 3. Find the power of a concave lens of focal length 2 m.**

$$\text{Focal length of concave lens, } f = 2 \text{ m}$$

$$\text{Power of the lens, } P = \frac{1}{f(\text{in metres})} = \frac{1}{-2} = -0.5D$$

Here, negative sign arises due to the divergent nature of concave lens.

Hence, the power of the given concave lens is -0.5 D.

## **EXERCISE QUESTIONS PAGE No. 185 and 186**

1. Which one of the following materials cannot be used to make a lens?

(a) Water (b) Glass (c) Plastic (d) Clay

**Ans:**

(d) A lens allows light to pass through it. Since clay does not show such property, it cannot be used to make a lens.

2. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(a) Between the principal focus and the centre of curvature

(b) At the centre of curvature

(c) Beyond the centre of curvature

(d) Between the pole of the mirror and its principal focus.

**Ans:**

(d) When an object is placed between the pole and principal focus of a concave mirror, the image formed is virtual, erect, and larger than the object.

3. Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(a) At the principal focus of the lens (b) At twice the focal length (c) At infinity

(d) Between the optical centre of the lens and its principal focus.

**Ans:**

(b) When an object is placed at the centre of curvature in front of a convex lens, its image is formed at the centre of curvature on the other side of the lens. The image formed is real, inverted, and of the same size as the object.

4. A spherical mirror and a thin spherical lens have each a focal length of  $-15\text{ cm}$ . The mirror and the lens are likely to be

(a) both concave (b) both convex (c) the mirror is concave and the lens is convex

(d) the mirror is convex, but the lens is concave

**Ans:**

(a) By convention, the focal length of a concave mirror and a concave lens are taken as negative. Hence, both the spherical mirror and the thin spherical lens are concave in nature.

5. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be (a) plane (b) concave (c) convex (d) either plane or convex

**Ans:**

(d) A convex mirror always gives a virtual and erect image of smaller size of the object placed in front of it. Similarly, a plane mirror will always give a virtual and erect image of same size as that of the object placed in front of it. Therefore, the given mirror could be either plane or convex.

6. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(a) A convex lens of focal length  $50\text{ cm}$

(b) A concave lens of focal length  $50\text{ cm}$

(c) A convex lens of focal length  $5\text{ cm}$

(d) A concave lens of focal length  $5\text{ cm}$

**Ans.:**

(c) A convex lens gives a magnified image of an object when it is placed between the radius of curvature and focal length. Also, magnification is more for convex

lenses having shorter focal length. Therefore, for reading small letters, a convex lens of focal length 5 cm should be used.

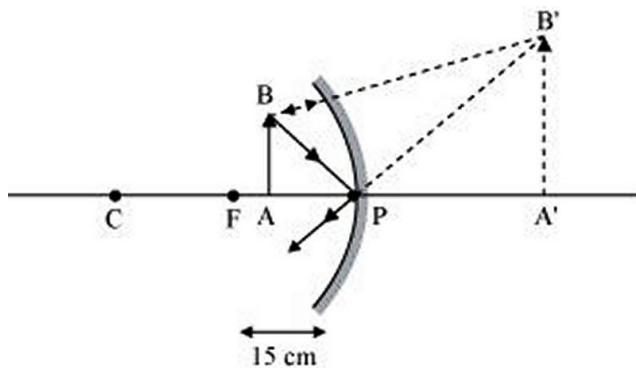
7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

**Ans:**

Range of object distance = 0 cm to 15 cm

A concave mirror gives an erect image when an object is placed between its pole (P) and the principal focus (F).

Hence, to obtain an erect image of an object from a concave mirror of focal length 15 cm, the object must be placed anywhere between the pole and the focus. The image formed will be virtual, erect, and magnified in nature, as shown in the given figure.



8. Name the type of mirror used in the following situations.

- (a) Headlights of a car.  
(b) Side/rear-view mirror of a vehicle.  
(c) Solar furnace.

Support your answer with reason.

**Ans:**

- (a) Concave (b) Convex (c) Concave

**Explanation:**

(a) Concave mirror is used in the headlights of a car. This is because concave mirrors can produce powerful parallel beam of light when the light source is placed at their principal focus.

(b) Convex mirror is used in side/rear view mirror of a vehicle. Convex mirrors give a virtual, erect, and diminished image of the objects placed in front of it. Because of this, they have a wide field of view. It enables the driver to see most of the traffic behind him/her.

(c) Concave mirrors are convergent mirrors. That is why they are used to construct solar furnaces. Concave mirrors converge the light incident on them at a single point known as principal focus. Hence, they can be used to produce a large amount of heat at that point.

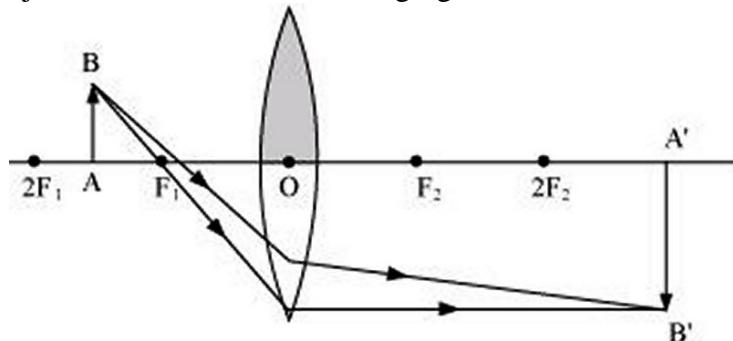
9. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

**Ans:**

The convex lens will form complete image of an object, even if its one half is covered with black paper. It can be understood by the following two cases.

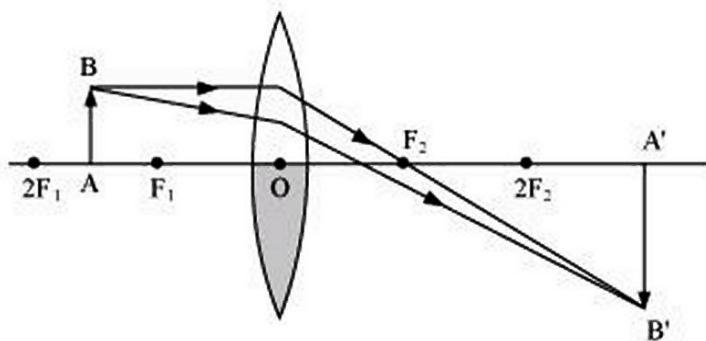
### **Case I: When the upper half of the lens is covered**

In this case, a ray of light coming from the object will be refracted by the lower half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in the following figure.



### **Case II: When the lower half of the lens is covered**

In this case, a ray of light coming from the object is refracted by the upper half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in the following figure.



10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.

**Ans:**

Object distance,  $u = -25 \text{ cm}$

Object height,  $h_o = 5 \text{ cm}$

Focal length,  $f = +10 \text{ cm}$

According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$$

$$\Rightarrow v = \frac{50}{3} = 16.67 \text{ (approx)} \text{ cm}$$

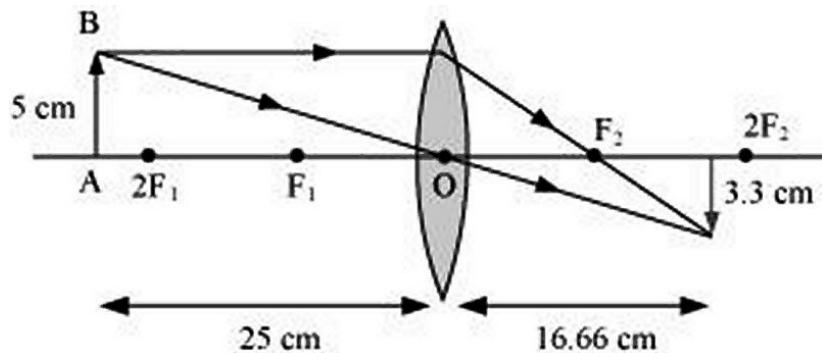
The positive value of  $v$  shows that the image is formed at the other side of the lens.

$$\text{Magnification, } m = \frac{\text{Height of the Image}}{\text{Height of the object}} = \frac{v}{u} = \frac{16.67}{-25} = -0.67$$

The negative sign shows that the image is real and formed behind the lens.

$$\text{Magnification, } m = \frac{h'}{h} = \frac{h'}{5} = \frac{v}{u} = -0.67 \Rightarrow h' = -5 \times 0.67 = -3.3 \text{ cm}$$

The negative value of image height indicates that the image formed is inverted. The position, size, and nature of image are shown in the following ray diagram.



11. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

**Ans:**

Focal length of concave lens ( $OF_1$ ),  $f = -15 \text{ cm}$

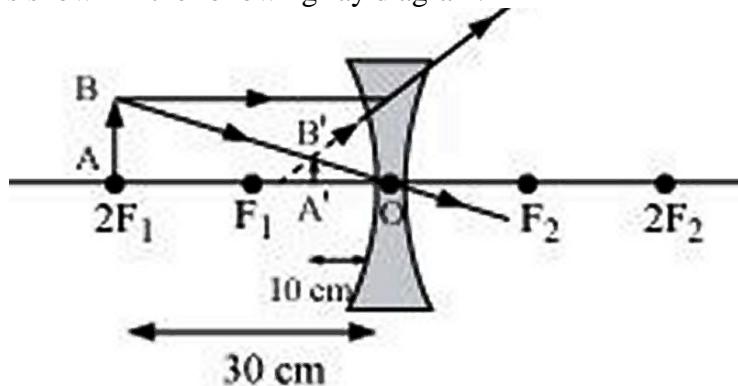
Image distance,  $v = -10 \text{ cm}$

According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{-1}{10} + \frac{1}{15} = \frac{-3+2}{30} = \frac{-1}{30}$$

$$\Rightarrow u = -30 \text{ cm}$$

The negative value of  $u$  indicates that the object is placed 30 cm in front of the lens. This is shown in the following ray diagram.



12. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

**Ans:**

Focal length of convex mirror,  $f = +15 \text{ cm}$

Object distance,  $u = -10 \text{ cm}$

According to the mirror formula,

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

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} - \frac{1}{10} = \frac{2+3}{30} = \frac{5}{30} = \frac{1}{6}$$

$$\Rightarrow v = 6 \text{ cm}$$

The positive value of  $v$  indicates that the image is formed behind the mirror.

$$\text{Magnification, } m = -\frac{\text{Image distance}}{\text{Object distance}} = -\frac{v}{u} = -\frac{6}{-10} = +0.6$$

The positive value of magnification indicates that the image formed is virtual and erect.

- 13.** The magnification produced by a plane mirror is +1. What does this mean?

**Ans:**

Magnification produced by a mirror is given by the relation

$$\text{Magnification, } m = -\frac{\text{Image distance}}{\text{Object distance}} = \frac{h_2}{h_1}$$

The magnification produced by a plane mirror is +1. It shows that the image formed by the plane mirror is of the same size as that of the object. The positive sign shows that the image formed is virtual and erect.

- 14.** An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

**Ans:**

Object distance,  $u = -20 \text{ cm}$

Object height,  $h = 5 \text{ cm}$

Radius of curvature,  $R = 30 \text{ cm}$

Radius of curvature =  $2 \times$  Focal length

$$R = 2f$$

$$f = 15 \text{ cm}$$

According to the mirror formula,

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

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{20} = \frac{4+3}{60} = \frac{7}{60}$$

$$\Rightarrow v = \frac{60}{7} = 8.57 \text{ cm}$$

The positive value of  $v$  indicates that the image is formed behind the mirror.

$$\text{Magnification, } m = -\frac{\text{Image distance}}{\text{Object distance}} = -\frac{v}{u} = -\frac{8.57}{-20} = +0.428$$

The positive value of magnification indicates that the image formed is virtual and erect.

$$\text{Magnification, } m = -\frac{\text{Image distance}}{\text{Object distance}} = \frac{h_2}{h_1} = \frac{h_2}{5} = +0.428$$

$$\Rightarrow h_2 = 0.428 \times 5 = +2.14 \text{ cm}$$

The positive value of image height indicates that the image formed is erect.

Therefore, the image formed is virtual, erect, and smaller in size.

- 15.** An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image.

**Ans:**

Object distance,  $u = -27 \text{ cm}$

Object height,  $h = 7 \text{ cm}$

Focal length,  $f = -18 \text{ cm}$

According to the mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{-1}{18} + \frac{1}{27} = \frac{-3+2}{54} = \frac{-1}{54}$$

$$\Rightarrow v = -54 \text{ cm}$$

The screen should be placed at a distance of 54 cm in front of the given mirror.

$$Magnification, m = -\frac{\text{Image distance}}{\text{Object distance}} = -\frac{v}{u} = -\frac{-54}{-27} = -2$$

The negative value of magnification indicates that the image formed is real.

$$Magnification, m = -\frac{\text{Image distance}}{\text{Object distance}} = \frac{h_2}{h_1} = \frac{h_2}{7} = -2$$

The negative value of image height indicates that the image formed is inverted.

$$\Rightarrow h_2 = -2 \times 7 = -14 \text{ cm}$$

- 16.** Find the focal length of a lens of power – 2.0 D. What type of lens is this?

**Ans:**

$$\text{Power of the lens, } P = \frac{1}{f(\text{in metres})} = -2D$$

$$\Rightarrow f = \frac{-1}{2} = -0.5 \text{ m}$$

A concave lens has a negative focal length. Hence, it is a concave lens.

- 17.** A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

**Ans:**

$$\text{Power of the lens, } P = \frac{1}{f(\text{in metres})} = 1.5D$$

$$\Rightarrow f = \frac{1}{1.5} = \frac{10}{15} = 0.66 \text{ m}$$

A convex lens has a positive focal length. Hence, it is a convex lens or a converging lens.

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# **CHAPTER - 10**

## **LIGHT – REFLECTION AND REFRACTION**

### **ASSIGNMENT QUESTIONS SET – 1**

- 1.** Define refraction.
- 2.** Define refractive index.
- 3.** What is the unit of refractive index?
- 4.** List out the factors on which the refractive index of a medium depends.
- 5.** Define angle of incidence.
- 6.** What is the angle of incidence if a ray of light is incident normal to the surface separating the two media?
- 7.** What is a lens?
- 8.** What is a concave lens?
- 9.** What is the nature of the focus of a concave lens?
- 10.** What type of image is formed by a concave lens?
- 11.** A thin lens has a focal length  $f = -12$  cm. Is it convex or concave lens?
- 12.** A lens forms an erect image for all positions of the object in front of it. Is the lens convex or concave?
- 13.** Where should an object be placed so that a real and inverted image of same size is obtained using a convex lens?
- 14.** Write the relation between  $u, v$  and  $f$  of a thin lens.
- 15.** What is the sign of  $u, v$  and  $f$  for a convex lens according to Cartesian sign convention?
- 16.** An object of height 1m is placed at a distance of  $2f$  from a convex lens. What is the height of the image formed?
- 17.** Define power.
- 18.** What is least distance of distinct vision?
- 19.** What happens when a ray of light passes through the optical centre of a lens?
- 20.** State the laws of refraction.
- 21.** Diagrammatically represent the refraction of light through a rectangular glass slab.
- 22.** Define convex lens. Why is it referred to as converging lens?
- 23.** Draw a diagram to show the second principal focus of a convex lens.
- 24.** Distinguish between a convex and a concave lens.
- 25.** Draw a ray diagram to show the refraction of light when it passes through the optic centre of a convex lens.

- 26.** List out the uses of convex lenses.
- 27.** With the help of a ray diagram show how an object gets magnified in a simple microscope.
- 28.** Define the power of a lens. What is its unit?
- 29.** With the help of a diagram explain how light gets refracted when it passes through a rectangular glass slab.
- 30.** An object is placed at a distance of 50 cm from a concave lens of focal length 20 cm. Find the nature and position of the image.
- 31.** An object is placed 50 cm from a lens which produces a virtual image at a distance of 10 cm in front of the lens. Draw a diagram to show the formation of image and calculate the focal length of the lens.
- 32.** An object of height 4 cm is placed at a distance of 10 cm from a convex lens of focal length 20 cm. Find the position, nature and size of the image.
- 33.** What is the power of a lens having a focal length of a) 50 cm b) -50cm
- 34.** Draw a ray diagram to show the position and nature of the image formed by a convex lens when the object is placed a) at  $2F_1$  b) between  $F_1$  and  $2F_1$  c) beyond  $2F_1$
- 35.** State and verify Snell's law.
- 36.** The bending of a beam of light when it passes obliquely from one medium to another is known as \_\_\_\_\_.
1. reflection
  2. refraction
  3. dispersion
  4. deviation
- 37.** The part of the lens through which the ray of light passes without suffering deviation is called \_\_\_\_\_.
1. optical centre
  2. focus
  3. centre of curvature
  4. pole
- 38.** Convex lens always gives a real image if the object is situated beyond \_\_\_\_\_.
1. optical centre
  2. centre of curvature
  3. Focus
  4. radius of curvature

- 39.** Parallel rays of light entering a convex lens always converge at \_\_\_\_\_.  
1. centre of curvature  
2. the principal focus  
3. optical centre  
4. the focal plane
- 40.** Where should an object be placed so that a real and inverted image of the same size is obtained, using a convex lens?  
1. Between O and F  
2. At F  
3. At  $2F$   
4. At infinity
- 41.** SI unit of the power of a lens is \_\_\_\_\_.  
1. dioptre  
2. cm  
3. metre  
4. watt
- 42.** 1 D is the power of the lens of focal length of \_\_\_\_\_ cm.  
1. 100  
2. 10  
3.  $1/100$   
4.  $1/10$
- 43.** In a simple microscope lens used is \_\_\_\_\_.  
1. biconvex  
2. biconcave  
3. plano convex  
4. cylindrical
- 44.** Reciprocal of focal length in metres is known as the \_\_\_\_\_ of a lens.  
1. focus  
2. power  
3. power of accommodation  
4. far point
- 45.** A convex lens is called \_\_\_\_\_.  
1. converging lens  
2. diverging lens  
3. both converging and diverging lens  
4. refracting lens
- 46.** A positive magnification greater than unity indicates \_\_\_\_\_.  
1. real image  
2. virtual image  
3. neither real nor virtual image  
4. distorted image

- 47.** The power of a convex lens of focal length 50 cm is \_\_\_\_\_.  
1. + 2D  
2. - 2D  
3. 50 D  
4. - 5D
- 48.** The focal length of a lens whose power is -1.5 D is \_\_\_\_\_.  
1. -66.66 cm  
2. + 1.5 m  
3. + 66.66 cm  
4. -1.5 m
- 49.** Real images formed by single convex lenses are always \_\_\_\_\_.  
1. on the same side of the lens as the object  
2. Inverted  
3. Erect  
4. smaller than the object
- 50.** An object is placed 12 cm from a convex lens whose focal length is 10 cm. The image must be.  
1. virtual and enlarged  
2. virtual and reduced in size  
3. real and reduced in size  
4. real and enlarged
- 51.** When a person uses a convex lens as a simple magnifying glass, the object must be placed at a distance.  
1. less than one focal length  
2. more than one focal length  
3. less than twice the focal length  
4. more than twice the focal length
- 52.** The image produced by a concave lens is \_\_\_\_\_.  
1. always virtual and enlarged  
2. always virtual and reduced in size  
3. always real  
4. sometimes real, sometimes virtual
- 53.** A virtual image is formed by \_\_\_\_\_.  
1. a slide projector in a cinema hall  
2. the ordinary camera  
3. a simple microscope  
4. Telescope
- 54.** An object is placed 25 cm from a convex lens whose focal length is 10 cm. The image distance is \_\_\_\_\_ cm.  
1. 50 cm  
2. 16.66 cm  
3. 6.66 cm

4. 10 cm
55. The least distance of distinct vision is \_\_\_\_\_.  
1. 25 cm  
2. 25 m  
3. 0.25 cm  
4. 2.5 m
56. A convex lens has a focal length of 20 cm. Its power in dioptres is \_\_\_\_\_.  
1. 2  
2. 5  
3. 0.5  
4. 0.2
57. An object is placed before a concave lens. The image formed \_\_\_\_\_.  
1. is always erect  
2. may be erect or inverted  
3. is always inverted  
4. is always real
58. A ray of light travels from a medium of refractive index  $n_1$  to a medium of refractive index  $n_2$ . If angle of incidence is  $i$  and the angle of refraction is  $r$ , then  $\frac{\sin i}{\sin r}$  is equal to  
1.  $n_1$   
2.  $n_2$   
3.  $n_{21}$   
4.  $n_{12}$
59. Two thin lenses of power +5 D and -2 D are placed in contact with each other. Focal length of the combination is  
1. +3 m  
2. -3 m  
3. 0.33 m  
4. -0.33 m
60. The lens formula in cartesian frame is \_\_\_\_\_.  
1.  $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$   
2.  $\frac{1}{f} = \frac{1}{u} - \frac{1}{v}$   
3.  $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$   
4.  $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$
61. An object is placed between two plane mirrors inclined at an angle of  $45^\circ$  to each other. How many images do you expect to see?

62. How can an inverted image of an object be obtained with a plane mirror?
63. How many images of himself can an observer see in a room whose ceiling and two adjacent walls are mirrors?
64. A convex mirror is held in water. What should be the change in its focal length?
65. If the light from the Sun subtend an angle  $Q$  at the pole of a concave mirror of focal length  $f$ , where will it converge? Also find the diameter of the image. Draw the necessary ray diagram.
66. When does Snell's law of refraction fail?
67. How does the frequency of a beam of ultraviolet light changes when it goes from air to glass?
68. State two conditions under which a ray of light suffering refraction from medium 1 to medium 2 does not undergo any change in direction
69. Name the factor on which lateral shift produced by glass slab depends?
70. A glass lens is immersed in water. How is the power of the lens affected?
71. Why is the power of a lens is measured as reciprocal of focal length? Give reason.
72. A convex lens is made of a material of refractive index  $m_1$  when placed in a medium of refractive index  $m_2$ , behaves as a diverging lens. How are  $m_1$  and  $m_2$  related?
73. An object is held at a distance of 60 cm from a convex mirror of focal length 20 cm. At what distance from the mirror, should a plane mirror be held so that images in the two mirrors coincide?(ans. 22.5 cm)
74. How do you find the rough focal length of a convex lens? Is the same method applicable to a concave lens?
75. Which factors determines the focal length of a lens?
76. The formula for linear magnification of a spherical mirror is  $m=h'/h = -v/u$ . What determines the sign of  $m$ ? What is the significance of this sign?
77. A convex lens made of material of refractive index  $n_2$  is kept in a medium of refractive index  $n_1$ . A parallel beam of light is incident on the lens. Compare the path of rays of light emerging from the convex lens if (i) $n_1 < n_2$  (ii) $n_1 = n_2$  (iii)  $n_1 > n_2$
78. A concave lens of focal length 25 cm and a convex lens of focal length 20 cm are placed in contact with each other. What is the power of this combination? Also, calculate focal length of this combination. (ans. 1m)

- 79.** A convergent lens of power 8D is combined with a divergent lens of power -10 D. Calculate focal length of the combination. (ans.-0.5 m)
- 80.** A concave lens has a focal length of 15 cm. At what distance should an object from the lens be placed so that it forms an image at 10 cm from the lens? Also find the magnification of the lens.
- 81.** Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever be the angle of incidence? Show the same with the help of diagram.
- 82.** How much time will light take to cross 2 mm thick glass pane if refractive index of glass is  $3/2$ ? (ans.  $10^{-11}$ s)
- 83.** Light travel from rarer medium 1 to a denser medium 2. The angle of incidence and refraction are respectively  $45^\circ$  and  $30^\circ$ . Calculate the refractive index of second medium with respect to the first medium.
- 84.** A pond of depth 20 cm is filled with water of refractive index  $4/3$ . Calculate apparent depth of the tank when viewed normally.
- 85.** What is the real depth of a swimming pool when its bottom appears to be realized by 1m?given refractive index of water is  $4/3$
- 86.** An object is placed in front of a concave mirror of radius of curvature 15cm at a distance of (a) 10cm. and (b) 5cm. Find the position, nature and magnification of the image in each case.
- 87.** An object is placed 15cm from a concave mirror of radius of curvature 60 cm. Find the position of image and its magnification?
- 88.** An object is kept at a distance of 5cm in front of a convex mirror of focal length 10cm. Give the position, magnification and the nature of the image formed.
- 89.** An object is placed at a distance of 50cm from a concave lens of focal length 20cm. Find the nature and position of the image.
- 90.** The power of a lens is 2.5 dioptrre. What is the focal length and the type of lens?
- 91.** What is the power of a concave lens of focal length 50cm?
- 92.** Find the power of a concave lens of focal length 2m.
- 93.** Two lens of power +3.5D and -2.5D are placed in contact. find the power and focal length of the lens combination.
- 94.** A convex lens has a focal length of 20 cm. Calculate at what distance from the lens should an object be placed so that it forms an image at a distance of 40cm on the other side of the lens. State the nature of the image formed?

- 95.** A 10cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 30cm. The distance of the object from the line is 20cm. find the i)position ii)nature and iii) size of the image formed.
- 96.** Find the focal length of a line power is given as +2.0D.
- 97.** With respect to air the refractive index of ice and rock salt benzene are 1.31 and 1.54 respectively. Calculate the refractive index of rock salt with respect to ice.
- 98.** An object 5cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30cm. Find the position of the image, its nature and size.
- 99.** The far point of a myopic person is 150cm in front of the eye. Calculate the focal length and the power of the lens required to enable him to see distant objects clearly.
- 100.** To obtain magnified erect image on a concave mirror, object should be held  
a) At pole b) At focus c) Between p and f d) Beyond 2f
- 101.** If  $f$  is the focal length and  $R$  is the radius of curvature of a spherical mirror, then  
a)  $R=f$  b)  $R=2f$  c)  $R=3f$  d)  $R=4f$
- 102.** The image formed by a concave mirror is real, inverted and of same size as that of the object. The position of the object is  
a) At C b) At F c) Between C and F d) Beyond C
- 103.** The image formed by a concave mirror is virtual, erect and magnified. The position of the object is  
a) At F b) At c c) At infinity d) Between P and F
- 104.** The image formed by a spherical mirror is virtual, erect and smaller in size. Whatever be the position of the object. The mirror is  
a) Convex b) Concave c) Either convex or concave d) Cannot say
- 105.** When light goes from one medium to another, the characteristics that remain unaffected is  
a) Speed b) Direction c) Wave length d) Frequency
- 106.** Reflective index of glass w.r.t air is  $3/2$ . What is the refractive index of air w.r.t glass?

a) 2/3 b) 1 c) Zero d) (3/2)2

**107.** A convex lens of focal length 15 cm is used to form an image of the size of the object. Where from the lens should be the object placed.

a) 15 cm b) 30 cm c) 60 cm d) 10 cm

**108.** To form an image twice the size of the object, using a convex lens of focal length 20 cm, the object distance must be

a) <20 cm b) >20 cm c) <20 cm and between 20 cm and 40 cm d) Cannot say

**109.** Bending of a ray of light due to change in velocity with medium is called

a) Reflection b) Refraction c) Diffraction d) Dispersion

**110.** If correct value of refractive index of a medium( $\mu$ ) in terms of velocity of light in vacuum (C) and velocity of light in medium (v) is

a)  $n = vC$  b)  $n = 1 / v$  c)  $n = C / v$  d)  $n = v / C$ .

**111.** Total internal reflection takes place when light travels

a) From denser to rarer medium b) From rarer to denser medium  
c) In same denser medium from one side to other. d) In same rarer medium from one side to other.

**112.** For no bending of a ray of light through a glass slab, angle of incidence must be

a)  $0^\circ$  b)  $30^\circ$  c)  $60^\circ$  d)  $90^\circ$

**113.** A convex lens is

a) Thin in the middle, thick at the room. b) Thick in the middle, thin at the rim.  
c) Thick throughout. d) Thin throughout.

**114.** Power of convex lens is

a) Zero. b) Infinite. c) Positive d) Negative.

**115.** An object is placed in front of a concave mirror of radius of curvature 15cm at a distance of (a) 10cm. and (b) 5cm. Find the position, nature and magnification of the image in each case.

**116.** An object is placed 15cm from a concave mirror of radius of curvature 60 cm. Find the position of image and its magnification?

**117.** An object is kept at a distance of 5cm in front of a convex mirror of focal length 10cm. Give the position, magnification and the nature of the image formed.

**118.** An object is placed at a distance of 50cm from a concave lens of focal length 20cm. Find the nature and position of the image.

**119.** The power of a lens is 2.5 dioptre. What is the focal length and the type of lens?

**120.** What is the power of a concave lens of focal length 50cm?

**121.** Find the power of a concave lens of focal length 2m.

- 122.** Two lens of power +3.5D and -2.5D are placed in contact. find the power and focal length of the lens combination.
- 123.** A convex lens has a focal length of 20 cm. Calculate at what distance from the lens should an object be placed so that it forms an image at a distance of 40cm on the other side of the lens. State the nature of the image formed?
- 124.** A 10cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 30cm. The distance of the object from the line is 20cm.find the i)position ii)nature and iii) size of the image formed.
- 125.** Find the focal length of a line power is given as +2.0D.
- 126.** With respect to air the refractive index of ice and rock salt benzene are 1.31 and 1.54 respectively. Calculate the refractive index of rock salt with respect to ice.
- 127.** An object 5cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30cm. Find the position of the image, its nature and size.
- 128.** The far point of a myopic person is 150cm in front of the eye. Calculate the focal length and the power of the lens required to enable him to see distant objects clearly.
- .....

# **CHAPTER - 10**

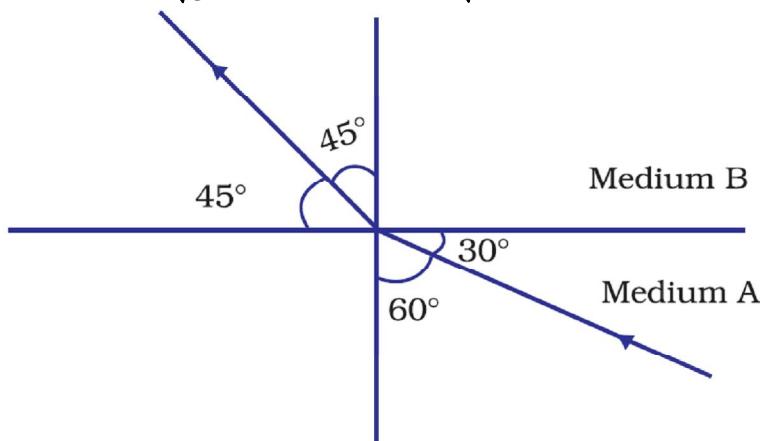
## **LIGHT – REFLECTION AND REFRACTION**

### **ASSIGNMENT QUESTIONS SET – 2**

## **MULTIPLE CHOICE QUESTIONS**

- Which of the following can make a parallel beam of light when light from a point source is incident on it?
    - Concave mirror as well as convex lens
    - Convex mirror as well as concave lens
    - Two plane mirrors placed at  $90^\circ$  to each other
    - Concave mirror as well as concave lens
  - A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is
    - 30 cm
    - 20 cm
    - 40 cm
    - 60 cm
  - Under which of the following conditions a concave mirror can form an image larger than the actual object?
    - When the object is kept at a distance equal to its radius of curvature
    - When object is kept at a distance less than its focal length
    - When object is placed between the focus and centre of curvature
    - When object is kept at a distance greater than its radius of curvature
  - The below Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is

(a)  $\frac{\sqrt{3}}{\sqrt{2}}$       (b)  $\frac{\sqrt{2}}{\sqrt{3}}$       (c)  $\frac{1}{\sqrt{2}}$       (d)  $\sqrt{2}$



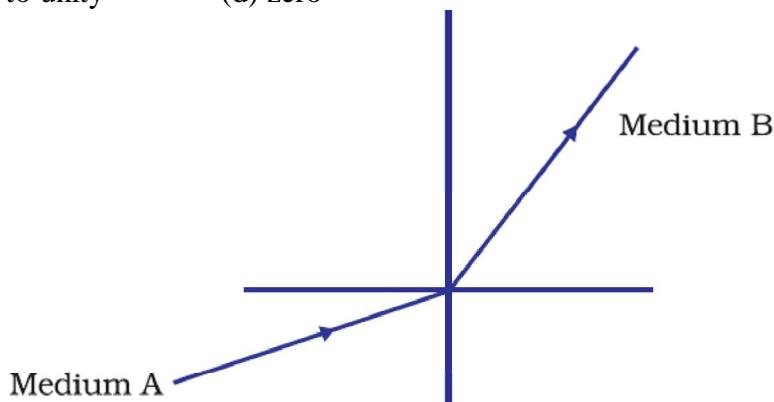
5. Which of the following statements is true?

  - (a) A convex lens has 4 dioptre power having a focal length 0.25 m
  - (b) A convex lens has -4 dioptre power having a focal length 0.25 m
  - (c) A concave lens has 4 dioptre power having a focal length 0.25 m
  - (d) A concave lens has -4 dioptre power having a focal length 0.25 m

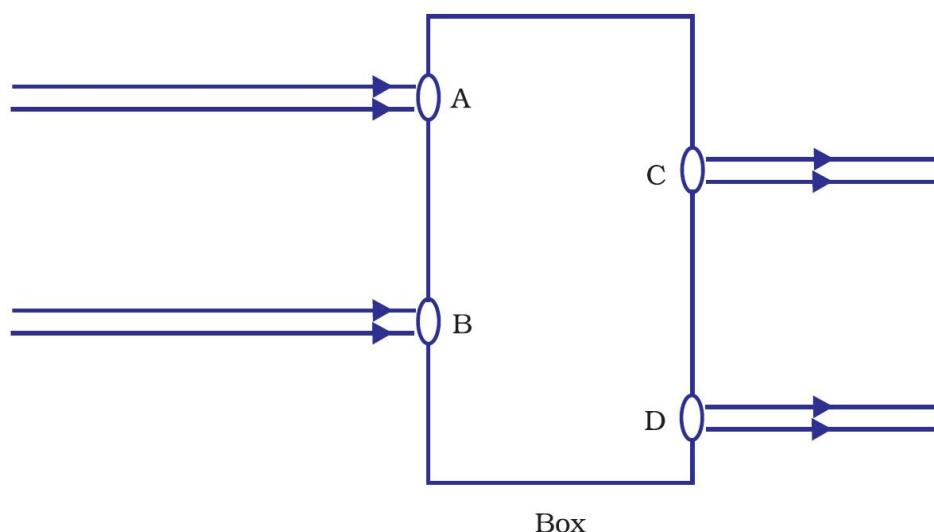
6. Magnification produced by a rear view mirror fitted in vehicles

  - (a) is less than one
  - (b) is more than one
  - (c) is equal to one
  - (d) can be more than or less than one depending upon the position of the object in front of it

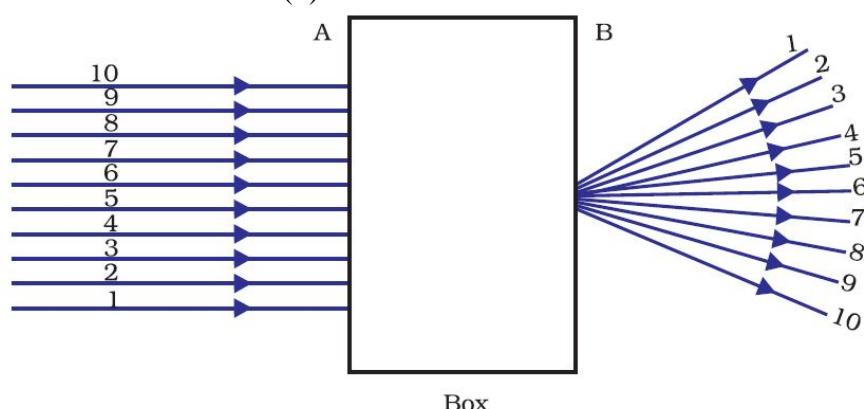
7. A light ray enters from medium A to medium B as shown in below Figure. The refractive index of medium B relative to A will be  
 (a) greater than unity      (b) less than unity  
 (c) equal to unity      (d) zero



8. Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively as shown in the below Figure. Which of the following could be inside the box?  
 (a) A rectangular glass slab      (b) A convex lens  
 (c) A concave lens      (d) A prism



9. A beam of light is incident through the holes on side A and emerges out of the holes on the other face of the box as shown in the below Figure. Which of the following could be inside the box?  
 (a) Concave lens      (b) Rectangular glass slab  
 (c) Prism      (d) Convex lens



**10.** Rays from Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?

- (a) 15 cm in front of the mirror
- (b) 30 cm in front of the mirror
- (c) between 15 cm and 30 cm in front of the mirror
- (d) more than 30 cm in front of the mirror

**11.** A full length image of a distant tall building can definitely be seen by using

- (a) a concave mirror
- (b) a convex mirror
- (c) a plane mirror
- (d) both concave as well as plane mirror

**12.** In torches, search lights and headlights of vehicles the bulb is placed

- (a) between the pole and the focus of the reflector
- (b) very near to the focus of the reflector
- (c) between the focus and centre of curvature of the reflector
- (d) at the centre of curvature of the reflector

**13.** The laws of reflection hold good for

- (a) plane mirror only
- (b) concave mirror only
- (c) convex mirror only
- (d) all mirrors irrespective of their shape

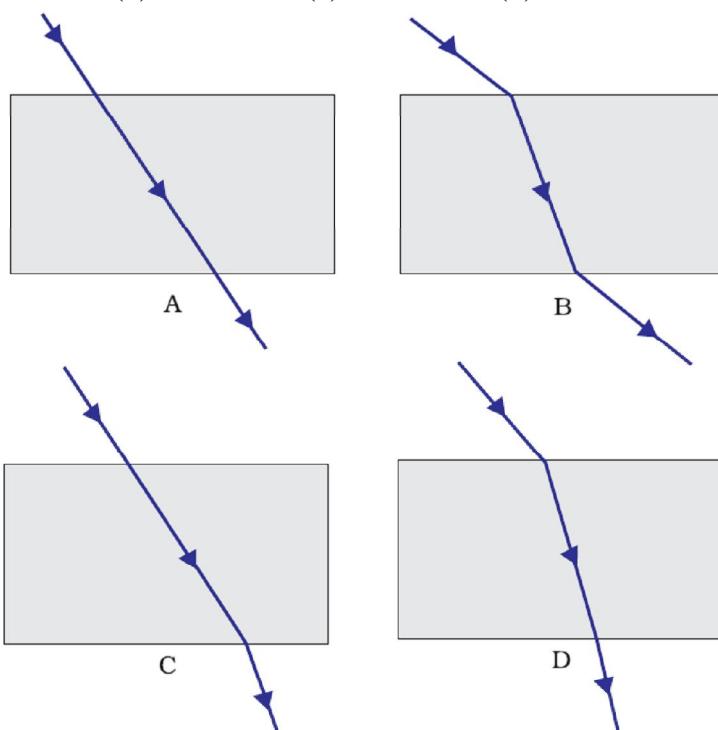
**14.** The path of a ray of light coming from air passing through a rectangular glass slab traced by four students are shown as A, B, C and D in Figure. Which one of them is correct?

(a) A

(b) B

(c) C

(d) D



**15.** You are given water, mustard oil, glycerine and kerosene. In which of these media a ray of light incident obliquely at same angle would bend the most?

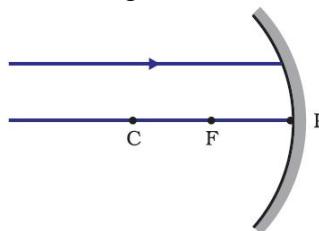
- (a) Kerosene
- (b) Water
- (c) Mustard oil
- (d) Glycerine

**16.** A child is standing in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller. The following is the order of combinations for the magic mirror from the top.

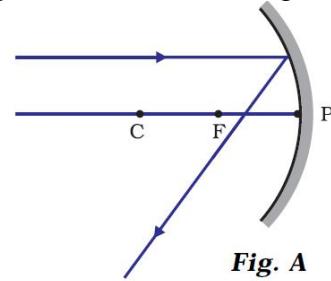
- (a) Plane, convex and concave
- (b) Convex, concave and plane
- (c) Concave, plane and convex
- (d) Convex, plane and concave

**17.** Which of the following ray diagrams is correct for the ray of light incident on a concave mirror as shown in below Figure?

(a) Fig. A

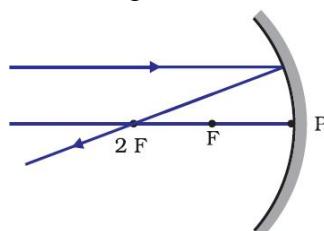


(b) Fig. B

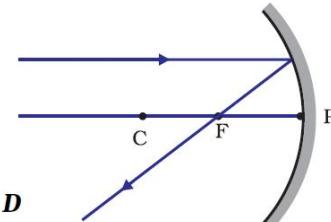
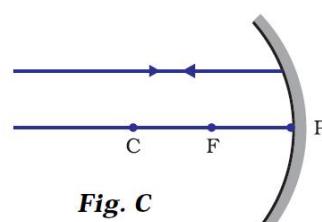


(c) Fig. C

(d) Fig. D

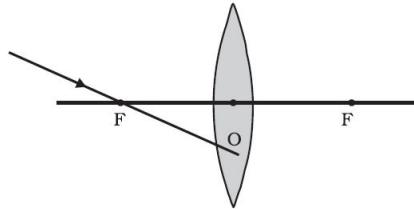


**Fig. B**

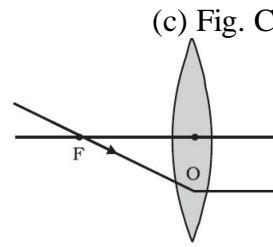


**18.** Which of the following ray diagrams is correct for the ray of light incident on a lens shown in below Figure?

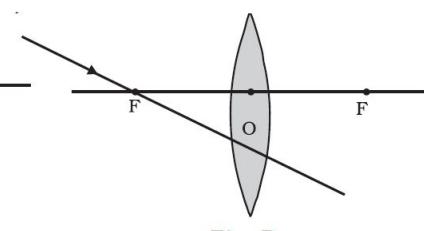
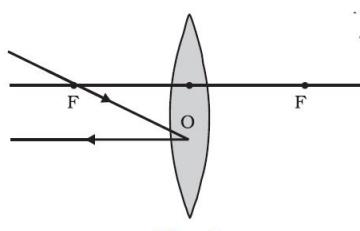
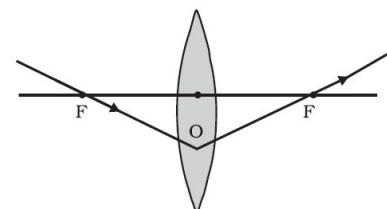
(a) Fig. A



(b) Fig. B



(c) Fig. C



**19.** In which of the following, the image of an object placed at infinity will be highly diminished and point sized?

- (a) Concave mirror only
- (b) Convex mirror only
- (c) Convex lens only
- (d) Concave mirror, convex mirror, concave lens and convex lens

## **SHORT ANSWER QUESTIONS**

- 26.** Identify the device used as a spherical mirror or lens in following cases, when the image formed is virtual and erect in each case.

  - (a) Object is placed between device and its focus, image formed is enlarged and behind it.
  - (b) Object is placed between the focus and device, image formed is enlarged and on the same side as that of the object.
  - (c) Object is placed between infinity and device, image formed is diminished and between focus and optical centre on the same side as that of the object.
  - (d) Object is placed between infinity and device, image formed is diminished and between pole and focus, behind it.

- 27.** Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself? Explain using a diagram.
- 28.** A pencil when dipped in water in a glass tumbler appears to be bent at the interface of air and water. Will the pencil appear to be bent to the same extent, if instead of water we use liquids like, kerosene or turpentine. Support your answer with reason.
- 29.** How is the refractive index of a medium related to the speed of light? Obtain an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?
- 30.** Refractive index of diamond with respect to glass is 1.6 and absolute refractive index of glass is 1.5. Find out the absolute refractive index of diamond.
- 31.** A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?
- 32.** Sudha finds out that the sharp image of the window pane of her science laboratory is formed at a distance of 15 cm from the lens. She now tries to focus the building visible to her outside the window instead of the window pane without disturbing the lens. In which direction will she move the screen to obtain a sharp image of the building? What is the approximate focal length of this lens?
- 33.** How are power and focal length of a lens related? You are provided with two lenses of focal length 20 cm and 40 cm respectively. Which lens will you use to obtain more convergent light?
- 34.** Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.
- 35.** Draw a ray diagram showing the path of rays of light when it enters with oblique incidence (i) from air into water; (ii) from water into air.

### **LONG ANSWER QUESTIONS**

- 36.** Draw ray diagrams showing the image formation by a concave mirror when an object is placed  
(a) between pole and focus of the mirror  
(b) between focus and centre of curvature of the mirror  
(c) at centre of curvature of the mirror  
(d) a little beyond centre of curvature of the mirror  
(e) at infinity
- 37.** Draw ray diagrams showing the image formation by a convex lens when an object is placed  
(a) between optical centre and focus of the lens  
(b) between focus and twice the focal length of the lens  
(c) at twice the focal length of the lens  
(d) at infinity  
(e) at the focus of the lens

- 38.** Write laws of refraction. Explain the same with the help of ray diagram, when a ray of light passes through a rectangular glass slab.
- 39.** Draw ray diagrams showing the image formation by a concave lens when an object is placed  
(a) at the focus of the lens  
(b) between focus and twice the focal length of the lens  
(c) beyond twice the focal length of the lens
- 40.** Draw ray diagrams showing the image formation by a convex mirror when an object is placed  
(a) at infinity  
(b) at finite distance from the mirror
- 41.** The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. If the image is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the lens? What is the nature of the image at a distance of 80 cm and the lens?
- 42.** Size of image of an object by a mirror having a focal length of 20 cm is observed to be reduced to 1/3rd of its size. At what distance the object has been placed from the mirror? What is the nature of the image and the mirror?
- 43.** Define power of a lens. What is its unit? One student uses a lens of focal length 50 cm and another of -50 cm. What is the nature of the lens and its power used by each of them?
- 44.** A student focussed the image of a candle flame on a white screen using a convex lens. He noted down the position of the candle screen and the lens as under  
Position of candle = 12.0 cm  
Position of convex lens = 50.0 cm  
Position of the screen = 88.0 cm  
(i) What is the focal length of the convex lens?  
(ii) Where will the image be formed if he shifts the candle towards the lens at a position of 31.0 cm?  
(iii) What will be the nature of the image formed if he further shifts the candle towards the lens?  
(iv) Draw a ray diagram to show the formation of the image in case (iii) as said above.
- 45.** (a) State the relationship between object distance, image distance and focal length of a spherical mirror.  
(b) Draw a ray diagram to show the image formation by a concave mirror when an object is placed between pole and focus of the mirror.  
(c) A concave mirror of focal length 15 cm forms an image of an object kept at a distance of 10cm from the mirror. Find the position, nature and size of the image formed by it.

# CHAPTER - 11

## THE HUMAN EYE AND THE COLOURFUL WORLD

### THE HUMAN EYE

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

The main parts of the human eye include:

**Cornea:** transparent tissue covering the front of the eye that lets light travel through

**Iris:** a ring of muscles in the colored part of the eye that controls the size of the pupil

**Pupil:** an opening in the center of the iris that changes size to control how much light is entering the eye.

**Sclera:** the white part of the eye that is composed of fibrous tissue that protects the inner workings of the eye

**Lens:** located directly behind the pupil, it focuses light rays onto the retina

**Retina:** membrane at the back of the eye that changes light into nerve signals

**Optic Nerve:** a bundle of nerve fibers that carries messages from the eyes to the brain

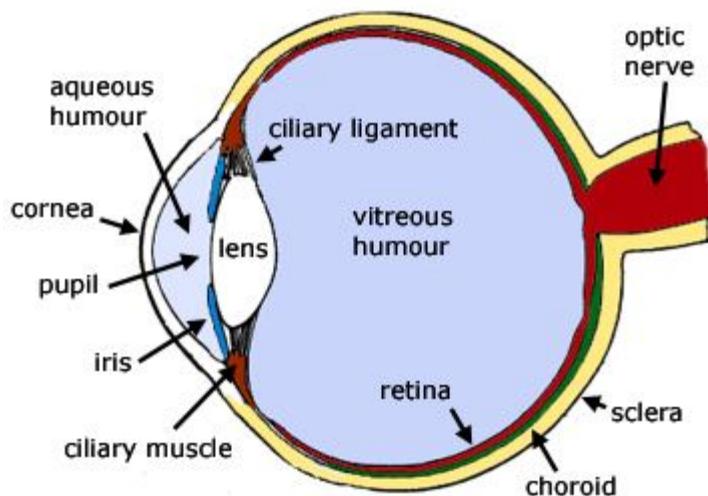
Macula: a small and highly sensitive part of the retina responsible for central vision, which allows a person to see shapes, colors, and details clearly and sharply.

**Choroid:** The choroid is a layer of blood vessels between the retina and sclera; it supplies blood to the retina.

**Ciliary muscle:** it changes the shape of the lens - (this is called accommodation). It relaxes to flatten the lens for distance vision; for close work it contracts rounding out the lens.

**Aqueous humour:** A water like fluid, produced by the ciliary body, it fills the front of the eye between the lens and cornea and provides the cornea and lens with oxygen and nutrients. It drains back into the blood stream through the canals of schlemm.

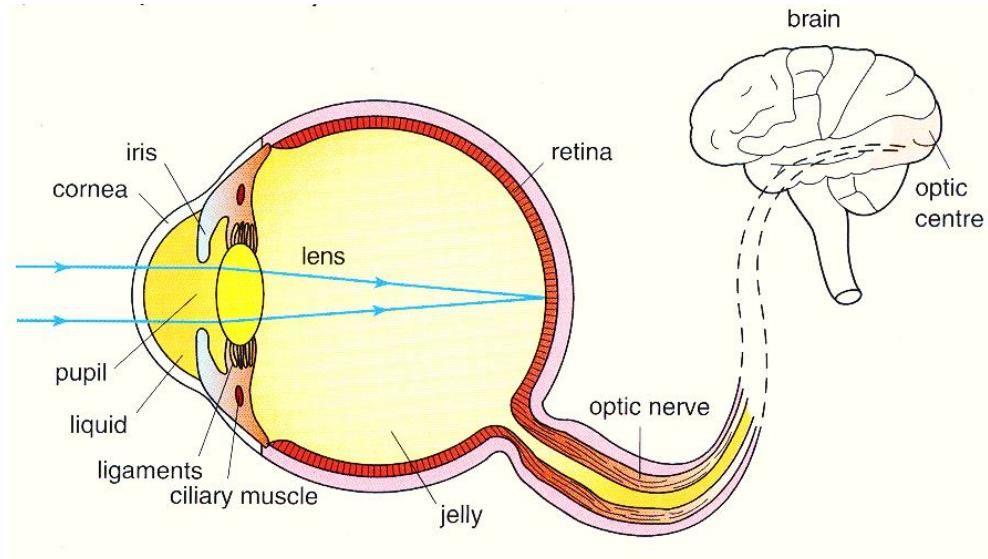
**Vitreous humour:** The space between the lens and retina filled with the gel like Vitreous Humor.



### WORKING OF HUMAN EYE

Light enters the eye through a thin membrane called the cornea. It forms the transparent bulge on the front surface of the eyeball as shown in below figure. The eyeball is approximately spherical in shape with a diameter of about 2.3 cm. 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 objects at different distances on the retina. We find a structure called *iris* behind the cornea. Iris is a dark muscular diaphragm that controls the size of the pupil. The pupil regulates and controls the amount of light entering the eye. The eye lens forms an inverted real image of the object on the retina. The light-sensitive cells get activated upon illumination and generate electrical signals. These signals are sent to the brain via the optic nerves. The brain interprets these signals, and finally, processes the information so that we perceive objects as they are, i.e. without inversion.

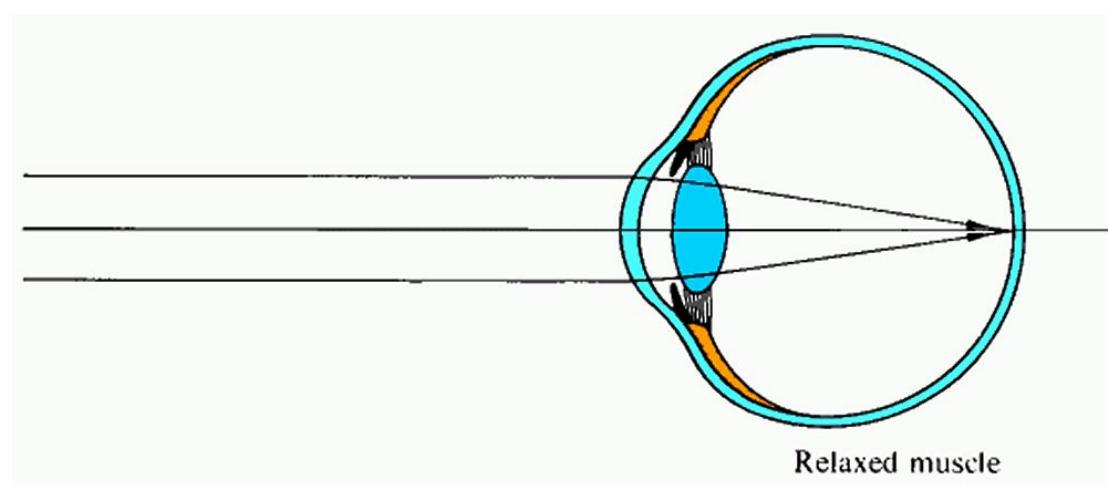


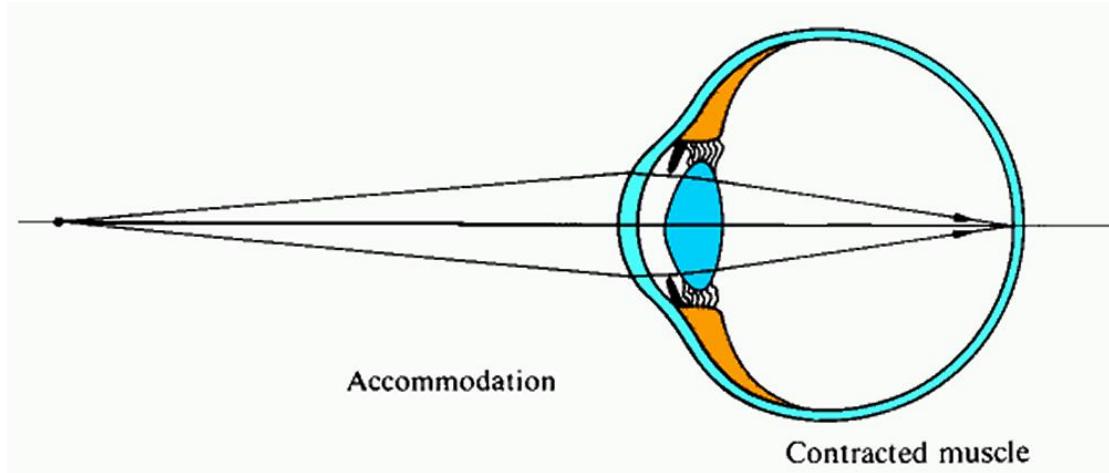
### **POWER OF ACCOMMODATION**

The process by which the ciliary muscles change the focal length of an eye lens to focus distant or near objects clearly on the retina is called the accommodation of the eye.

#### **How Does an Eye Focus Objects at Varying Distances?**

To focus on distant objects the ciliary muscles relax making the eye lens thin. As a result the focal length of the eye lens increases and we see the distant objects. But to focus on nearby objects the ciliary muscles contract making the eye lens thick. As a result the focal length of the eye lens decreases and we see the nearby objects. In short it is the adjustment of the focal length of the eye lens which enables us to focus on objects situated at different distances.





### Near point or Least Distance of Distinct Vision

Near point or least distance of distinct vision is the point nearest to the eye at which an object is visible distinctly. For a normal eye the least distance of distinct vision is about 25 centimetres. However, it varies with age of the person. For example, for infants it is only 5 to 8 cm.

### Far Point

Far point of the eye is the maximum distance up to which the normal eye can see things clearly. It is infinity for a normal eye.

### Range of Vision

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

## DEFECTS OF VISION

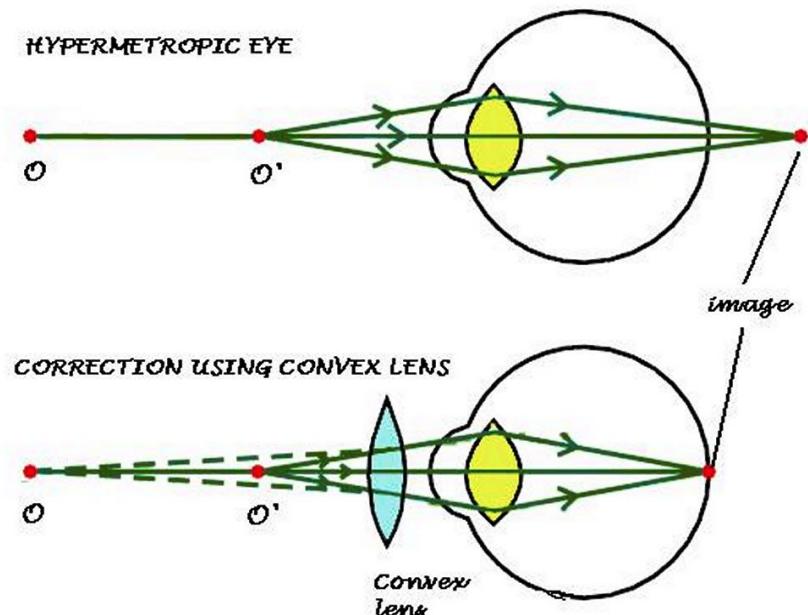
A normal eye can see all objects over a wide range of distances i.e., from 25 cm to infinity. But due to certain abnormalities the eye is not able see objects over such a wide range of distances and such an eye is said to be defective. Some of the defects of vision are

- Hypermetropia or long sightedness
- Myopia or short sightedness and
- Presbyopia
- Astigmatism

## HYPERMETROPIA

Hypermetropia is also known as far-sightedness. Hypermetropia or hyperopia is the defect of the eye due to which the eye is not able to see clearly the nearby objects though it can see the distant objects clearly. The near point, for the person, is farther away from the normal near point (25 cm). Such a person has to keep a reading material much beyond 25 cm from the eye for comfortable reading. This is because the light rays from a closeby object are focussed at a point behind the retina as shown in below figure. This defect arises either because (i) the focal length of the eye lens is too long, or (ii) the eyeball has become too small. This defect can be corrected by

using a convex lens of appropriate power. This is illustrated in below figure. Eye-glasses with converging lenses provide the additional focusing power required for forming the image on the retina.



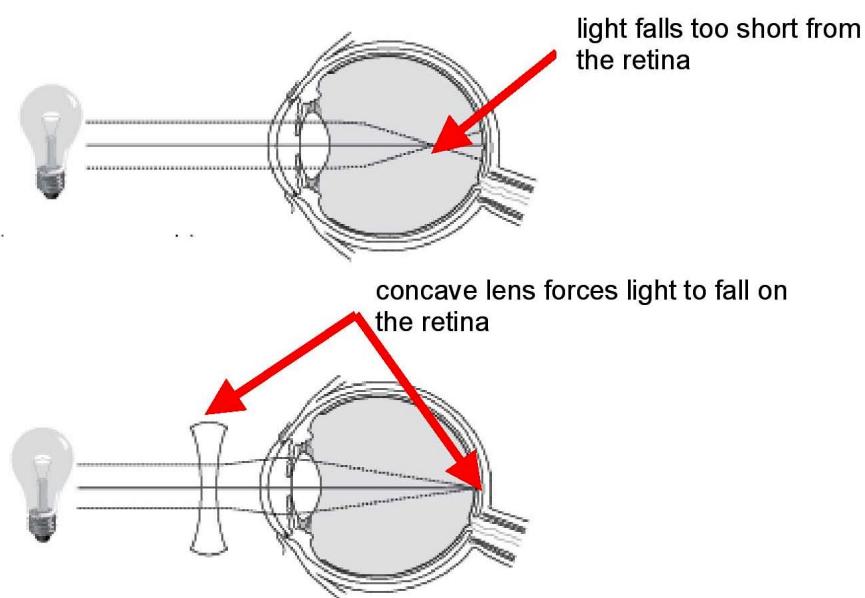
### MYOPIA

Myopia is also known as near-sightedness. A myopic person cannot see distant objects clearly because the far point of his eye is less than infinity. Myopia is the defect of the eye due to which the eye is not able to see the distant objects clearly.

Myopia is due to:

- the elongation of the eye ball, that is, the distance between the retina and eye lens is increased.
- decrease in focal length of the eye lens.

In a myopic eye, the image of a distant object is formed in front of the retina and not at the retina itself. This defect may arise due to (i) excessive curvature of the eye lens, or (ii) elongation of the eyeball. This defect can be corrected by using a concave lens of suitable power. This is illustrated in below figure. A concave lens of suitable power will bring the image back on to the retina and thus the defect is corrected.

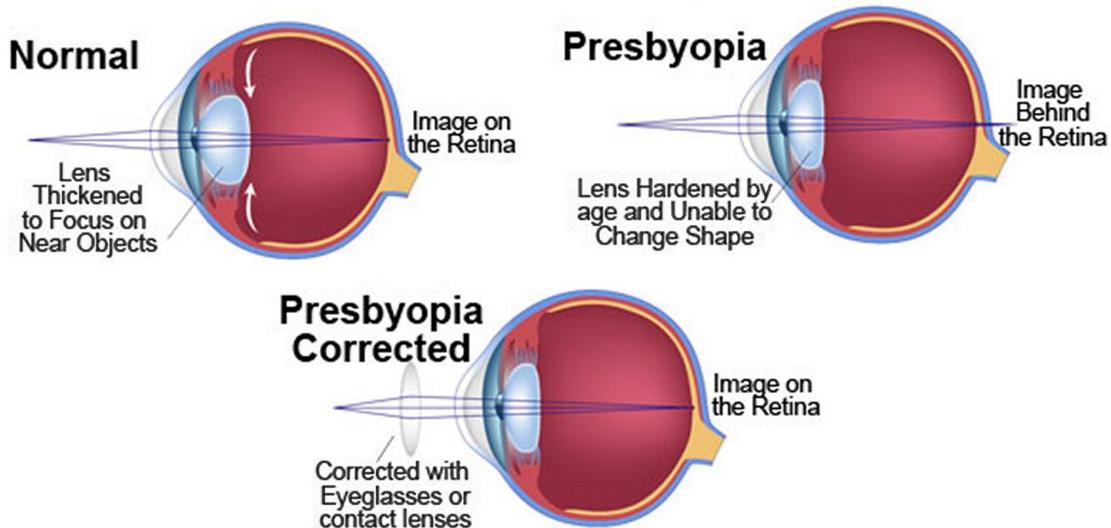


## **PRESBYOPIA**

Presbyopia occurs at the age of 40 years and its main symptom is reduced near vision. Difficulty in reading without glasses at 35-40 cm and fatigue after a short period of close work are present. Normally the lens is flexible enough to change its shape when focusing at close objects. Loss of its flexibility and elasticity known as loss of the eye's adjustment mechanism results in presbyopia.

Presbyopia (which literally means "aging eye") is an age-related eye condition that makes it more difficult to see very close.

At the young age, the lens in your eye is soft and flexible. The lens of the eye changes its shape easily, allowing you to focus on objects both close and far away. After the age of 40, the lens becomes more rigid. Because the lens can't change shape as easily as it once did, it is more difficult to read at close range. This normal condition is called presbyopia. Since nearly everyone develops presbyopia, if a person also has myopia (nearsightedness), hyperopia (farsightedness) or astigmatism, the conditions will combine. People with myopia may have fewer problems with presbyopia.



## **ASTIGMATISM**

Astigmatism is an eye condition with blurred vision as its main symptom. The front surface of the eye (cornea) of a person with astigmatism is not curved properly - the curve is irregular - usually one half is flatter than the other - sometimes one area is steeper than it should be.

When light rays enter the eye they do not focus correctly on the retina, resulting in a blurred image. Astigmatism may also be caused by an irregularly shaped lens, which is located behind the cornea.

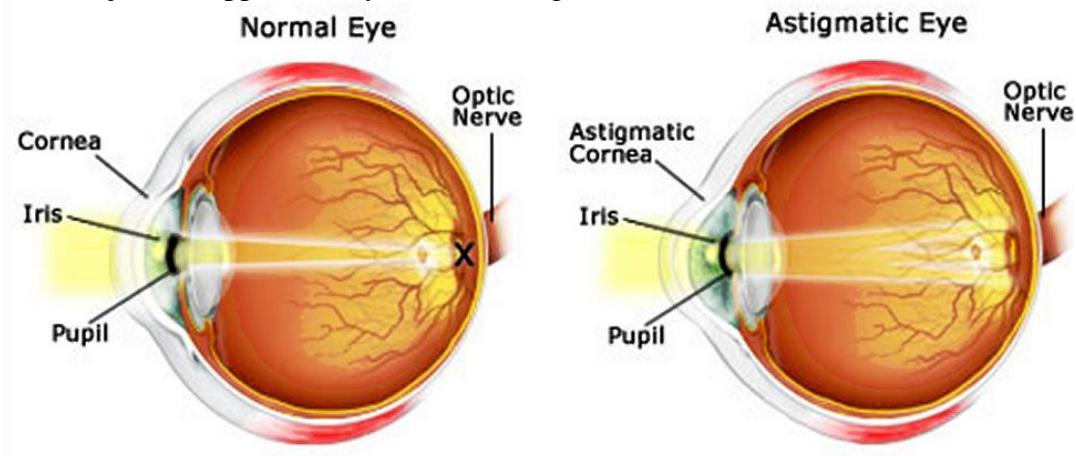
Astigmatism is a type of refractive error. A refractive error means that the shape of the eye does not bend light properly, resulting in a blurred image. Light has to be bent (refracted) by the lens and the cornea correctly before it reaches the retina in order to see things clearly.

The two most common types of astigmatism are:

Corneal astigmatism - the cornea has an irregular shape

Lenticular astigmatism - the lens has an irregular shape

In astigmatism, images focus in front of and beyond the retina, causing both close and distant objects to appear blurry (see below figure).



### INTEXT QUESTIONS PAGE No. 190

#### 1. What is meant by power of accommodation of the eye?

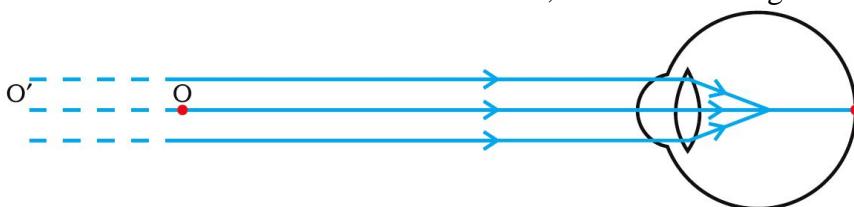
**Ans:**

When the ciliary muscles are relaxed, the eye lens becomes thin, the focal length increases, and the distant objects are clearly visible to the eyes. To see the nearby objects clearly, the ciliary muscles contract making the eye lens thicker. Thus, the focal length of the eye lens decreases and the nearby objects become visible to the eyes. Hence, the human eye lens is able to adjust its focal length to view both distant and nearby objects on the retina. This ability is called the power of accommodation of the eyes.

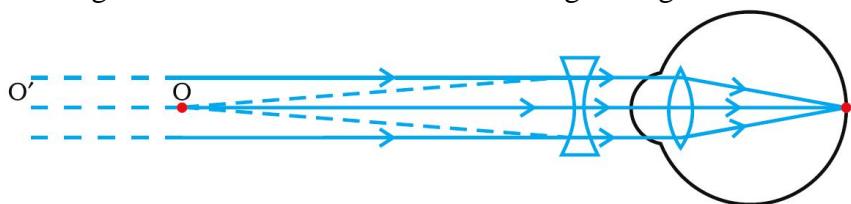
#### 2. A person with a myopic eye cannot see objects beyond 1.2 m distinctly. What should be the type of the corrective lens used to restore proper vision?

**Ans:**

The person is able to see nearby objects clearly, but he is unable to see objects beyond 1.2 m. This happens because the image of an object beyond 1.2 m is formed in front of the retina and not at the retina, as shown in the given figure.



To correct this defect of vision, he must use a concave lens. The concave lens will bring the image back to the retina as shown in the given figure.



#### 3. What is the far point and near point of the human eye with normal vision?

**Ans:**

The near point of the eye is the minimum distance of the object from the eye, which can be seen distinctly without strain. For a normal human eye, this distance is 25 cm.

The far point of the eye is the maximum distance to which the eye can see the objects clearly. The far point of the normal human eye is infinity.

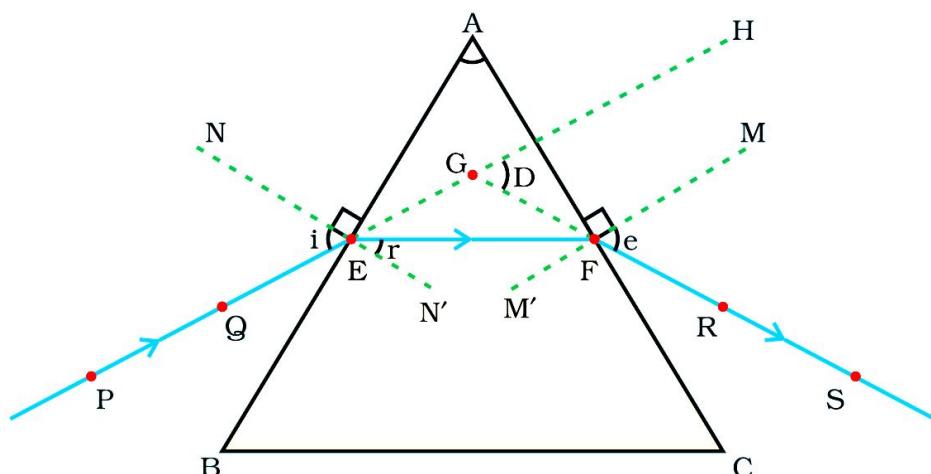
- 4. A student has difficulty reading the blackboard while sitting in the last row. What could be the defect the child is suffering from? How can it be corrected?**

**Ans:**

A student has difficulty in reading the blackboard while sitting in the last row. It shows that he is unable to see distant objects clearly. He is suffering from myopia. This defect can be corrected by using a concave lens.

### **REFRACTION OF LIGHT THROUGH A PRISM**

Prism is a transparent optical element, which refracts light. An optical object to be defined as prism must have at least two faces with an angle between them. A triangular glass prism has two triangular bases and three rectangular lateral surfaces. These surfaces are inclined to each other. The angle between its two lateral faces is called the angle of the prism



PE – Incident ray

$\angle i$  – Angle of incidence

EF – Refracted ray

$\angle r$  – Angle of refraction

FS – Emergent ray

$\angle e$  – Angle of emergence

$\angle A$  – Angle of the prism

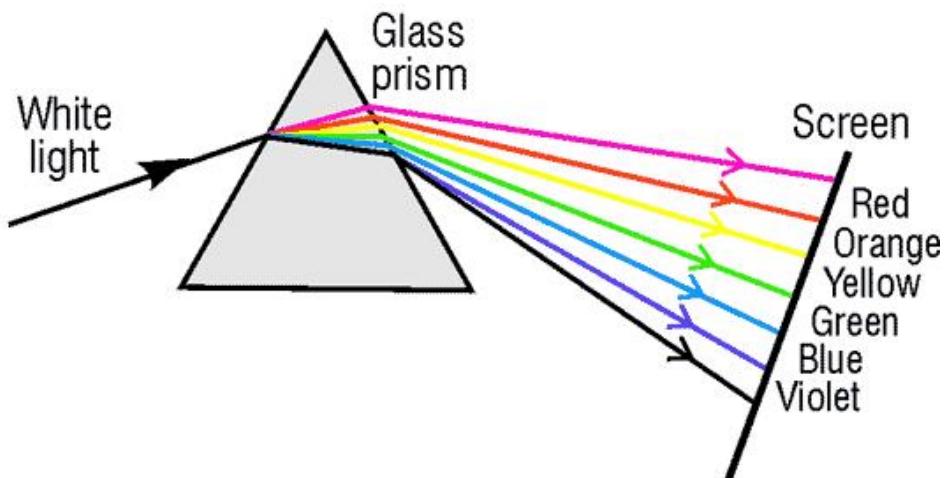
$\angle D$  – Angle of deviation

PE is the incident ray, EF is the refracted ray and FS is the emergent ray. A ray of light is entering from air to glass at the first surface AB. So, the light ray on refraction has bent towards the normal. At the second surface AC, the light ray has entered from glass to air. Hence it has bent away from normal. The peculiar shape of the prism makes the emergent ray bend at an angle to the direction of the incident ray. This angle is called the angle of deviation. In this case D is the angle of deviation.

### **DISPERSION OF WHITE LIGHT BY A GLASS PRISM**

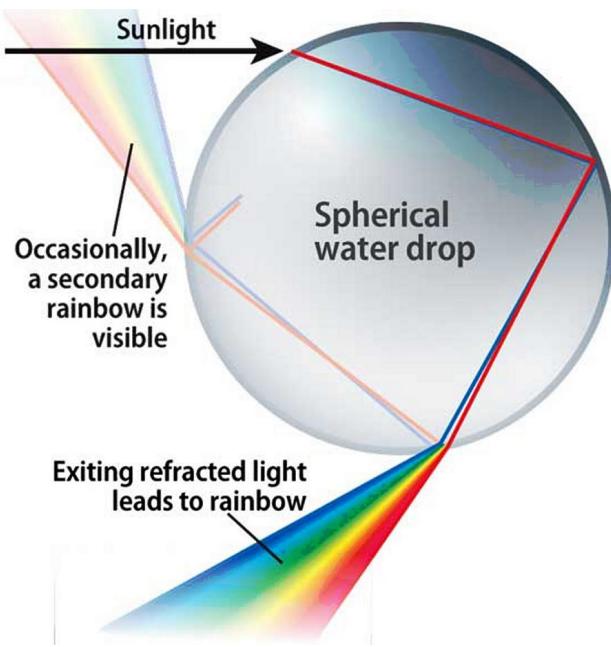
When a ray of light enters the prism, it bends towards the normal; because light is entering from a rarer medium to a denser medium. Similarly, when the light emerges from the prism, it follows the laws of refraction of light. Due to the angle of the prism and due to different wavelengths of different components of white light; the emergent

ray gets segregated into different colours. Finally, a colourful band of seven colours is obtained. This phenomenon is called dispersion of white light by the prism.



### **RAINBOW FORMATION**

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop (see below figure). Due to the dispersion of light and internal reflection, different colours reach the observer's eye.



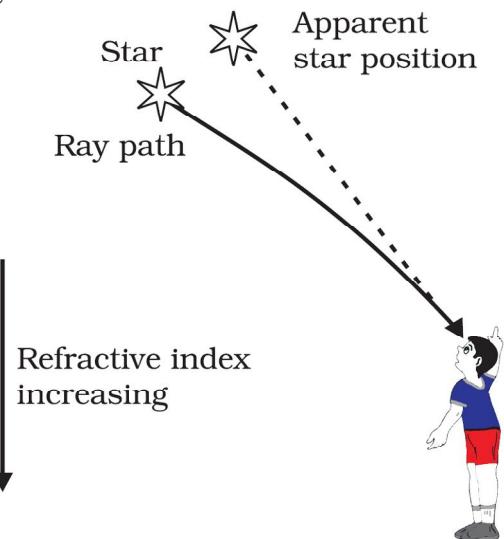
### **ATMOSPHERIC REFRACTION**

Atmospheric refraction is the shift in apparent direction of a celestial object caused by the refraction of light rays as they pass through Earth's atmosphere.

### **TWINKLING OF STARS**

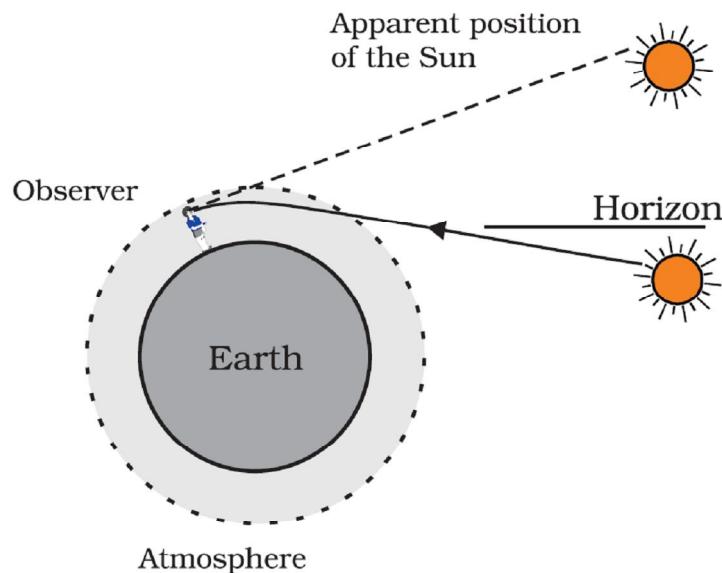
Stars emit their own light and they twinkle due to the atmospheric refraction of light. Stars are very far away from the earth. Hence, they are considered as point sources of light. When the light coming from stars enters the earth's atmosphere, it gets refracted

at different levels because of the variation in the air density at different levels of the atmosphere. When the star light refracted by the atmosphere comes more towards us, it appears brighter than when it comes less towards us. Therefore, it appears as if the stars are twinkling at night.



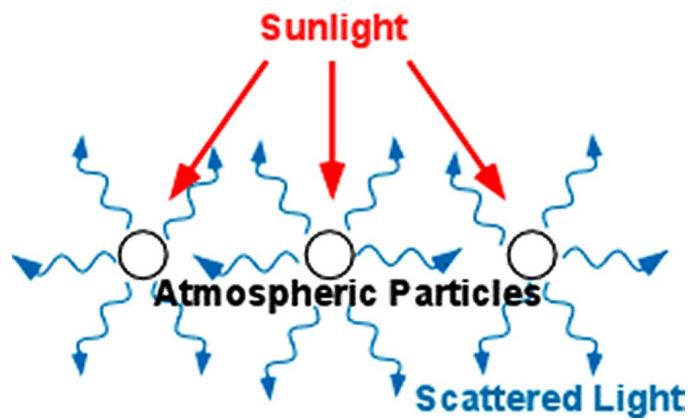
### ADVANCE SUNRISE AND DELAYED SUNSET

The Sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after the actual sunset because of atmospheric refraction. By actual sunrise, we mean the actual crossing of the horizon by the Sun. The below figure shows the actual and apparent positions of the Sun with respect to the horizon. The time difference between actual sunset and the apparent sunset is about 2 minutes. The apparent flattening of the Sun's disc at sunrise and sunset is also due to the same phenomenon.



### SCATTERING OF LIGHT

In the air, part of the sunlight is scattered. The small particles (molecules, tiny water droplets and dust particles) scatter photons the more, the shorter their wavelength is. Therefore, in the scattered light, the short wavelengths predominate, the sky appears blue, while direct sunlight is somewhat yellowish, or even reddish when the sun is very low.

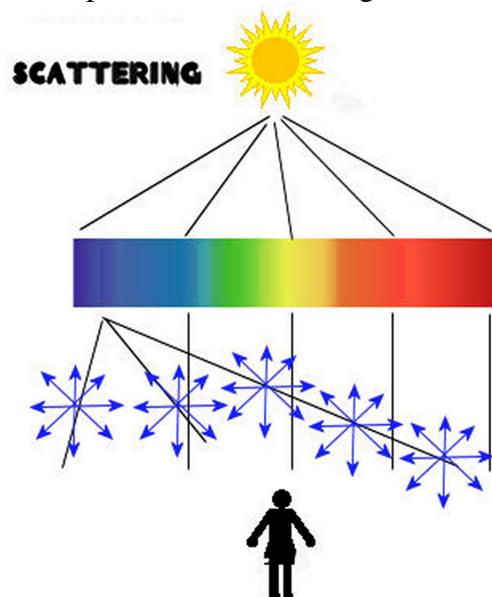


### **TYNDALL EFFECT**

The earth's atmosphere is a heterogeneous mixture of minute particles. These particles include smoke, tiny water droplets, suspended particles of dust and molecules of air. When a beam of light strikes such fine particles, the path of the beam becomes visible. The light reaches us, after being reflected diffusely by these particles. The phenomenon of scattering of light by the colloidal particles gives rise to Tyndall effect. This phenomenon is seen when a fine beam of sunlight enters a smoke-filled room through a small hole. Thus, scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest.

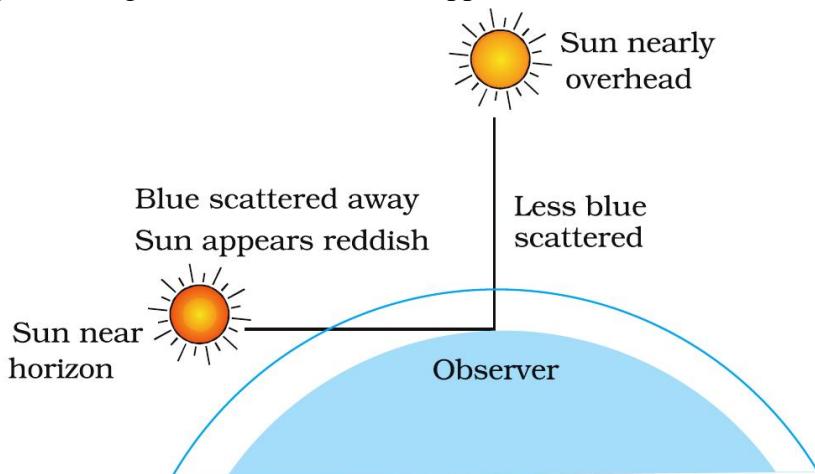
### **WHY IS THE COLOUR OF THE CLEAR SKY BLUE?**

The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. The red light has a wavelength about 1.8 times greater than blue light. Thus, when sunlight passes through the atmosphere, the fine particles in air scatter the blue colour (shorter wavelengths) more strongly than red. The scattered blue light enters our eyes. If the earth had no atmosphere, there would not have been any scattering. Then, the sky would have looked dark. The sky appears dark to passengers flying at very high altitudes, as scattering is not prominent at such heights.



## **COLOUR OF THE SUN AT SUNRISE AND SUNSET**

Light from the Sun near the horizon passes through thicker layers of air and larger distance in the earth's atmosphere before reaching our eyes (see below figure). However, light from the Sun overhead would travel relatively shorter distance. At noon, the Sun appears white as only a little of the blue and violet colours are scattered. Near the horizon, most of the blue light and shorter wavelengths are scattered away by the particles. Therefore, the light that reaches our eyes is of longer wavelengths. This gives rise to the reddish appearance of the Sun.



### **EXERCISE QUESTIONS PAGE No. 197 & 198**

1. **The human eye can focus objects at different distances by adjusting the focal length of the eye lens. This is due to (a) Presbyopia (b) accommodation (c) near-sightedness (d) far-sightedness.**

**Ans:**

(b) Human eye can change the focal length of the eye lens to see the objects situated at various distances from the eye. This is possible due to the power of accommodation of the eye lens.

2. **The human eye forms the image of an object at its (a) cornea (b) iris (c) pupil (d) retina**

**Ans:**

(d) The human eye forms the image of an object at its retina.

3. **The least distance of distinct vision for a young adult with normal vision is about (a) 25 m (b) 2.5 cm (c) 25 cm (d) 2.5 m**

**Ans:**

(c) The least distance of distinct vision is the minimum distance of an object to see clear and distinct image. It is 25 cm for a young adult with normal visions.

4. **The change in focal length of an eye lens is caused by the action of the (a) pupil (b) retina (c) ciliary muscles (d) iris**

**Ans:**

(c) The relaxation or contraction of ciliary muscles changes the curvature of the eye lens. The change in curvature of the eye lens changes the focal length of the eyes. Hence, the change in focal length of an eye lens is caused by the action of ciliary muscles.

- 5. A person needs a lens of power  $-5.5$  dioptres for correcting his distant vision. For correcting his near vision he needs a lens of power  $+1.5$  dioptre. What is the focal length of the lens required for correcting (i) distant vision, and (ii) near vision?**

**Ans:**

For distant vision =  $-0.181$  m, for near vision =  $0.667$  m

The power  $P$  of a lens of focal length  $f$  is given by the relation

$$P = \frac{1}{f(\text{in metres})}$$

(i) Power of the lens used for correcting distant vision =  $-5.5$  D

$$\text{Focal length of the required lens, } f = \frac{1}{P} = \frac{1}{-5.5} = -0.181\text{m}$$

The focal length of the lens for correcting distant vision is  $-0.181$  m.

(ii) Power of the lens used for correcting near vision =  $+1.5$  D

$$\text{Focal length of the required lens, } f = \frac{1}{P} = \frac{1}{1.5} = +0.667\text{m}$$

The focal length of the lens for correcting near vision is  $0.667$  m.

- 6. The far point of a myopic person is  $80$  cm in front of the eye. What is the nature and power of the lens required to correct the problem?**

**Ans:**

The person is suffering from an eye defect called myopia. In this defect, the image is formed in front of the retina. Hence, a concave lens is used to correct this defect of vision.

Object distance,  $u$  = infinity

Image distance,  $v$  =  $-80$  cm

Focal length =  $f$

According to the lens formula,

$$\begin{aligned} \frac{1}{v} - \frac{1}{u} &= \frac{1}{f} \Rightarrow \frac{1}{-80} - \frac{1}{\infty} = \frac{1}{f} \\ \Rightarrow \frac{1}{f} &= \frac{1}{-80} \Rightarrow f = -80\text{cm} = -0.8\text{m} \end{aligned}$$

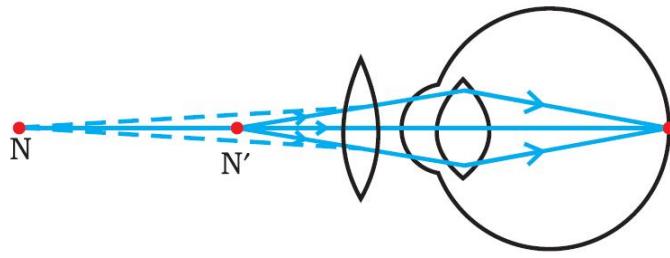
$$P = \frac{1}{f(\text{in metres})} = \frac{1}{-0.8} = -1.25\text{D}$$

A concave lens of power  $-1.25$  D is required by the person to correct his defect.

- 7. Make a diagram to show how hypermetropia is corrected. The near point of a hypermetropic eye is  $1$  m. What is the power of the lens required to correct this defect? Assume that the near point of the normal eye is  $25$  cm.**

**Ans:**

A person suffering from hypermetropia can see distinct objects clearly but faces difficulty in seeing nearby objects clearly. It happens because the eye lens focuses the incoming divergent rays beyond the retina. This defect of vision is corrected by using a convex lens. A convex lens of suitable power converges the incoming light in such a way that the image is formed on the retina, as shown in the following figure.



The convex lens actually creates a virtual image of a nearby object ( $N'$  in the figure) at the near point of vision ( $N$ ) of the person suffering from hypermetropia.

The given person will be able to clearly see the object kept at 25 cm (near point of the normal eye), if the image of the object is formed at his near point, which is given as 1 m.

Object distance,  $u = -25 \text{ cm}$

Image distance,  $v = -1 \text{ m} = -100 \text{ cm}$

Focal length,  $f$

Using the lens formula,

$$\begin{aligned}\frac{1}{v} - \frac{1}{u} &= \frac{1}{f} \Rightarrow \frac{1}{-100} - \frac{1}{-25} = \frac{1}{f} \\ \Rightarrow \frac{1}{f} &= \frac{1}{25} - \frac{1}{100} = \frac{4-1}{100} = \frac{3}{100} \\ \Rightarrow f &= \frac{100}{3} \text{ cm} = \frac{1}{3} \text{ m}\end{aligned}$$

$$\text{Power of lens, } P = \frac{1}{f(\text{in metres})} = \frac{1}{1/3} = +3.0D$$

A convex lens of power +3.0 D is required to correct the defect.

#### 8. Why is a normal eye not able to see clearly the objects placed closer than 25 cm?

**Ans:**

A normal eye is unable to clearly see the objects placed closer than 25 cm because the ciliary muscles of eyes are unable to contract beyond a certain limit.

If the object is placed at a distance less than 25 cm from the eye, then the object appears blurred and produces strain in the eyes.

#### 9. What happens to the image distance in the eye when we increase the distance of an object from the eye?

**Ans:**

Since the size of eyes cannot increase or decrease, the image distance remains constant. When we increase the distance of an object from the eye, the image distance in the eye does not change. The increase in the object distance is compensated by the change in the focal length of the eye lens. The focal length of the eyes changes in such a way that the image is always formed at the retina of the eye.

#### 10. Why do stars twinkle?

**Ans:**

Stars emit their own light and they twinkle due to the atmospheric refraction of light. Stars are very far away from the earth. Hence, they are considered as point sources of light. When the light coming from stars enters the earth's atmosphere, it gets refracted at different levels because of the variation in the air density at

different levels of the atmosphere. When the star light refracted by the atmosphere comes more towards us, it appears brighter than when it comes less towards us. Therefore, it appears as if the stars are twinkling at night.

**11. Explain why the planets do not twinkle?**

**Ans:**

Planets do not twinkle because they appear larger in size than the stars as they are relatively closer to earth. Planets can be considered as a collection of a large number of point-size sources of light. The different parts of these planets produce either brighter or dimmer effect in such a way that the average of brighter and dimmer effect is zero. Hence, the twinkling effects of the planets are nullified and they do not twinkle.

**12. Why does the Sun appear reddish early in the morning?**

**Ans:**

During sunrise, the light rays coming from the Sun have to travel a greater distance in the earth's atmosphere before reaching our eyes. In this journey, the shorter wavelengths of lights are scattered out and only longer wavelengths are able to reach our eyes. Since blue colour has a shorter wavelength and red colour has a longer wavelength, the red colour is able to reach our eyes after the atmospheric scattering of light. Therefore, the Sun appears reddish early in the morning.

**13. Why does the sky appear dark instead of blue to an astronaut?**

**Ans:**

The sky appears dark instead of blue to an astronaut because there is no atmosphere in the outer space that can scatter the sunlight. As the sunlight is not scattered, no scattered light reaches the eyes of the astronauts and the sky appears black to them.

# **CHAPTER - 11**

## **THE HUMAN EYE AND THE COLOURFUL WORLD**

### **ASSIGNMENTS QUESTIONS SET – 1**

- 1.** A man can read the number of a distant bus clearly but he finds difficulty in reading a book. From which defect of the eye is suffering from?
- 2.** What type of spectacles should be worn by a person having the defects of myopia as well as hypermetropia? How does it help?
- 3.** The sun near the horizon appears flattened at the sun set and sun rise. Explain why.
- 4.** Explain why and when the sun is overhead at noon it appears white
- 5.** A boy uses spectacles of focal length -50 cm. Name the defect of vision he is suffering from. Compute the power of this lens.
- 6.** Give the meaning of the term , VIBGYOR` with which phenomenon is it connected?
- 7.** Explain the following terms connected with the eye. (i) Ciliary muscles (ii) Accommodation.
- 8.** What is meant by spectrum of white light?
- 9.** What will be colour of the sky in the absence of atmosphere?
- 10.** Why are the traffic light signals (or danger signals) of red colour?
- 11.** Why does the sky appear dark and black to an astronaut instead of blue?
- 12.** Explain why, when the sun is overhead at noon, it appears white?
- 13.** What is Atmospheric Refraction?
- 14.** A person with myopic eye cannot see objects beyond 1.2metre distinctly. What should be the nature of corrective lenses to restore proper vision?
- 15.** The far point of a myopic person is 80 cm in front of the eye. What is the nature and power of the lens required to correct the problem?
- 16.** The far point of myopic person is 80 cm in front of the eye. What is the nature and power of the lens required to enable him to see very distant objects distinctly?
- 17.** The far point of a myopic person is 150 cm in front the eye. Calculate the focal length and power of a lens required to enable him to see distant objects clearly.
- 18.** How is the eye lens held in its position?
- 19.** What is meant by near point?
- 20.** What is meant by least distance of distinct vision?
- 21.** Which part of the eye controls the amount of the light entering the eye?
- 22.** Which liquid fills the space behind the cornea?

- 23.** Why is blind spot so called?
- 24.** What is meant by the accommodation of the eye?
- 25.** What is the least distance of distinct vision of a normal human eye?
- 26.** Name the defects of vision of human eye?
- 27.** What is the other name of near sightedness?
- 28.** Where is the image formed in an eye suffering from near sightedness?
- 29.** What is the other name of long sightedness?
- 30.** Where is the image formed in an eye suffering from long sightedness?
- 31.** How is long sightedness corrected?
- 32.** A person has to use a concave lens in his spectacles. What defect of vision is he suffering from?
- 33.** What is the other name of Presbyopia?
- 34.** What is the twinkling of stars due to?
- 35.** Give one example of source of white light.
- 36.** Which scientist first explains the dispersion of light?
- 37.** Name the delicate membrane in the eye having enormous number of light sensitive cells.
- 38.** What kind of lens is used in the spectacles of a person suffering from Myopia (near sightedness)?
- 39.** On what factor the colour of the scattered light depends?
- 40.** What is a function of choroids?
- 41.** Why does sky appear blue on a clear sky?
- 42.** What happens to the lens and the ciliary muscles when you are looking at nearby objects?
- 43.** In an experiment the image of a distant object formed by a concave mirror is obtained on a screen. To determine the focal length of the mirror, you need to measure the distance between the:-
- Mirror and the screen
  - Mirror and the object
  - Object and the screen
  - Mirror and the screen and also between the object and the screen.
- 44.** The image formed by concave mirror is real. The position of the screen should be
- behind the mirror
  - on the same side of object between focus and infinity
  - on the same side of object between focus and pole

(d) none of these

**45.** In the experiment to determine focal length of a convex lens, a student obtained a sharp inverted image of a distant tree on the screen behind the lens. She then removed the screen and looked through the lens in the direction of the object. She will see:-

- (a) An inverted image of the tree at the focus.
- (b) No image as the screen has been removed.
- (c) A blurred image on the wall of the laboratory.
- (d) An erect image of the tree on the lens.

**46.** While performing the experiment for determination of focal length of a convex lens by using the sun as a distant object a student could not find a screen with stand. Which one of the following methods he should adopt safely? He should see:-

- (a) The image of sun directly through convex lens.
- (b) Focus the image of sun on his hand
- (c) Focus the image of sun on his nylon shirt.
- (d) Focus the image of sun on the wall of the room.

**47.** In an experiment to determine the focal length of a convex lens, the image of a distant tree is obtained on the screen. To determine the focal length of the lens, you are required to measure the distance between the :-

- (a) Lens and the tree only
- (b) Lens and the screen only
- (c) Screen and the tree only
- (d) Screen and the tree and also between the screen and the lens

**48.** For performing an experiment, a student was asked to choose one concave mirror and one convex lens from a lot of mirrors and lenses of different kinds. The correct procedure adopted by her will be :-

- (a) To choose a mirror and lens which can form an enlarged and inverted image of an object.
- (b) To choose a mirror which can form a diminished and erect image and a lens which can form an enlarged and erect image of the object.
- (c) To choose a mirror and lens which can form an enlarged and erect image of an object.
- (d) To choose a mirror and a lens which can form a diminished and erect image of an object.

**49.** Your school laboratory has one large window. To find the focal length of a concave mirror using one of the walls as the screen, the experiment may be performed.

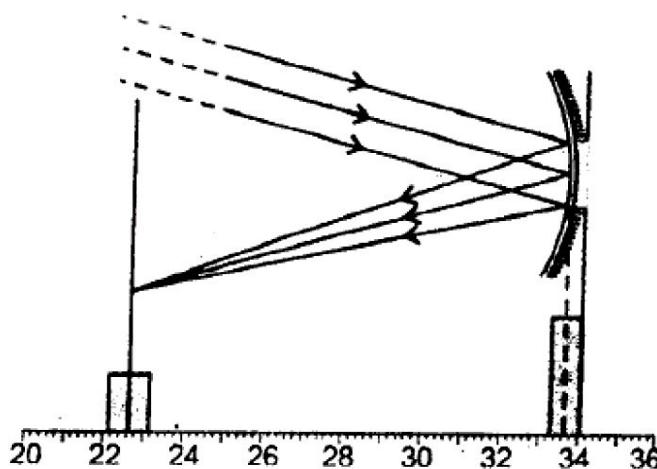
- (a) Near the wall opposite to the window.
- (b) On the same wall as the window
- (c) On the wall adjacent to the window
- (d) Only on the table as per the laboratory arrangement

**50.** A student obtains a blurred image of an object on a screen by using a concave mirror. In order to obtain a sharp image on the screen, he will have to shift the mirror :-

- (a) towards the screen
- (b) away from the screen
- (c) either towards or away from the screen depending upon the position of the object
- (d) to a position very far away from the screen

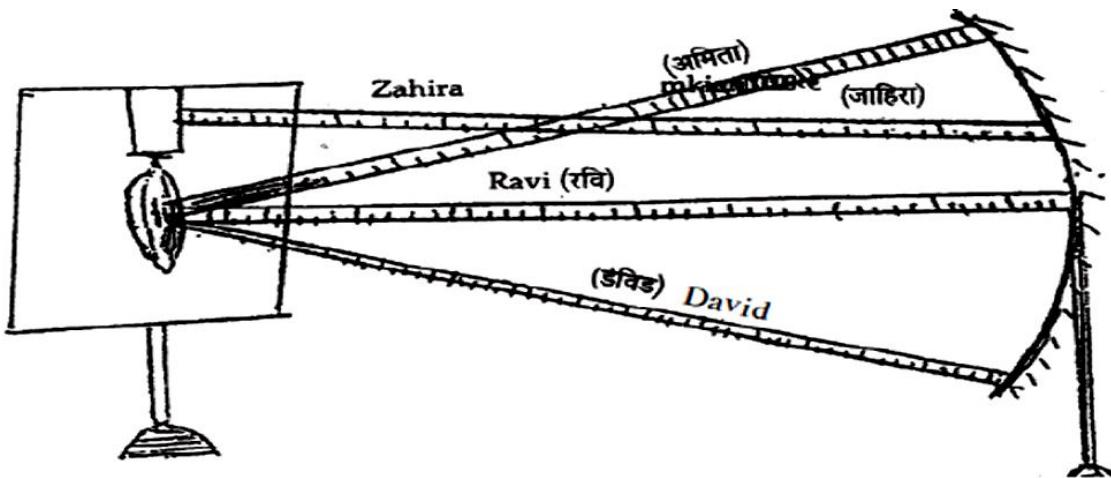
**51.** The focal length of the concave mirror in an experimental setup shown below, is

- (a) 10.2cm
- (b) 11.0cm
- (c) 11.4cm
- (d) 12.2cm



**52.** Four students, Ameeta, Zahira, Ravi and David performed the experiment for determination of focal length of a concave mirror separately. They measured the distance between the screen and the mirror as shown in the following diagram. Which one of these students is likely to get the correct value of focal length of the concave mirror?

(a) Ameeta (b) Zahira (c) Ravi (d) David



53. A student performs an experiment on finding a focal length of a convex lens by keeping a lighted candle on one end of laboratory table, a screen on its other end and the lens between them as shown in the figure. The positions of the three are adjusted to get a sharp image of the candle flame on the screen by making.

- (a) the screen in the direction of the lens or the lens in the direction of the screen
- (b) the screen in the direction of the lens or the lens away from the screen
- (c) the screen away from the lens or the lens in the direction of the screen
- (d) neither the screen nor the lens.

54. Given below are few steps (not in proper sequence) followed in the determination of focal length of a given convex lens by obtaining a sharp image of a distant object.

- (i) Measure the distance between the lens and screen
- (ii) Adjust the position of the lens to form a sharp image.
- (iii) Select a suitable distant object.
- (iv) Hold the lens between the object and the screen with its faces parallel to the screen.

The correct sequence of steps for determination of focal length is

- (a) (iii), (i), (iv), (ii)
- (b) (iii), (iv), (ii), (i)
- (c) (iii), (i), (ii), (iv)
- (d) (i), (ii), (iii), (iv)

# **CHAPTER - 11**

## **THE HUMAN EYE AND THE COLOURFUL WORLD**

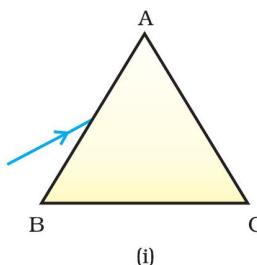
### **ASSIGNMENTS QUESTIONS SET – 2**

## **MULTIPLE CHOICE QUESTIONS**

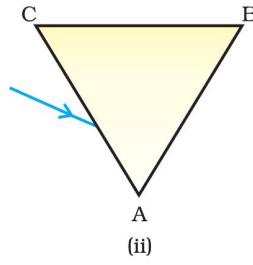


(a) (i)  
(c) (iii)

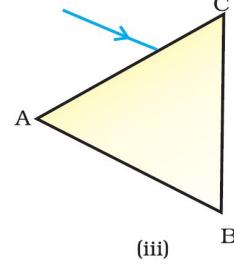
(b) (ii)  
(d) (iv)



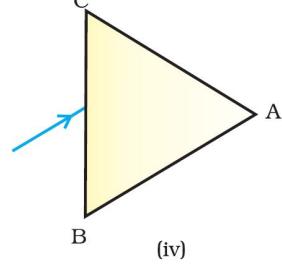
(i)



(i)



(ii)



3  
(iv)

4. At noon the sun appears white as
    - (a) light is least scattered
    - (b) all the colours of the white light are scattered away
    - (c) blue colour is scattered the most
    - (d) red colour is scattered the most
  5. Which of the following phenomena of light are involved in the formation of a rainbow?
    - (a) Reflection, refraction and dispersion
    - (b) Refraction, dispersion and total internal reflection
    - (c) Refraction, dispersion and internal reflection
    - (d) Dispersion, scattering and total internal reflection
  6. Twinkling of stars is due to atmospheric
    - (a) dispersion of light by water droplets
    - (b) refraction of light by different layers of varying refractive indices
    - (c) scattering of light by dust particles
    - (d) internal reflection of light by clouds

- 7.** The clear sky appears blue because  
(a) blue light gets absorbed in the atmosphere  
(b) ultraviolet radiations are absorbed in the atmosphere  
(c) violet and blue lights get scattered more than lights of all other colours by the atmosphere  
(d) light of all other colours is scattered more than the violet and blue colour lights by the atmosphere
- 8.** Which of the following statements is correct regarding the propagation of light of different colours of white light in air?  
(a) Red light moves fastest  
(b) Blue light moves faster than green light  
(c) All the colours of the white light move with the same speed  
(d) Yellow light moves with the mean speed as that of the red and the violet light
- 9.** The danger signals installed at the top of tall buildings are red in colour. These can be easily seen from a distance because among all other colours, the red light  
(a) is scattered the most by smoke or fog  
(b) is scattered the least by smoke or fog  
(c) is absorbed the most by smoke or fog  
(d) moves fastest in air
- 10.** Which of the following phenomena contributes significantly to the reddish appearance of the sun at sunrise or sunset?  
(a) Dispersion of light  
(b) Scattering of light  
(c) Total internal reflection of light  
(d) Reflection of light from the earth
- 11.** The bluish colour of water in deep sea is due to  
(a) the presence of algae and other plants found in water  
(b) reflection of sky in water  
(c) scattering of light  
(d) absorption of light by the sea
- 12.** When light rays enter the eye, most of the refraction occurs at the  
(a) crystalline lens                   (b) outer surface of the cornea  
(c) iris                                 (d) pupil
- 13.** The focal length of the eye lens increases when eye muscles  
(a) are relaxed and lens becomes thinner  
(b) contract and lens becomes thicker  
(c) are relaxed and lens becomes thicker  
(d) contract and lens becomes thinner
- 14.** Which of the following statement is correct?  
(a) A person with myopia can see distant objects clearly  
(b) A person with hypermetropia can see nearby objects clearly  
(c) A person with myopia can see nearby objects clearly  
(d) A person with hypermetropia cannot see distant objects clearly

### **SHORT ANSWER QUESTIONS**

- 15.** Draw ray diagrams each showing (i) myopic eye and (ii) hypermetropic eye.
- 16.** A student sitting at the back of the classroom cannot read clearly the letters written on the blackboard. What advice will a doctor give to her? Draw ray diagram for the correction of this defect.
- 17.** How are we able to see nearby and also the distant objects clearly?
- 18.** A person needs a lens of power  $-4.5\text{ D}$  for correction of her vision.
  - (a) What kind of defect in vision is she suffering from?
  - (b) What is the focal length of the corrective lens?
  - (c) What is the nature of the corrective lens?
- 19.** How will you use two identical prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light? Draw the diagram.
- 20.** Draw a ray diagram showing the dispersion through a prism when a narrow beam of white light is incident on one of its refracting surfaces. Also indicate the order of the colours of the spectrum obtained.
- 21.** Is the position of a star as seen by us its true position? Justify your answer.
- 22.** Why do we see a rainbow in the sky only after rainfall?
- 23.** Why is the colour of the clear sky blue?
- 24.** What is the difference in colours of the Sun observed during sunrise/sunset and noon? Give explanation for each.

### **LONG ANSWER QUESTIONS**

- 25.** Explain the structure and functioning of Human eye. How are we able to see nearby as well as distant objects?
  - 26.** When do we consider a person to be myopic or hypermetropic? Explain using diagrams how the defects associated with myopic and hypermetropic eye can be corrected?
  - 27.** Explain the refraction of light through a triangular glass prism using a labelled ray diagram. Hence define the angle of deviation.
  - 28.** How can we explain the reddish appearance of sun at sunrise or sunset? Why does it not appear red at noon?
  - 29.** Explain the phenomenon of dispersion of white light through a glass prism, using suitable ray diagram.
  - 30.** How does refraction take place in the atmosphere? Why do stars twinkle but not the planets?
- 
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# **CHAPTER - 12**

## **ELECTRICITY**

Electricity is a general term that encompasses a variety of phenomena resulting from the presence and flow of electric charge. These include many easily recognizable phenomena such as lightning and static electricity, but in addition, less familiar concepts such as the electromagnetic field and electromagnetic induction.

### **Electric charge**

Electric charge is a fundamental conserved property of some subatomic particles, which determines their electromagnetic interaction. Electrically charged matter is influenced by, and produces, electromagnetic fields. The interaction between a moving charge and an electromagnetic field is the source of the electromagnetic force, which is one of the four fundamental forces. Electric charge is conserved, additive and quantised. The S.I. unit of electric charge is 'C' coulomb.

Any other charged body will have a charge Q

$$Q = ne$$

where n is the number of electrons and e is the charge on electron =  $1.6 \times 10^{-19}$  coulombs.

### **Electric current**

Electric current is a flow of electrons in a conductor such as a metal wire. Electric current is expressed by the amount of charge flowing through a particular area in unit time. In other words, it is the rate of flow of electric charges. In circuits using metallic wires, electrons constitute the flow of charges. However, electrons were not known at the time when the phenomenon of electricity was first observed. So, electric current was considered to be the flow of positive charges and the direction of flow of positive charges was taken to be the direction of electric current. Conventionally, in an electric circuit the direction of electric current is taken as opposite to the direction of the flow of electrons, which are negative charges.

The magnitude of electric current in a conductor is the amount of electric charge passing through a given point of conductor in 1 second.

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

S.I. unit of electric current is 'A' (Ampere).

The electric current is expressed by a unit called ampere (A), named after the French scientist, Andre-Marie Ampere (1775–1836).

### **One Ampere**

When 1 coulomb of charge flows through any cross-section of a conductor in 1 second, the electric charge flowing through it is said to be 1 ampere.

Smaller unit current is milliampere(mA) and microampere( $\mu A$ )

$$1 \text{ mA} = 10^{-3} \text{ A}$$

$$1 \text{ } \mu \text{ A} = 10^{-6} \text{ A}$$

An instrument called ammeter measures electric current in a circuit. It is always connected in series in a circuit through which the current is to be measured.

The direction of electric current is from positive terminal to negative terminal through the electric circuit.

## **INTEXT QUESTIONS PAGE NO. 200**

### **1. What does an electric circuit mean?**

**Ans.** An electric circuit consists of electric devices, switching devices, source of electricity, etc. that are connected by conducting wires.

### **2. Define the unit of current.**

**Ans.** The unit of electric current is ampere (A). 1 A is defined as the flow of 1 C of charge through a wire in 1 s.

### **3. Calculate the number of electrons constituting one coulomb of charge.**

**Ans.** One electron possesses a charge of  $1.6 \times 10^{-19}$  C, i.e.,  $1.6 \times 10^{-19}$  C of charge is contained in 1 electron.

$$\therefore 1 \text{ C of charge is contained in } \frac{1}{1.6 \times 10^{-19}} = 6.25 \times 10^{18} \text{ electrons}$$

Therefore,  $6.25 \times 10^{18}$  electrons constitute one coulomb of charge.

## **Potential difference**

Potential difference,  $V_A - V_B$  between two points A and B is the work done per unit charge in taking a charge from B to A.

Potential difference,  $V_A - V_B = \frac{\text{work done}}{\text{charge}}$ , where  $V_A$  is potential at point A,  $V_B$  is potential at point B and S.I. unit of potential is volts (V), named after Alessandro Volta (1745–1827), an Italian physicist.

## **Electric Potential**

Electric Potential at a point is defined as the work done per unit charge in bringing a charge from infinity to that point.

$$V = \frac{\text{work done}}{\text{charge}} = \frac{W}{Q}$$

The potential difference is measured by means of an instrument called the voltmeter. The voltmeter is always connected in parallel across the points between which the potential difference is to be measured.

**One volt:** The potential difference between two points is said to be 1 volt if 1 joule of work is done in moving 1 coulomb of electric charge from one point to the other. Electrons always flow from lower potential to higher potential.

## **INTEXT QUESTIONS PAGE NO. 202**

### **1. Name a device that helps to maintain a potential difference across a conductor.**

**Ans.** A source of electricity such as cell, battery, power supply, etc. helps to maintain a potential difference across a conductor.

### **2. What is meant by saying that the potential difference between two points is 1 V?**

**Ans.** If 1 J of work is required to move a charge of amount 1 C from one point to another, then it is said that the potential difference between the two points is 1 V.

### **3. How much energy is given to each coulomb of charge passing through a 6 V battery?**

**Ans.** The energy given to each coulomb of charge is equal to the amount of work required to move it. The amount of work is given by the expression,

$$\text{Potential difference} = \frac{\text{Work done}}{\text{Charge}}$$

$$\text{Work done} = \text{Potential difference} \times \text{Charge}$$

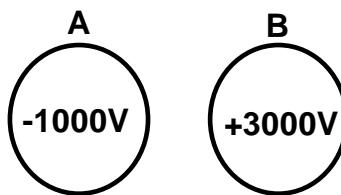
Where, Charge = 1 C and Potential difference = 6 V

$$\text{Work done} = 6 \times 1 = 6 \text{ J}$$

Therefore, 6 J of energy is given to each coulomb of charge passing through a battery of 6 V.

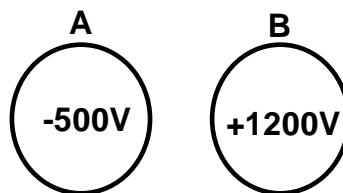
### **NUMERICAL PROBLEMS**

1. Find the charge if the number of electrons is  $4 \times 10^{-18}$ .
2. Find the number of electrons constituting one coulomb of charge.
3. How much work done in moving a charge of 3 coulombs from a point at 118 V to a point at 128 volt?
4. How much work done in moving a charge of 2C across two points having a potential difference of 12V?
5. Calculate the amount of work done to carry 4C from a point at 100 V to a point at 120 volt?
6. How much work will be done in bringing a charge of  $2 \times 10^{-3}$  coulombs from infinity to a point P at which the potential is 5 V?
7. How much work will be done in bringing a charge of  $3 \times 10^{-2}$  coulombs from infinity to a point P at which the potential is 20 V?
8. How much energy is given to each coulomb of charge passing through a 6V battery?
9. How much energy is transferred by a 12 V power supply to each coulomb of charge which it moves around a circuit?
10. What is the potential difference between the terminals of a battery if 250 joules of work is required to transfer 20 coulombs of charge from one terminal of battery to the other?
11. What is the potential difference between the conductors A and B shown in below figure? If the conductors are connected by a length of wire, which way will electrons flow? When will this flow of electrons stop?



**12.** A particle of charge  $2\text{C}$  is taken from a point at a potential of  $100\text{V}$  to another point at a potential of  $150\text{V}$ . Calculate the work done.

**13.** What is the potential difference between the conductors A and B shown in below figure? If the conductors are connected by a length of wire, which way will electrons flow? When will this flow of electrons stop?



**14.** A particle of charge  $5 \times 10^{-2} \text{ C}$  is taken from a point at a potential of  $50\text{V}$  to another point at a potential of  $250\text{V}$ . Calculate the work done.

**15.** Three  $2\text{V}$  cells are connected in series and used as a battery in a circuit.

(a) What is the potential difference at the terminals of the battery?

(b) How many joules of electrical energy does  $1\text{ C}$  gain on passing through (i)one cell (ii) all three cells.

### **CIRCUIT DIAGRAM**

The Schematic diagram, in which different components of the circuit are represented by the symbols conveniently used, is called a circuit diagram. Conventional symbols used to represent some of the most commonly used electrical components are given below:

**1.** An electric cell



**2.** A battery or a combination of cells



**3.** Plug key or switch (open)



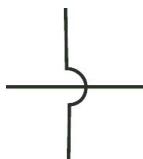
**4.** Plug key or switch (closed)



**5.** A wire joint



**6.** Wires crossing without joining



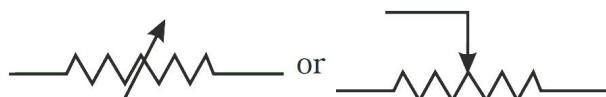
**7.** Electric bulb



8. A resistor of resistance  $R$



9. Variable resistance or rheostat



10. Ammeter



11. Voltmeter



### Ohm's law

According to Ohm's law, "At constant temperature, the current flowing through a conductor is directly proportional to the potential difference across its ends."

$$I \propto V \text{ or } V \propto I \text{ at constant temperature}$$

$V = IR$  where  $R$  is constant of proportionality which is known as resistance.

### Resistance

It is the ratio of potential difference applied between the ends of a conductor and the current flowing through it. The unit of resistance is ohm ( $\Omega$ ).

$$R = \frac{V}{I} \Rightarrow I = \frac{V}{R}$$

$$1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ ampere}}$$

### One Ohm

One Ohm is the resistance of a conductor such that when a potential difference of 1 volt is applied to its ends, a current of 1 ampere flows through it.

If the resistance is doubled the current gets halved. In many practical cases it is necessary to increase or decrease the current in an electric circuit. A component used to regulate current without changing the voltage source is called variable resistance. In an electric circuit, a device called rheostat is often used to change the resistance in the circuit.

### Factors on which the Resistance of a conductor depends

The resistance of the conductor depends (i) on its length, (ii) on its area of cross-section, and (iii) on the nature of its material.

**Resistance depends on area of cross section:** It is inversely proportional to the area of cross section ( $A$ )

$$R \propto \frac{1}{A}$$

**Resistance depends on length of wire:** It is directly proportional to the length of the wire ( $l$ )

$$R \propto l$$

Combining the above we get  $R \propto \frac{l}{A}$

$$\Rightarrow R = \rho \frac{l}{A}$$

where  $\rho$  (rho) is a constant of proportionality which is called the resistivity or specific resistance of the material.

If  $l = 1\text{m}$ ,  $A = 1\text{m}^2$  then  $R = \rho$

Resistivity of a material is the resistance of a unit length of the material having unit area of cross section.

### **INTEXT QUESTIONS PAGE NO. 209**

#### **1. On what factors does the resistance of a conductor depend?**

**Ans.** The resistance of a conductor depends upon the following factors:

- (a) Length of the conductor
- (b) Cross-sectional area of the conductor
- (c) Material of the conductor
- (d) Temperature of the conductor

#### **2. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?**

**Ans.** Resistance of a wire,

$$\text{Where, } R = \rho \frac{l}{A}$$

$\rho$  = Resistivity of the material of the wire

$l$  = Length of the wire

$A$  = Area of cross-section of the wire

Resistance is inversely proportional to the area of cross-section of the wire.

Thicker the wire, lower is the resistance of the wire and vice-versa. Therefore, current can flow more easily through a thick wire than a thin wire.

#### **3. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half of its former value. What change will occur in the current through it?**

**Ans.** The change in the current flowing through the component is given by Ohm's law as,

$$V = IR$$

$$I = \frac{V}{R}$$

Where,

Resistance of the electrical component =  $R$

Potential difference =  $V$

Current =  $I$

The potential difference is reduced to half, keeping resistance constant.

Let the new resistance be  $R'$  and the new amount of current be  $I'$ .

Therefore, from Ohm's law, we obtain the amount of new current.

$$I' = \frac{V'}{R'} = \frac{V/2}{R} = \frac{1}{2} \left( \frac{V}{R} \right) = \frac{1}{2} I$$

Therefore, the amount of current flowing through the electrical component is reduced by half.

- 4. Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?**

**Ans.** The resistivity of an alloy is higher than the pure metal. Moreover, at high temperatures, the alloys do not melt readily. Hence, the coils of heating appliances such as electric toasters and electric irons are made of an alloy rather than a pure metal.

- 5. (a) Which among iron and mercury is a better conductor?**

- (b) Which material is the best conductor?**

**Ans.** (a) Resistivity of iron =  $10.0 \times 10^{-8} \Omega m$

Resistivity of mercury =  $94.0 \times 10^{-8} \Omega m$

Resistivity of mercury is more than that of iron. This implies that iron is a better conductor than mercury.

(b) It can be observed from Table 12.2 that the resistivity of silver is the lowest among the listed materials. Hence, it is the best conductor.

### **NUMERICAL PROBLEMS**

1. What current must flow if 0.24 coulombs is to be transferred in 15 ms?
2. If a current of 10 A flows for four minutes, find the quantity of electricity transferred.
3. An electric bulb draws a current of 0.25A for 20 minutes. Calculate the electric charge that flows through the circuit.
4. If the amount of electric charge passing through a conductor in 10min is 300C, find the current.
5. How many electrons are flowing per second past a point in a circuit in which there is a current of 4A?
6. A lamp of resistance  $80\Omega$  draw a current of 0.75A. Find the line voltage.
7. A electric heater draw a current of 5A when connected to 220V mains. Calculate the resistance of its filament.
8. How much current will an electric bulb draw from a 200V source, if the resistance of the filament is  $1200\Omega$ ?
9. How much current will an electric heater draw from a 200V source, if the resistance of the filament is  $100\Omega$ ?
10. How much current does an electric heater draw from a 220V line, if the resistance of the heater (when hot) is  $50\Omega$ ?
11. A bulb when cold has  $1\Omega$  resistance. It draws a current of 0.3A when glowing from a source of 3V. Calculate the resistance of the bulb when flowing and explain the reason for the difference in resistance.

- 12.** Calculate the potential difference required across a conductor of resistance  $5\Omega$  to make a current of  $1.5A$  flow through it.
- 13.** What is the resistance of an electric arc lamp when hot, if the lamp uses  $20A$  when connected to a  $220V$  line?
- 14.** Calculate the amount of work done to draw a current of  $8A$  from a point at  $100V$  to a point at  $120V$  in  $2$  seconds.
- 15.** If  $200C$  of charge pass a point in a circuit in  $4$  sec, what current is flowing?
- 16.** A current of  $4A$  flows around a circuit in  $10$  seconds. How much charge flows past a point in the circuit in this time? Also find the number of electrons passes in the circuit.
- 17.** The current flowing through a resistor is  $0.8 A$  when a p.d. of  $20 V$  is applied. Determine the value of the resistance.
- 18.** Determine the p.d. which must be applied to a  $2 k\Omega$  resistor in order that a current of  $10 mA$  may flow.
- 19.** A coil has a current of  $50 mA$  flowing through it when the applied voltage is  $12 V$ . What is the resistance of the coil?
- 20.** A  $100 V$  battery is connected across a resistor and causes a current of  $5 mA$  to flow. Determine the resistance of the resistor. If the voltage is now reduced to  $25 V$ , what will be the new value of the current flowing?
- 21.** What is the resistance of a coil which draws a current of (a)  $50 mA$  and (b)  $200 \mu A$  from a  $120 V$  supply?
- 22.** If a current of  $5 A$  flows for  $2$  minutes, find the quantity of electricity transferred.
- 23.** A current of  $0.5 A$  is drawn by a filament of an electric bulb for  $10$  minutes. Find the amount of electric charge that flows through the circuit.
- 24.** How much current will an electric bulb draw from a  $220 V$  source, if the resistance of the bulb filament is  $1200\Omega$ ?
- 25.** How much current will an electric heater coil draw from a  $220 V$  source, if the resistance of the heater coil is  $100\Omega$ ?
- 26.** The potential difference between the terminals of an electric heater is  $60 V$  when it draws a current of  $4 A$  from the source. What current will the heater draw if the potential difference is increased to  $120 V$ ?
- 27.** When a  $12 V$  battery is connected across an unknown resistor, there is a current of  $2.5 mA$  in the circuit. Find the value of the resistance of the resistor.

- 28.** An electric heater is connected to the 230 V mains supply. A current of 8A flows through the heater (a) How much charge flows around the circuit each second.  
(b) How much energy is transferred to the heater each second?
- 29.** How many electrons are flowing per second past a point in a circuit in which there is a current of 5A?
- 30.** An electric iron draws a current of 3.4A from the 220V supply line. What current will this electric iron draw when connected to 110V supply line?
- 31.** A simple electric circuit has a 24V battery and a resistor of  $60\Omega$ . What will be the current in the circuit?
- 32.** When a  $4\Omega$  resistor is connected across the terminal of 12V battery, find the number of coulombs passing through the resistor per second.
- 33.** An electric room heater draw a current of 2.4A from the 120V supply line. What current will this room heater draw when connected to 240V supply line?
- 34.** A current of 200mA flows through a  $4k\Omega$  resistor. What is the p.d. across the resistor?
- 35.** A p.d. of 10V is needed to make a current of 0.02 A flow through a wire. What p.d. is needed to make a current of 250mA flow through the same wire?
- 36.** A TV draws a current of 5 A from the 240V supply line. What current will this TV draw when it is connected to 100V supply line.
- 37.** The potential difference between the terminals of an electric heater is 60V when it draw a current of 4A from the source. What current will the heater draw if the potential difference is increased to 120V?
- 38.** A bulb of resistance  $400\Omega$  is connected to 220V mains. Calculate the magnitude of current.
- 39.** A battery of two cells is used to light a torch bulb of resistance  $5\Omega$ . The cells maintain a potential difference of 3V across the bulb. How much current will flow through the bulb?
- 40.** A steady current of 5A flows through a circuit for 30minutes. How much charge has circulated through the circuit in this time?

### **NUMERICAL PROBLEMS ON RESISTIVITY**

- Calculate the resistance of a copper wire of length 2m and area of cross section  $10^{-6}m^2$ . Resistivity of copper is  $1.7 \times 10^{-8} \Omega m$
- A copper wire of length 2m and area of cross section  $1.7 \times 10^{-6}m^2$  has a resistance of  $2 \times 10^{-2}$  ohms. Calculate the resistivity of copper.

3. The amount of charge passing through a cell in 12 seconds is 3C. What is the current supplied by the cell?
4. A 12 V battery of a car is connected across a  $4\Omega$  resistor. Calculate the current passing through the resistor.
5. Resistivity of a given copper wire of length 2m is  $1.7 \times 10^{-8} \Omega \text{ m}$ . The wire is stretched so that its length becomes 4m. Find new resistivity of the copper wire.
6. Resistance of a given wire of length ' $l$ ' is  $3\Omega$ . The wire is stretched uniformly such that its length becomes  $2l$ . Find the new resistance of the stretched wire.
7. Resistance of a given wire of length ' $l$ ' is  $4\Omega$ . The wire is stretched uniformly such that its length becomes  $3l$ . Find the new resistance of the stretched wire.
8. A copper wire has a diameter of 0.5 mm and resistivity of  $1.6 \times 10^{-8} \Omega \text{ m}$ . What will be the length of this wire to make its resistance  $10\Omega$ ? How much does the resistance change if the diameter is doubled?
9. A  $6\Omega$  resistance wire is doubled up by folding. Calculate the new resistance of the wire.
10. Calculate the resistance of an aluminium cable of length 10km and diameter 20mm if the resistivity of aluminum is  $2.7 \times 10^{-8} \Omega \text{ m}$ .
11. Calculate the area of cross section of a wire if its length is 1.0m, its resistance is  $23\Omega$  and the resistivity of the material of the wire is  $1.84 \times 10^{-6} \Omega \text{ m}$ .
12. A piece of wire of resistance  $20\Omega$  is drawn out so that its length is increased to twice its original length. Calculate the resistance of the wire in the new situation.
13. Two cylindrical wires of the same material have their lengths in the ratio of 4 : 9. What should be the ratio of their radii so that their resistances are in the ratio of 4 : 1?
14. Two wires of the same metal, have the same area of cross section but their lengths in the ratio of 3 : 1. What should be the ratio of current flowing through them respectively, when the same potential difference is applied across each of their length?
15. Two wires A and B of length 30m and 10m have radii 2cm and 1cm respectively. Compare the resistances of the two wires. Which will have less resistance?
16. Calculate the resistance of 1km long copper wire of radius 1mm. Resistivity of copper is  $1.7 \times 10^{-8} \Omega \text{ m}$
17. A  $4\Omega$  wire is doubled on it. Calculate the new resistance of the wire.
18. What should be the length of the nichrome wire of resistance  $4.5\Omega$ , if the length of a similar wire is 60cm and resistance  $2.5\Omega$ ?

19. A metal wire of resistivity  $64 \times 10^{-6} \Omega m$  and length 198cm has a resistance of  $7\Omega$ . Calculate its radius.
20. Calculate the resistivity of the material of a wire 1.0m long, 0.4mm in diameter and having a resistance of  $2.0\Omega$ .

## RESISTANCE OF A SYSTEM OF RESISTORS

### RESISTORS IN SERIES

#### In a series circuit

- (a) the current  $I$  is the same in all parts of the circuit, and
- (b) the sum of the voltages  $V_1$ ,  $V_2$  and  $V_3$  is equal to the total applied voltage,  $V$ , i.e.

$$V = V_1 + V_2 + V_3$$

From Ohm's law:

$$V_1 = IR_1,$$

$$V_2 = IR_2,$$

$$V_3 = IR_3$$

and  $V = IR$

where  $R$  is the total circuit resistance.

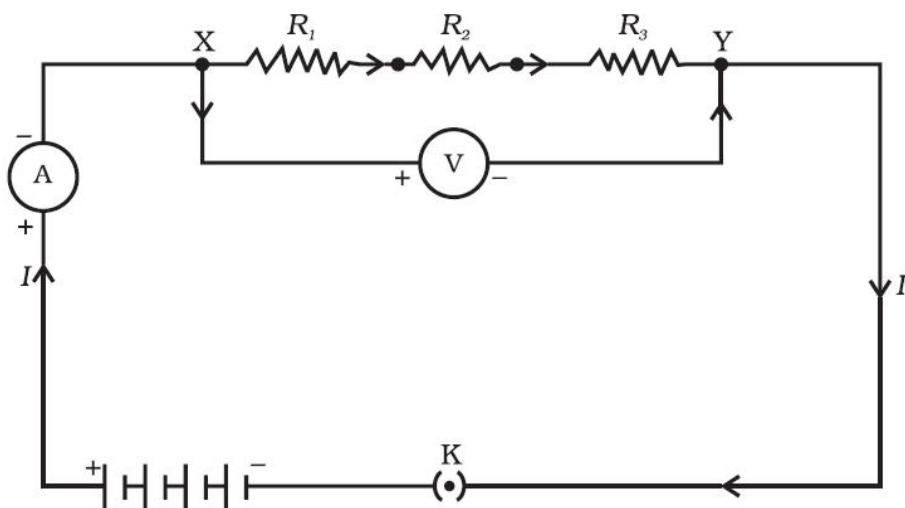
Since  $V = V_1 + V_2 + V_3$

then  $IR = IR_1 + IR_2 + IR_3$

Dividing throughout by  $I$  gives

$$R = R_1 + R_2 + R_3$$

Thus for a series circuit, the total resistance is obtained by adding together the values of the separate resistances.



When several resistors are connected in series, the resistance of the combination  $R_s$  is equal to the sum of their individual resistances  $R_1$ ,  $R_2$ ,  $R_3$  and is thus greater than any individual resistance.

### RESISTORS IN PARALLEL

#### In a parallel circuit:

- (a) the sum of the currents  $I_1$ ,  $I_2$  and  $I_3$  is equal to the total circuit current,  $I$ , i.e.  $I = I_1 + I_2 + I_3$ , and
- (b) the source p.d.,  $V$  volts, is the same across each of the resistors.

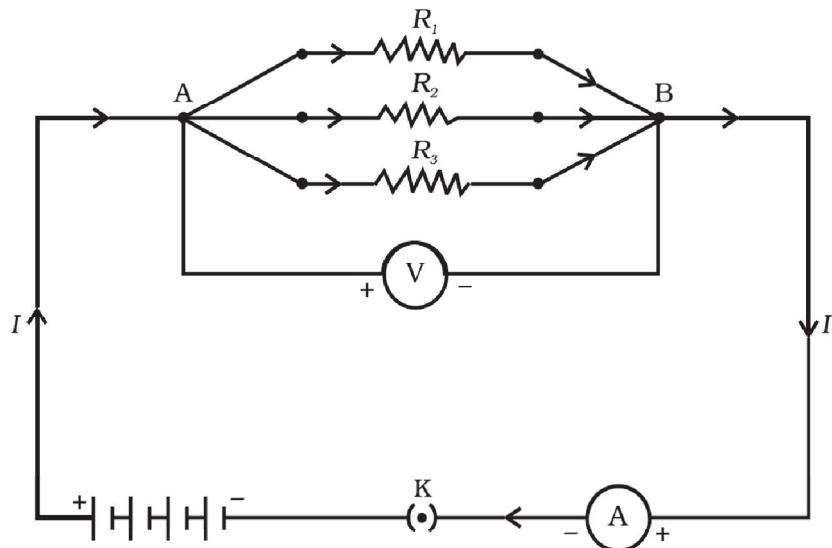
From Ohm's law:

$$I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2}, \quad I_3 = \frac{V}{R_3} \quad \text{and} \quad I = \frac{V}{R}$$

where R is the total resistance of the circuit.

Since  $\mathbf{I} = \mathbf{I}_1 + \mathbf{I}_2 + \mathbf{I}_3$

$$\text{then } \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$



dividing throughout by V, we get

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

This equation must be used when finding the total resistance R of a parallel circuit.  
Thus the reciprocal of the equivalent resistance of a group of resistance joined in parallel is equal to the sum of the reciprocals of the individual resistance.

For the special case of **two resistors in parallel**

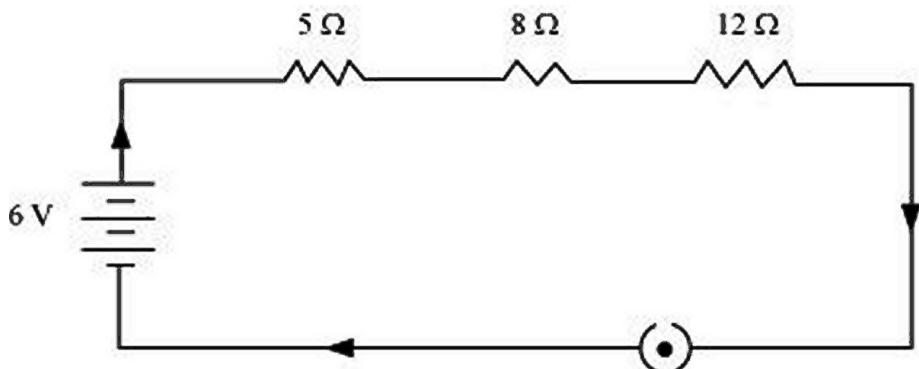
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$$

$$\text{Hence } R = \frac{R_1 R_2}{R_1 + R_2} \text{ i.e. } \left( \frac{\text{product}}{\text{sum}} \right)$$

### **INTEXT QUESTIONS PAGE NO. 213**

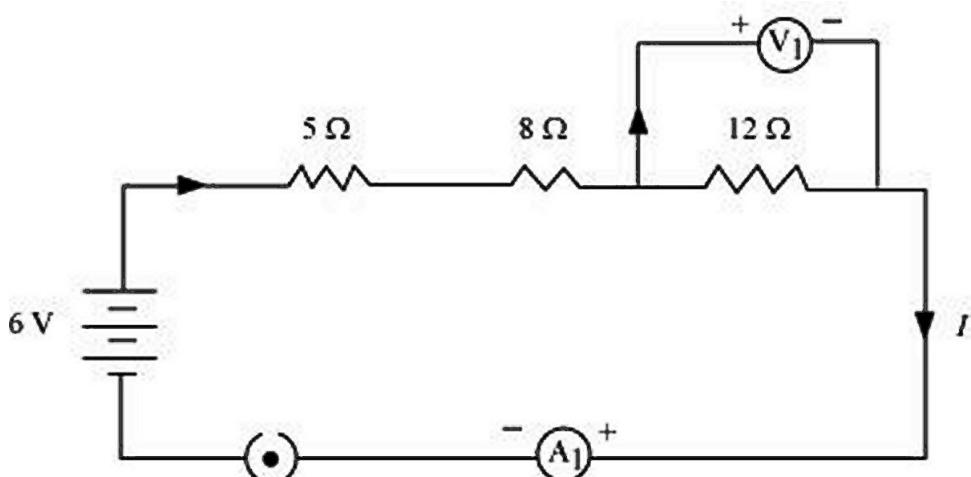
1. Draw a schematic diagram of a circuit consisting of a battery of three cells of 2 V each, a  $5\Omega$  resistor, an  $8\Omega$  resistor, and a  $12\Omega$  resistor, and a plug key, all connected in series.

**Ans.** Three cells of potential 2 V, each connected in series, is equivalent to a battery of potential  $2\text{V} + 2\text{V} + 2\text{V} = 6\text{V}$ . The following circuit diagram shows three resistors of resistances  $5\Omega$ ,  $8\Omega$  and  $12\Omega$  respectively connected in series and a battery of potential 6 V.



2. Redraw the circuit of question 1, putting in an ammeter to measure the current through the resistors and a voltmeter to measure potential difference across the  $12\ \Omega$  resistor. What would be the readings in the ammeter and the voltmeter?

**Ans.** To measure the current flowing through the resistors, an ammeter should be connected in the circuit in series with the resistors. To measure the potential difference across the  $12\ \Omega$  resistor, a voltmeter should be connected parallel to this resistor, as shown in the following figure.



The resistances are connected in series.

Ohm's law can be used to obtain the readings of ammeter and voltmeter. According to Ohm's law,

$$V = IR,$$

where, Potential difference,  $V = 6\text{ V}$

Current flowing through the circuit/resistors =  $I$

Resistance of the circuit,  $R = 5 + 8 + 12 = 25\ \Omega$

$$I = \frac{V}{R} = \frac{6}{25} = 0.24\text{ A}$$

Potential difference across  $12\ \Omega$  resistor =  $V_1$

Current flowing through the  $12\ \Omega$  resistor,  $I = 0.24\text{ A}$

Therefore, using Ohm's law, we obtain

$$V_1 = IR = 0.24 \times 12 = 2.88\text{ V}$$

Therefore, the reading of the ammeter will be  $0.24\text{ A}$ .

The reading of the voltmeter will be  $2.88\text{ V}$ .

#### **INTEXT QUESTIONS PAGE NO. 216**

1. Judge the equivalent resistance when the following are connected in parallel

- (a)  $1\ \Omega$  and  $10^6\ \Omega$ , (b)  $1\ \Omega$  and  $10^3\ \Omega$  and  $10^6\ \Omega$ .

**Ans.** (a) When  $1\ \Omega$  and  $10^6\ \Omega$  are connected in parallel:

Let  $R$  be the equivalent resistance.

$$\therefore \frac{1}{R} = \frac{1}{1} + \frac{1}{10^6}$$

$$R = \frac{10^6}{10^6 + 1} \approx \frac{10^6}{10^6} = 1\Omega$$

Therefore, equivalent resistance = 1  $\Omega$

(b) When 1  $\Omega$ , 10<sup>3</sup> $\Omega$  and 10<sup>6</sup> $\Omega$  are connected in parallel:

Let  $R$  be the equivalent resistance.

$$\frac{1}{R} = \frac{1}{1} + \frac{1}{10^3} + \frac{1}{10^6} = \frac{10^6 + 10^3 + 1}{10^6}$$

$$R = \frac{1000000}{1001001} = 0.999\Omega$$

Therefore, equivalent resistance = 0.999  $\Omega$

2. An electric lamp of 100  $\Omega$ , a toaster of resistance 50  $\Omega$ , and a water filter of resistance 500  $\Omega$  are connected in parallel to a 220 V source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it?

Ans. Resistance of electric lamp,  $R_1 = 100\Omega$

Resistance of toaster,  $R_2 = 50\Omega$

Resistance of water filter,  $R_3 = 500\Omega$

Voltage of the source,  $V = 220\text{V}$

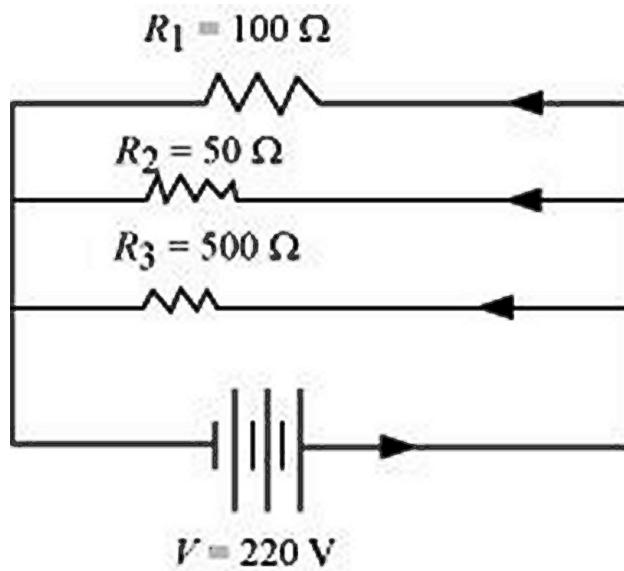
These are connected in parallel, as shown in the following figure.

Let  $R$  be the equivalent resistance of the circuit.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500}$$

$$\Rightarrow \frac{1}{R} = \frac{5+10+1}{500} = \frac{16}{500}$$

$$\Rightarrow R = \frac{500}{16}\Omega$$



According to Ohm's law,  $V = IR$

$$I = \frac{V}{R} \quad \text{Where, Current flowing through the circuit} = I$$

$$I = \frac{V}{R} = \frac{220}{500/16} = \frac{220 \times 16}{500} = 7.04\text{A}$$

7.04 A of current is drawn by all the three given appliances.

Therefore, current drawn by an electric iron connected to the same source of potential 220 V = 7.04 A

Let R' be the resistance of the electric iron. According to Ohm's law,

$$V = IR' \Rightarrow R' = \frac{V}{I} = \frac{220}{7.04} = 31.25\Omega$$

Therefore, the resistance of the electric iron is 31.25  $\Omega$  and the current flowing through it is 7.04 A.

**3. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?**

**Ans.** There is no division of voltage among the appliances when connected in parallel. The potential difference across each appliance is equal to the supplied voltage. The total effective resistance of the circuit can be reduced by connecting electrical appliances in parallel.

**4. How can three resistors of resistances 2  $\Omega$ , 3  $\Omega$  and 6  $\Omega$  be connected to give a total resistance of (a) 4  $\Omega$ , (b) 1  $\Omega$ ?**

**Ans.** There are three resistors of resistances 2  $\Omega$ , 3  $\Omega$ , and 6  $\Omega$  respectively.

(a) The following circuit diagram shows the connection of the three resistors.

Here, 6  $\Omega$  and 3  $\Omega$  resistors are connected in parallel.

Therefore, their equivalent resistance will be given by

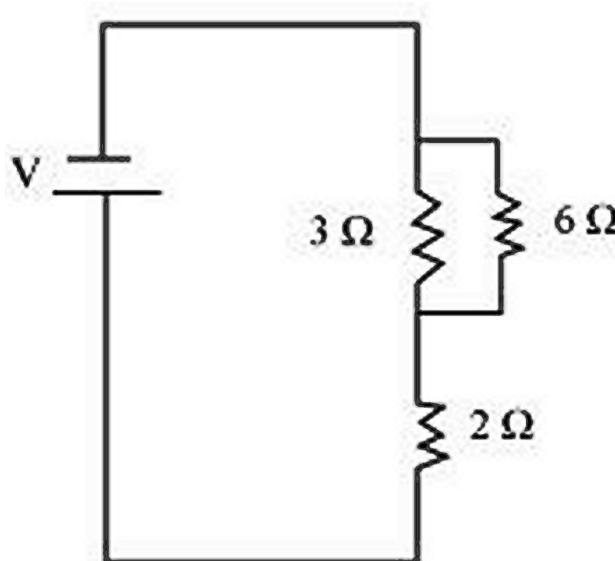
$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{6} + \frac{1}{3}} = \frac{6 \times 3}{6 + 3} = 2\Omega$$

This equivalent resistor of resistance 2  $\Omega$  is connected to a 2  $\Omega$  resistor in series.

Therefore, equivalent resistance of the circuit = 2  $\Omega$  + 2  $\Omega$  = 4  $\Omega$

Hence, the total resistance of the circuit is 4  $\Omega$

The following circuit diagram shows the connection of the three resistors.



All the resistors are connected in series. Therefore, their equivalent resistance will be given as

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{2} + \frac{1}{3} + \frac{1}{6}} = \frac{1}{\frac{3+2+1}{6}} = \frac{6}{6} = 1\Omega$$

Therefore, the total resistance of the circuit is 1  $\Omega$

5. What is (a) the highest, (b) the lowest total resistance that can be secured by combinations of four coils of resistance  $4\Omega$ ,  $8\Omega$ ,  $12\Omega$ ,  $24\Omega$ ?

**Ans.** There are four coils of resistances  $4\Omega$ ,  $8\Omega$ ,  $12\Omega$  and  $24\Omega$  respectively  
 (a) If these coils are connected in series, then the equivalent resistance will be the highest, given by the sum  $4 + 8 + 12 + 24 = 48\Omega$

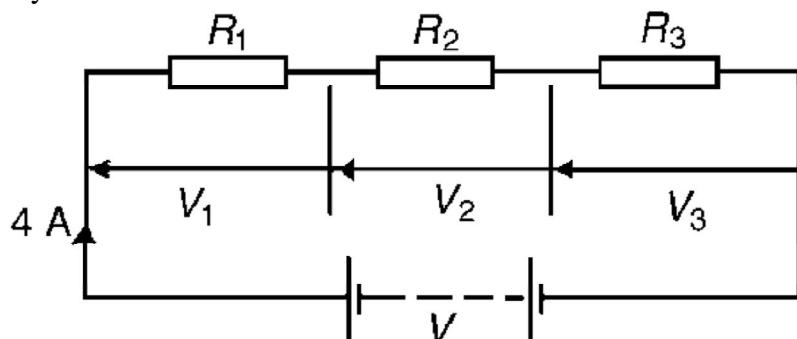
(b) If these coils are connected in parallel, then the equivalent resistance will be the lowest, given by

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}} = \frac{1}{\frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}} = \frac{1}{\frac{6+3+2+1}{24}} = \frac{24}{12} = 2\Omega$$

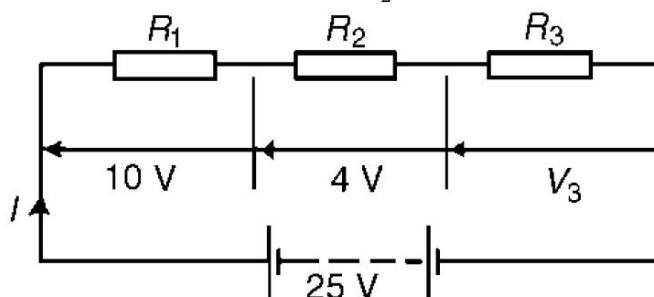
Therefore,  $2\Omega$  is the lowest total resistance.

### NUMERICAL PROBLEMS

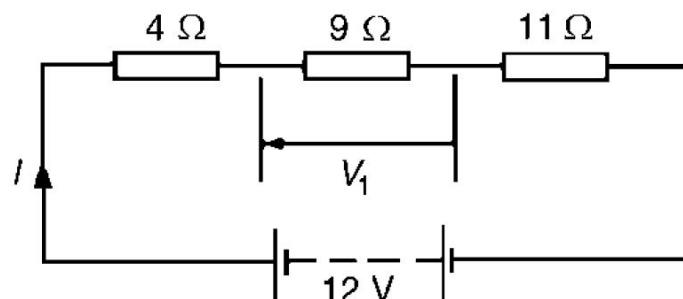
1. For the circuit shown in below Figure, determine (a) the battery voltage  $V$ , (b) the total resistance of the circuit, and (c) the values of resistance of resistors  $R_1$ ,  $R_2$  and  $R_3$ , given that the p.d.'s across  $R_1$ ,  $R_2$  and  $R_3$  are  $5V$ ,  $2V$  and  $6V$  respectively.



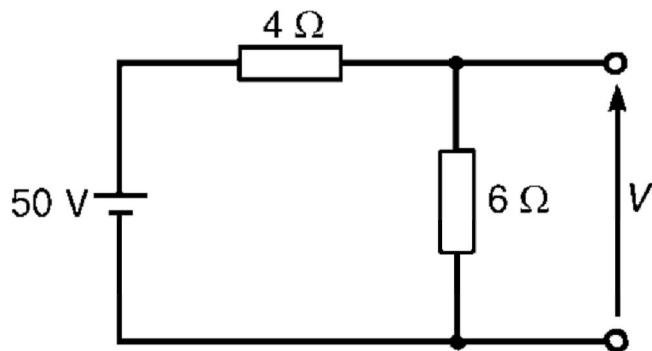
2. For the circuit shown in below Figure, determine the p.d. across resistor  $R_3$ . If the total resistance of the circuit is  $100\Omega$ , determine the current flowing through resistor  $R_1$ . Find also the value of resistor  $R_2$



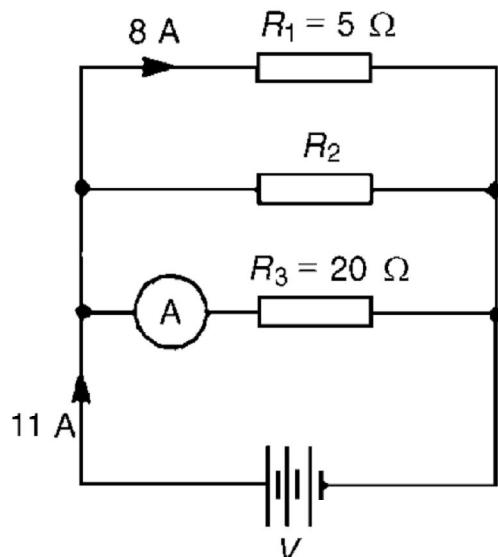
3. A  $12V$  battery is connected in a circuit having three series-connected resistors having resistances of  $4\Omega$ ,  $9\Omega$  and  $11\Omega$ . Determine the current flowing through, and the p.d. across the  $9\Omega$  resistor.



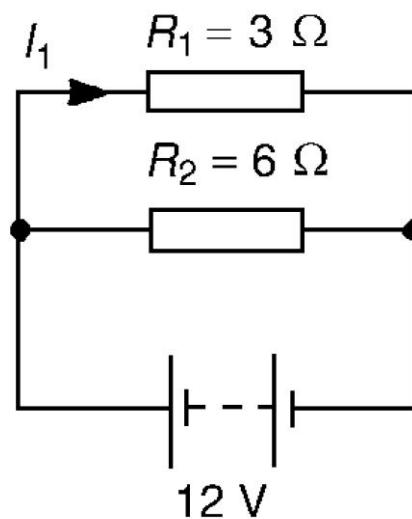
4. Find the voltage  $V$  in the given figure.



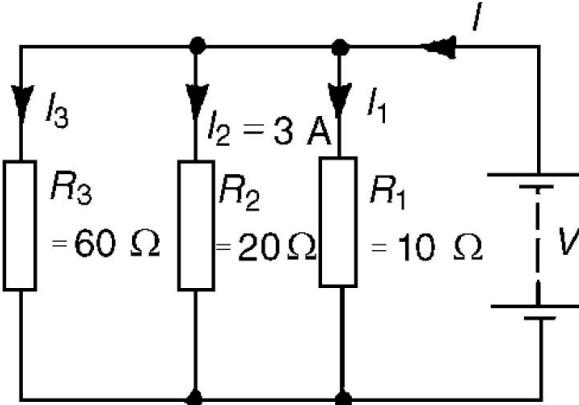
5. For the circuit shown in given Figure, determine (a) the reading on the ammeter, and (b) the value of resistor  $R_2$



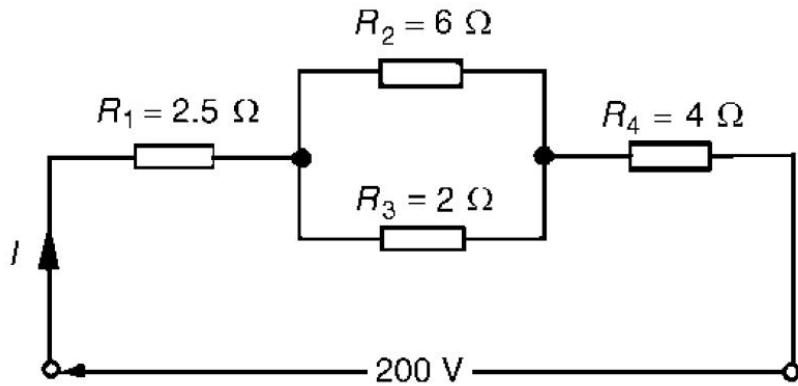
6. Two resistors are connected in series across a 24 V supply and a current of 3 A flows in the circuit. If one of the resistors has a resistance of  $2\Omega$  determine (a) the value of the other resistor, and (b) the p.d. across the  $2\Omega$  resistor. If the circuit is connected for 50 hours, how much energy is used?
7. Two resistors, of resistance  $3\Omega$  and  $6\Omega$ , are connected in parallel across a battery having a voltage of 12 V. Determine (a) the total circuit resistance and (b) the current flowing in the  $3\Omega$  resistor.



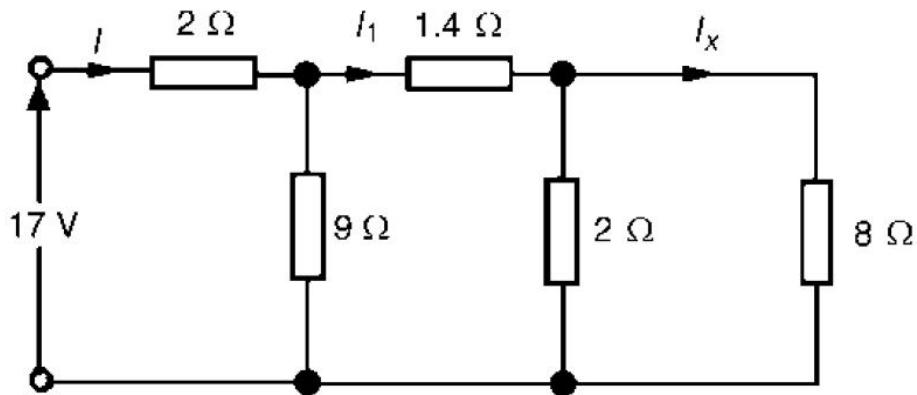
8. Given four  $1\ \Omega$  resistors, state how they must be connected to give an overall resistance of (a)  $\frac{1}{4}\ \Omega$  (b)  $1\ \Omega$  (c)  $1\frac{1}{3}\ \Omega$  (d)  $2\frac{1}{2}\ \Omega$ , all four resistors being connected in each case.
9. For the circuit shown in below Figure, find (a) the value of the supply voltage  $V$  and (b) the value of current  $I$ .



10. For the series-parallel arrangement shown in below Figure, find (a) the supply current, (b) the current flowing through each resistor and (c) the p.d. across each resistor.



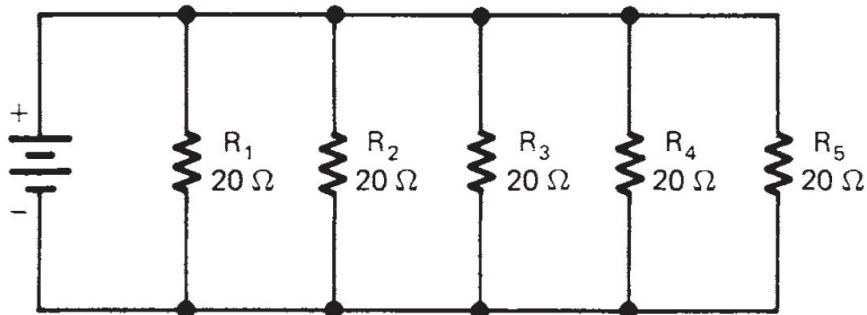
11. For the arrangement shown in below Figure, find the current  $I_x$ .



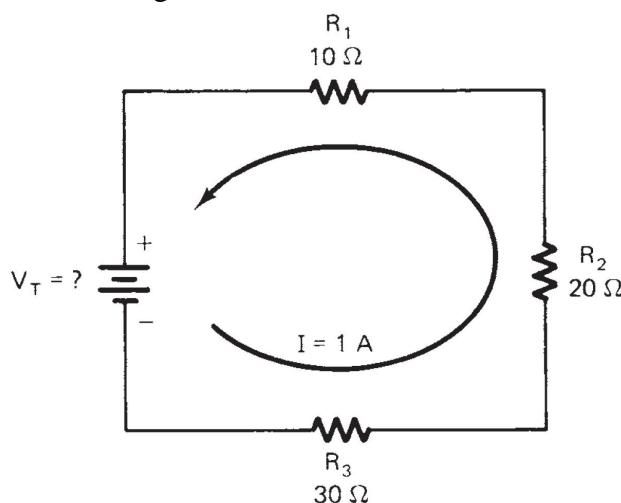
12. Four resistances of  $16\ \Omega$  each are connected in parallel. Four such combinations are connected in series. What is the total resistance?
13. A battery of 9 V is connected in series with resistors of  $0.2\ \Omega$ ,  $0.3\ \Omega$ ,  $0.4\ \Omega$ ,  $0.5\ \Omega$  and  $12\ \Omega$ . How much current would flow through the  $12\ \Omega$  resistor?

- 14.** An electric bulb of resistance  $20\Omega$  and a resistance wire of  $4\Omega$  are connected in series with a  $6V$  battery. Draw the circuit diagram and calculate: (a) total resistance of the circuit (b) current through the circuit (c) potential difference across the electric bulb (d) potential difference across the resistance wire.

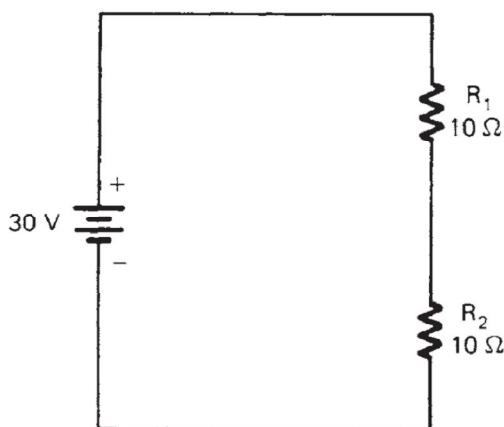
- 15.** Find the equivalent resistance of the given circuit.



- 16.** Find the value of  $V_T$  in the given circuit.



- 17.** Find the voltage across each resistance in the given circuit.

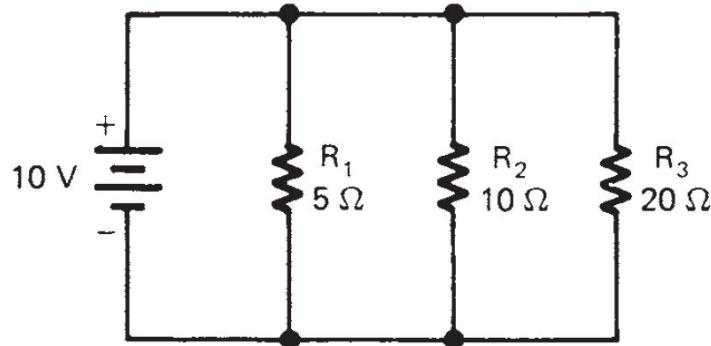


- 18.** A potential difference of  $4V$  is applied to two resistors of  $6\Omega$  and  $2\Omega$  connected in series. Calculate: (a) the combined resistance (b) the current flowing (c) the potential difference across the  $6\Omega$  resistor

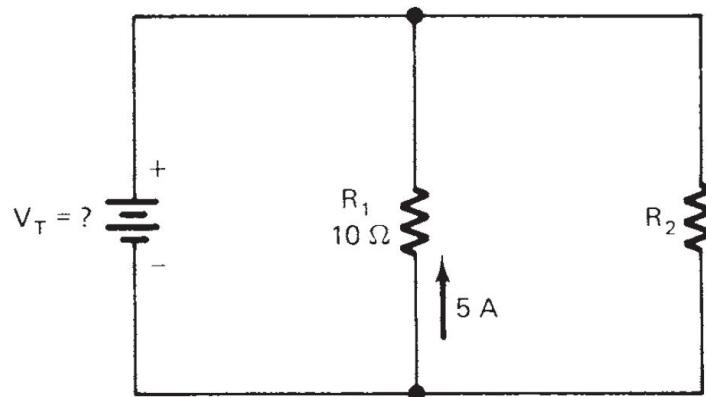
- 19.** Resistors of  $20\Omega$ ,  $20\Omega$  and  $30\Omega$  are connected in parallel. What resistance must be added in series with the combination to obtain a total resistance of  $10\Omega$ .

**20.** If four identical lamps are connected in parallel and the combined resistance is  $100\Omega$ , find the resistance of one lamp.

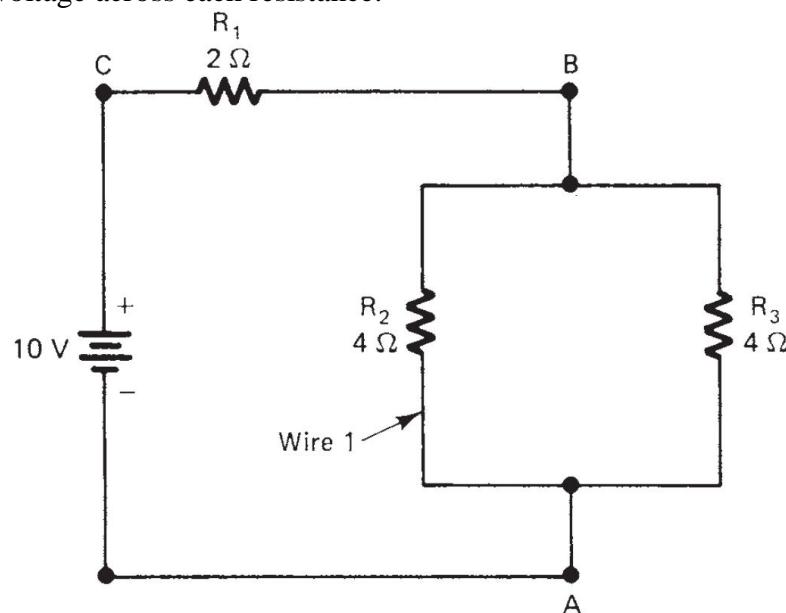
**21.** Find the current across the each resistance and total current flowing in the given circuit.



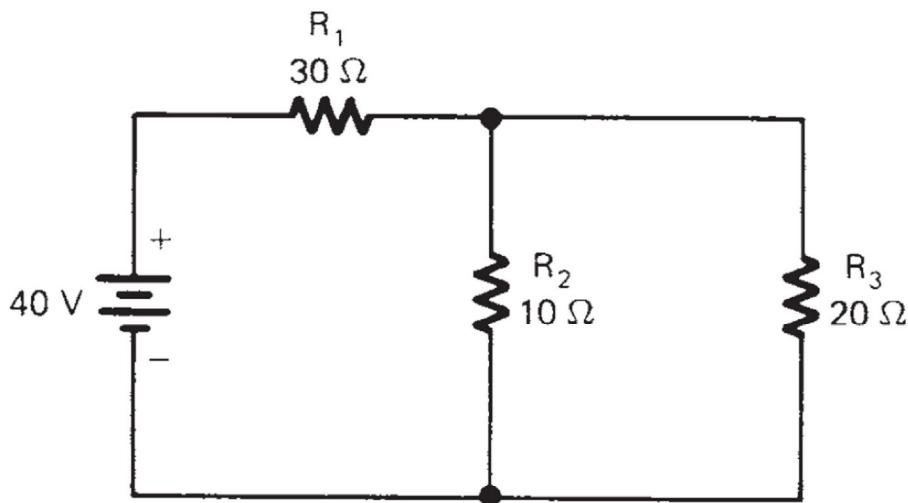
**22.** In the given circuit, the resistance  $R_1$  and  $R_2$  are connected in parallel. (i) Find the value of  $V_T$ . (ii) Find the total current and equivalent resistance in the circuit if resistance  $R_2 = 10\Omega$



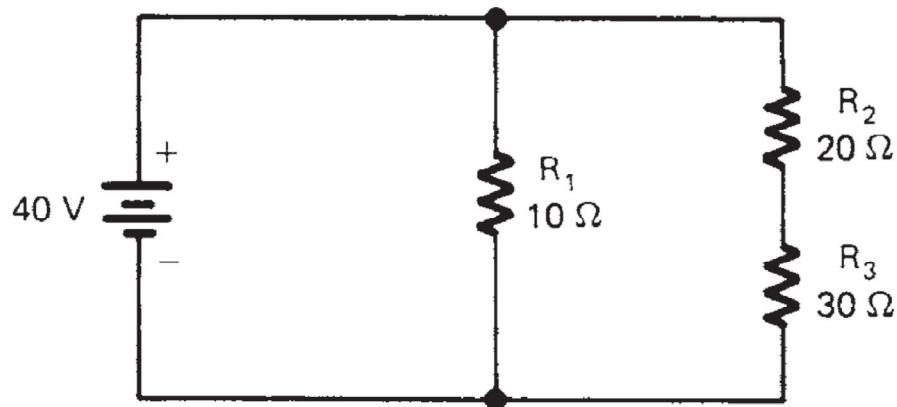
**23.** In the given circuit, (i) find the equivalent resistance of the circuit and total current flowing in the circuit. (ii) find the current flowing through  $R_2$  and  $R_3$ . (iii) find the voltage across each resistance.



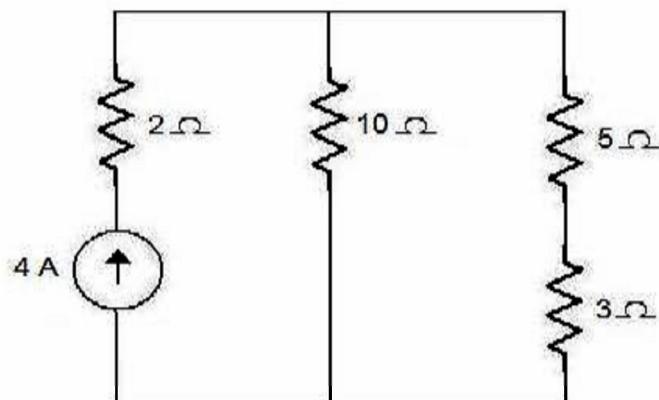
- 24.** In the given circuit, (i) find the equivalent resistance and total current flowing in the circuit. (ii) find the voltage and current across each resistance in the circuit.



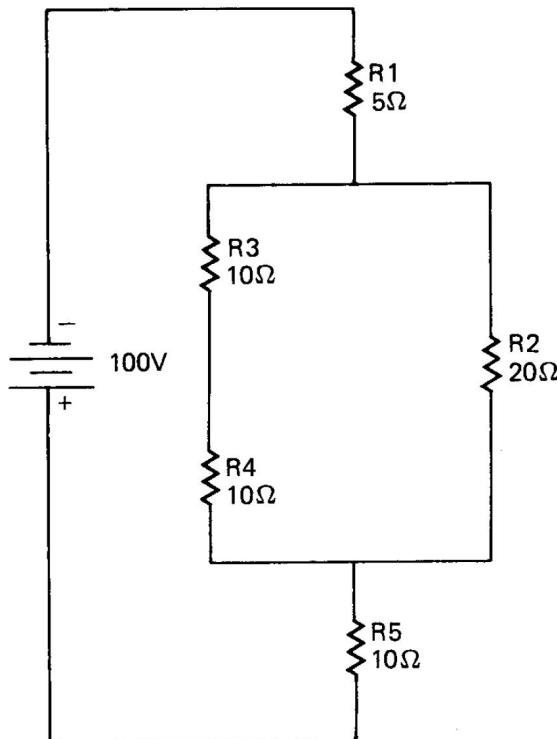
- 25.** In the given circuit, (i) find the equivalent resistance and total current flowing in the circuit. (ii) find the voltage and current across each resistance in the circuit.



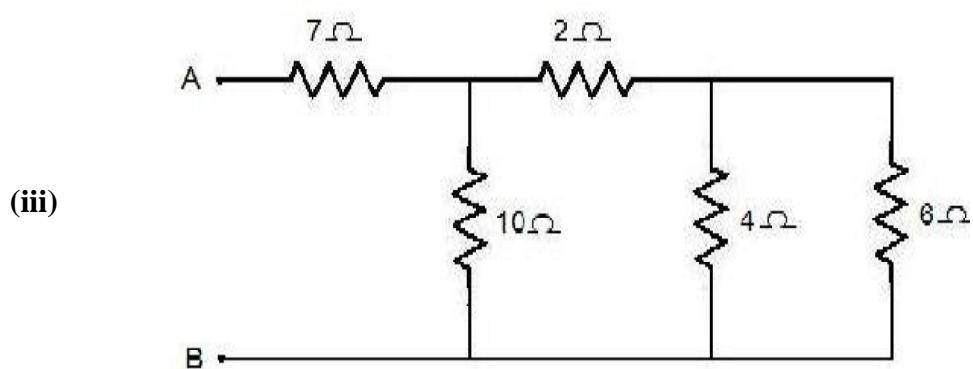
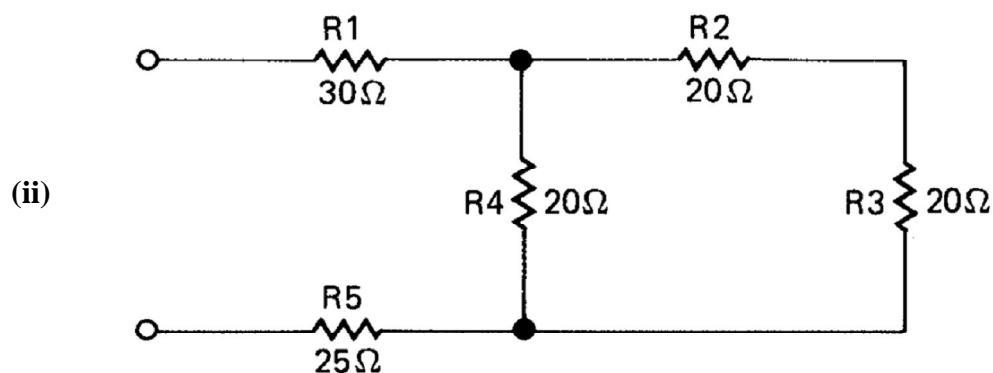
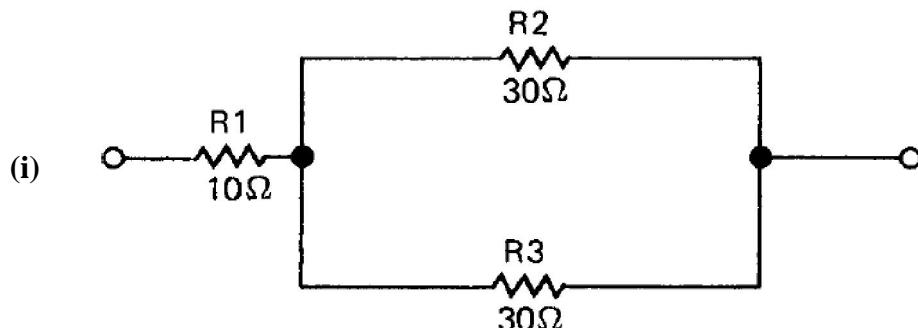
- 26.** Find the current through 10 ohm resistor for the following circuit.

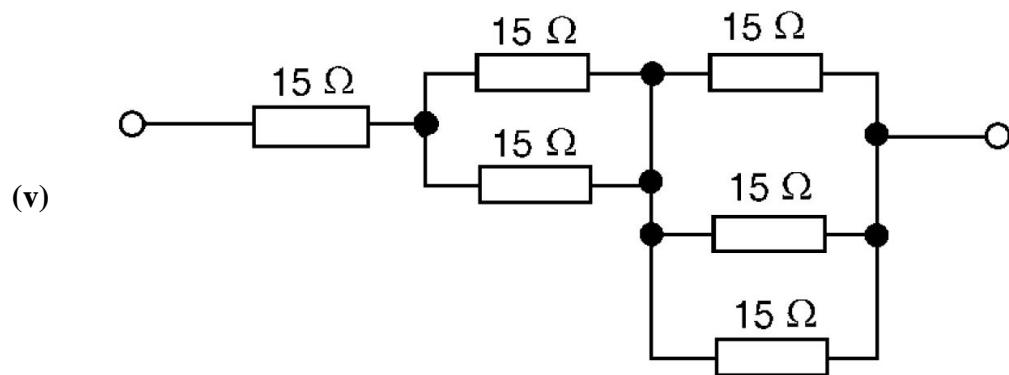
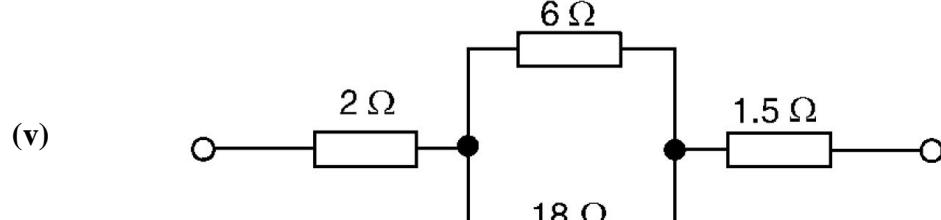
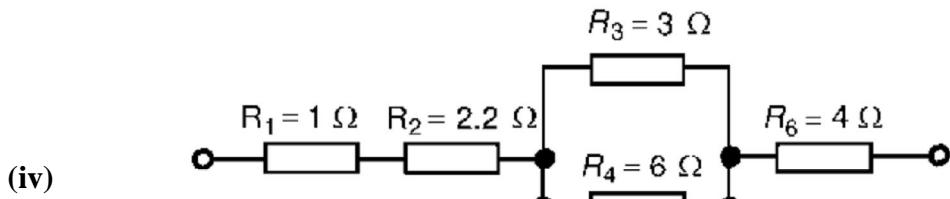


- 27.** In the given circuit, (i) find the equivalent resistance and total current flowing in the circuit. (ii) find the voltage and current across each resistance in the circuit.

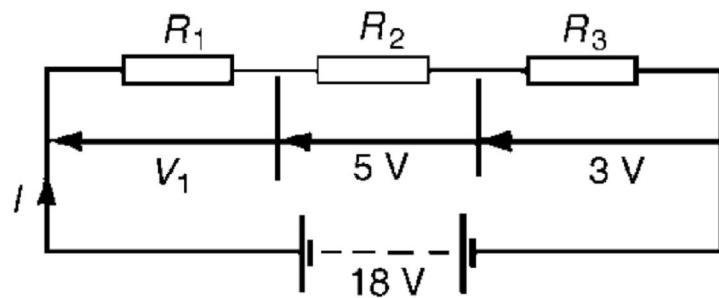


28. Find the equivalent resistance of the following circuits:

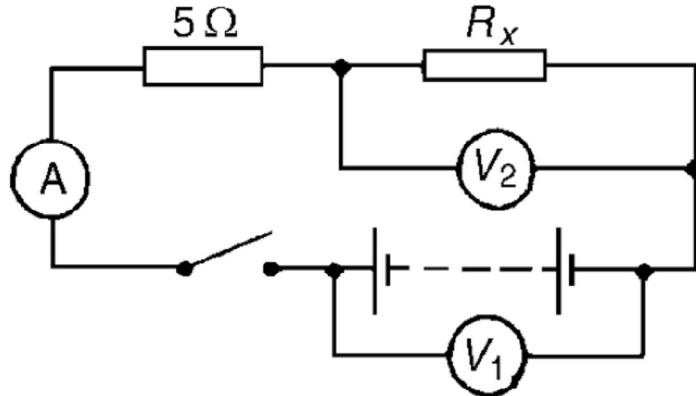




29. For the circuit shown in below Figure, determine the value of  $V_1$ . If the total circuit resistance is  $36\Omega$ , determine the supply current and the value of resistors  $R_1$ ,  $R_2$  and  $R_3$ .

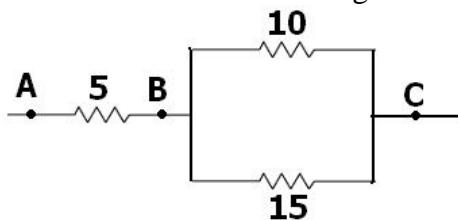


30. When the switch in the circuit in below Figure is closed the reading on voltmeter 1 is 30 V and that on voltmeter 2 is 10 V. Determine the reading on the ammeter and the value of resistor  $R_x$ .



31. A potential difference of 6V is applied to two resistors of  $3\Omega$  and  $6\Omega$  connected in parallel. Calculate: (a) the combined resistance (b) the current flowing in the main circuit (c) the current flowing in the  $3\Omega$  resistor.

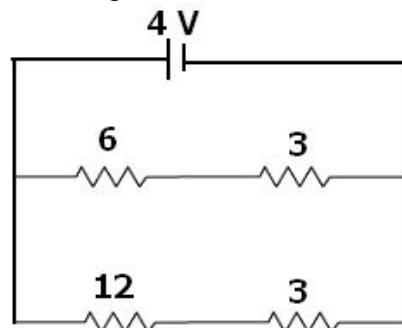
32. Three resistors are connected as shown in the diagram:



Through the resistor  $5\Omega$  ohm, a current of 1A is flowing.

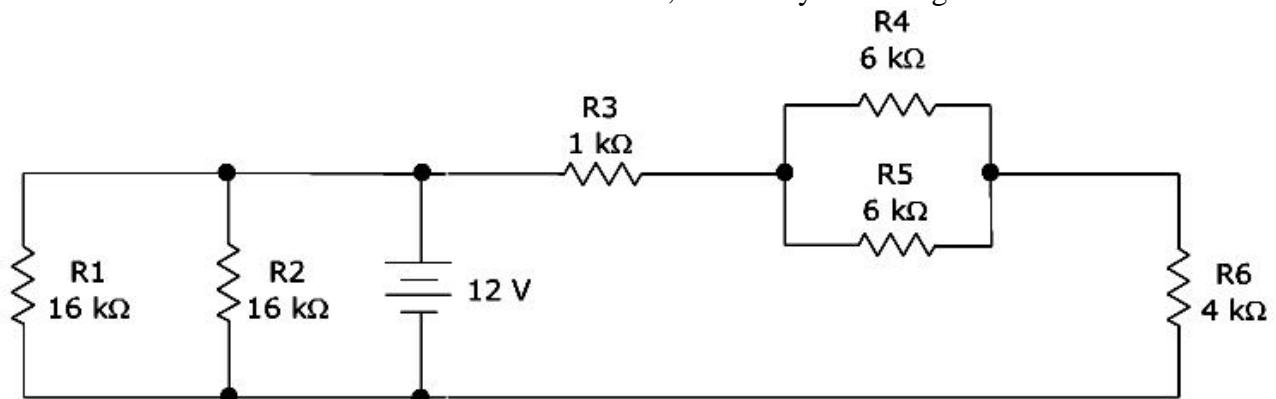
- (i) What is the current through the other two resistors?
- (ii) What is the p.d. across AB and across AC?
- (iii) What is the total resistance?

33. For the circuit shown in the diagram below:

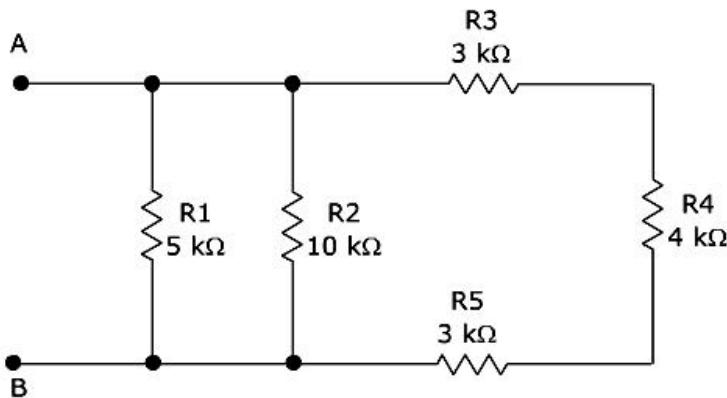


What is the value of: (i) current through  $6\Omega$  resistor? (ii) p.d. across  $12\Omega$  resistor?

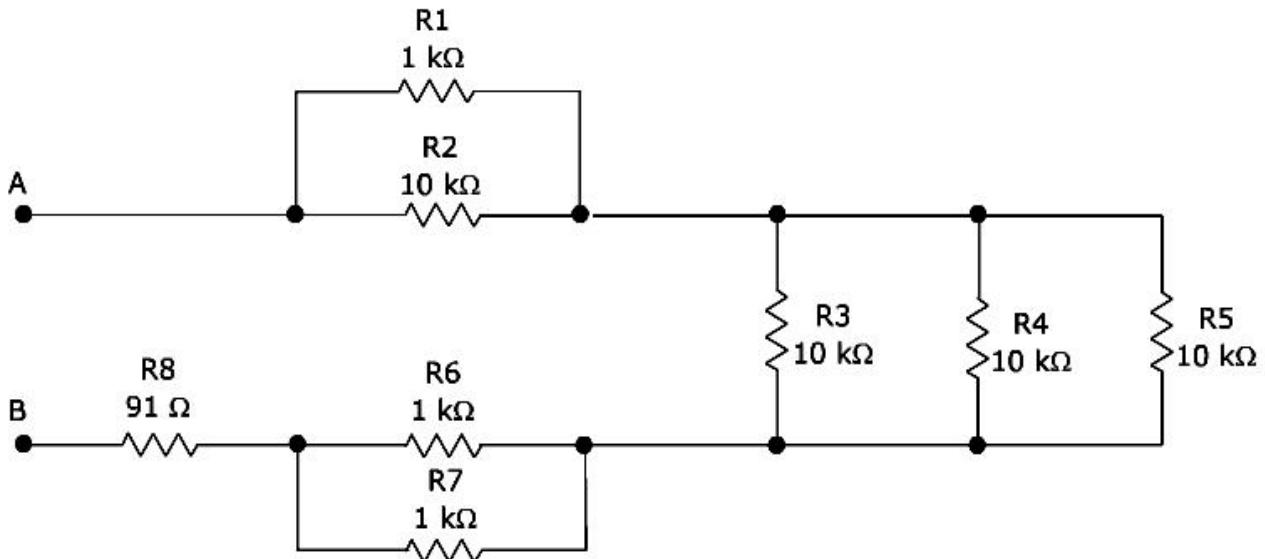
34. Calculate the total resistance of the circuit below, as seen by the voltage source.



35. What is the resistance between A and B in the given figure given below?



36. What is the resistance between A and B in the given figure given below?



37. Resistances of  $4\Omega$  and  $12\Omega$  are connected in parallel across a 9 V battery.

Determine (a) the equivalent circuit resistance, (b) the supply current, and (c) the current in each resistor.

38. Three identical lamps A, B and C are connected in series across a 150 V supply.

State (a) the voltage across each lamp, and (b) the effect of lamp C failing.

39. The p.d's measured across three resistors connected in series are 5 V, 7 V and 10 V,

and the supply current is 2 A. Determine (a) the supply voltage, (b) the total circuit resistance and (c) the values of the three resistors.

40. If three identical lamps are connected in parallel and the combined resistance is  $150\Omega$ , find the resistance of one lamp.

### HEATING EFFECT OF ELECTRIC CURRENT

If the electric circuit is purely resistive, that is, a configuration of resistors only connected to a battery; the source energy continually gets dissipated entirely in the form of heat. This is known as the heating effect of electric current. This effect is utilised in devices such as electric heater, electric iron etc

$$\text{Workdone, } W = Q \times V$$

$$I = \frac{Q}{t} \Rightarrow Q = I \times t$$

$$R = \frac{V}{I} \Rightarrow V = I \times R$$

$$\therefore W = I \times t \times I \times R$$

$$\Rightarrow W = I^2 \times R \times t$$

$$\therefore \text{Heat produced, } H = I^2 \times R \times t \text{ joules}$$

This is known as Joule's law of heating.

The law implies that heat produced in a resistor is (i) directly proportional to the square of current for a given resistance ( $I^2$ ), (ii) directly proportional to resistance for a given current (R), and (iii) directly proportional to the time for which the current flows through the resistor (t).

### **INTEXT QUESTIONS PAGE NO. 218**

- Why does the cord of an electric heater not glow while the heating element does?**

**Ans.** The heating element of an electric heater is a resistor. The amount of heat produced by it is proportional to its resistance. The resistance of the element of an electric heater is very high. As current flows through the heating element, it becomes too hot and glows red. On the other hand, the resistance of the cord is low. It does not become red when current flows through it.

- Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.**

**Ans.** The amount of heat (H) produced is given by the Joule's law of heating as  $H=VI$

Where, Voltage,  $V = 50 \text{ V}$ , Time,  $t = 1 \text{ h} = 1 \times 60 \times 60 \text{ s}$

$$\text{Amount of current, } I = \frac{\text{Amount of Charge}}{\text{Time of flow of charge}} = \frac{96000}{1 \times 60 \times 60} = \frac{80}{3} \text{ A}$$

$$H = 50 \times \frac{80}{3} \times 60 \times 60 = 4.8 \times 10^6 \text{ J}$$

Therefore, the heat generated is  $4.8 \times 10^6 \text{ J}$

- An electric iron of resistance  $20 \Omega$  takes a current of 5 A. Calculate the heat developed in 30 s.**

**Ans.** The amount of heat (H) produced is given by the Joule's law of heating as  $H=VI$

Where,

Current,  $I = 5 \text{ A}$

Time,  $t = 30 \text{ s}$

Voltage,  $V = \text{Current} \times \text{Resistance} = 5 \times 20 = 100 \text{ V}$

$$H = 100 \times 5 \times 30 = 1.5 \times 10^4 \text{ J}$$

Therefore, the amount of heat developed in the electric iron is  $1.5 \times 10^4 \text{ J}$

### **Practical Applications of Heating Effect of Electric Current**

The flowing of current through conductor produce heat. We are using this heat due to flow of current in our daily life as in electric iron, electric bulb, electric fuse, electric heater and more. Heating effect of electric current are below

(i) Electric iron: In an iron the upper part is grooved. In this groove a coil is placed. Mica as an insulator is placed between the metal part and the coil, so that there is no electrical connection between them. Mica is a bad conductor of electricity but it is a good conductor of heat. Due to the flow of current through the coil it becomes heated and the heat transferred to the metal part through mica. Finally the metal part becomes heated. Iron is used with the heating effect of an electric current.

(ii) Electric bulb: we see a thick metallic wire in the bulb. It is made of tungsten metal. In a glass vessel or bulb the tungsten wire is kept sealed. The glass bulb is filled with neutral gas or vacuum. Neutral gases are used now a days commonly. The tungsten wire is known as filament when the current flows through the tungsten wire or filament it becomes heated and emit light. Due to the flow of current heating effect of an electric current used as the source of light.

(iii) Electric heater: In an electric heater one type of coil is used. A high resistance material like nichrome or same type of material is used as coil. The coil is wound in grooves on ceramic format or china clay. Flowing electric current through the coil it becomes heated. Due to high resistance the coil becomes red color forms.

(iv) Electric fuse: It protects circuits and appliances by stopping the flow of any unduly high electric current. The fuse is placed in series with the device. It consists of a piece of wire made of a metal or an alloy of appropriate melting point, for example aluminium, copper, iron, lead etc. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit. The fuse wire is usually encased in a cartridge of porcelain or similar material with metal ends. The fuses used for domestic purposes are rated as 1 A, 2 A, 3 A, 5 A, 10 A, etc. For an electric iron which consumes 1 kW electric power when operated at 220 V, a current of  $(1000/220)$  A, that is, 4.54 A will flow in the circuit. In this case, a 5 A fuse must be used.

**Electric Power:** It is the electrical work done per unit time.

$$P = \frac{W}{t}$$

where W = work done and t = time

S.I. unit of power is watt

If W = 1 joule, t = 1 second then  $Power = \frac{1 \text{ joule}}{1 \text{ second}} = 1 \text{ watt}$

**One watt:** The rate of working of 1 joule per second is the power of 1 watt.

**Electric Energy:** It is the total work done by a current in an electric circuit.

$$\text{Electric power} = \frac{\text{work done by electric circuit}}{\text{time taken}}$$

$$\begin{aligned} \text{Work done by electric circuit} &= \text{Electric Power} \times \text{time taken} \\ \Rightarrow E &= P \times t \end{aligned}$$

The electrical energy consumed by an electrical appliance is given by the product of its power rating and the time for which it is used.

Unit of Electrical consumed is watt-hour(Wh)

If P = 1 watt, t = 1 hr, then E = 1 watt  $\times$  1 hr = 1 watt-hour.

**One watt-hour:** It is the amount of electrical energy consumed when an electrical appliance of 1 watt power is used for an hour.

Commercial unit of Electrical energy is **kilowatt-hour(KWh)**

**One Kilowatt-hour:** It is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used in 1 hour.

$$1 \text{ kilowatt-hour} = 36,00,000 \text{ joules or } 3.6 \times 10^6 \text{ J}$$

### **INTEXT QUESTIONS PAGE NO. 220**

**1. What determines the rate at which energy is delivered by a current?**

**Ans.** The rate of consumption of electric energy in an electric appliance is called electric power. Hence, the rate at which energy is delivered by a current is the power of the appliance.

**2. An electric motor takes 5 A from a 220 V line. Determine the power of the motor and the energy consumed in 2 h.**

**Ans.** Power ( $P$ ) is given by the expression,  $P = VI$

Where,

Voltage,  $V = 220 \text{ V}$

Current,  $I = 5 \text{ A}$

$$P = 220 \times 5 = 1100 \text{ W}$$

Energy consumed by the motor =  $Pt$

Where,

Time,  $t = 2 \text{ h} = 2 \times 60 \times 60 = 7200 \text{ s}$

$$\therefore P = 1100 \times 7200 = 7.92 \times 10^6 \text{ J}$$

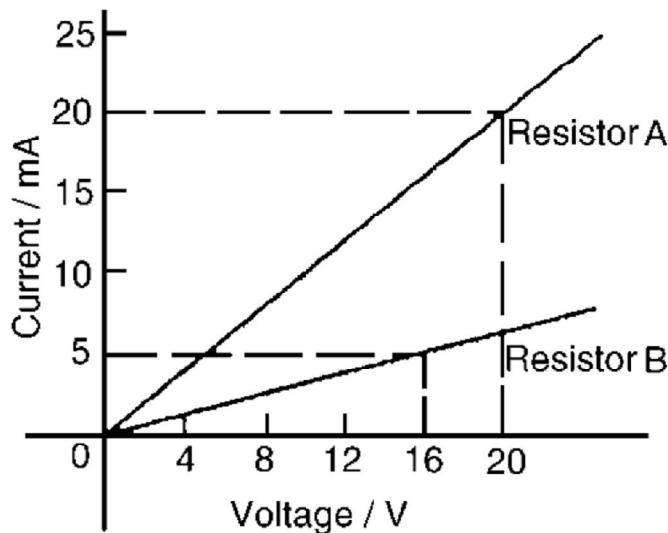
Therefore, power of the motor = 1100 W

$$\text{Energy consumed by the motor} = 7.92 \times 10^6 \text{ J}$$

### **NUMERICAL PROBLEMS**

1. What will be the current drawn by an electric bulb of 40 W when it is connected to a source of 220V?
2. A bulb is rated as 250V; 0.4A. Find its power and resistance.
3. An electric bulb is connected to a 220V power supply line. If the bulb draw a current of 0.5A, calculate the power of the bulb.
4. An electric bulb is connected to a 250 V generator. The current is 0.50 A. What is the power of the bulb?
5. What current will be taken by a 920W appliance if the supply voltage is 230V?
6. When an electric lamp is connected to 12V battery, it draws a current 0.5A. Find the power of the lamp.
7. Calculate the power used in  $2\Omega$  resistor in each (i) a 6V battery in series with  $1\Omega$  and  $2\Omega$  resistor (ii) a 4V battery in parallel with  $12\Omega$  and  $2\Omega$  resistor.
8. A 100 W electric light bulb is connected to a 250 V supply. Determine (a) the current flowing in the bulb, and (b) the resistance of the bulb.
9. Calculate the power dissipated when a current of 4 mA flows through a resistance of  $5 \text{ k}\Omega$

- 10.** An electric kettle has a resistance of  $30\Omega$ . What current will flow when it is connected to a 240 V supply? Find also the power rating of the kettle.
- 11.** A current of 5 A flows in the winding of an electric motor, the resistance of the winding being  $100\Omega$ . Determine (a) the p.d. across the winding, and (b) the power dissipated by the coil.
- 12.** The current/voltage relationship for two resistors A and B is as shown in below Figure. Determine the value of the resistance of each resistor and also find the power dissipated through each resistor.



- 13.** The hot resistance of a 240 V filament lamp is  $960\Omega$ . Find the current taken by the lamp and its power rating.
- 14.** A 12 V battery is connected across a load having a resistance of  $40\Omega$ . Determine the current flowing in the load, the power consumed and the energy dissipated in 2 minutes.
- 15.** A source of e.m.f. of 15 V supplies a current of 2 A for six minutes. How much energy is provided in this time?
- 16.** Electrical equipment in an office takes a current of 13 A from a 240 V supply. Estimate the cost per week of electricity if the equipment is used for 30 hours each week and 1 kWh of energy costs 7p
- 17.** An electric heater consumes 3.6 MJ when connected to a 250 V supply for 40 minutes. Find the power rating of the heater and the current taken from the supply.
- 18.** Determine the power dissipated by the element of an electric fire of resistance  $20\Omega$  when a current of 10 A flows through it. If the fire is on for 6 hours determine the energy used and the cost if 1 unit of electricity costs 7p.

- 19.** A business uses two 3 kW fires for an average of 20 hours each per week, and six 150 W lights for 30 hours each per week. If the cost of electricity is 7p per unit, determine the weekly cost of electricity to the business.
- 20.** If 5 A, 10 A and 13 A fuses are available, state which is most appropriate for the following appliances which are both connected to a 240 V supply (a) Electric toaster having a power rating of 1 kW (b) Electric fire having a power rating of 3 kW
- 21.** The hot resistance of a 250 V filament lamp is 625 . Determine the current taken by the lamp and its power rating.
- 22.** Determine the resistance of a coil connected to a 150 V supply when a current of (a) 75 mA (b) 300  $\mu$ A flows through it. Determine the power dissipated through it.
- 23.** Determine the resistance of an electric fire which takes a current of 12A from a 240 V supply. Find also the power rating of the fire and the energy used in 20 h.
- 24.** Determine the power dissipated when a current of 10 mA flows through an appliance having a resistance of 8 k.
- 25.** 85.5 J of energy are converted into heat in nine seconds. What power is dissipated?
- 26.** A current of 4 A flows through a conductor and 10 W is dissipated. What p.d. exists across the ends of the conductor?
- 27.** Find the power dissipated when:
- a current of 5 mA flows through a resistance of 20 k
  - a voltage of 400 V is applied across a 120 k resistor
  - a voltage applied to a resistor is 10 kV and the current flow is 4 mA.
- 28.** A battery of e.m.f. 15 V supplies a current of 2 A for 5 min. How much energy is supplied in this time?
- 29.** In a household during a particular week three 2 kW fires are used on average 25 h each and eight 100 W light bulbs are used on average 35 h each. Determine the cost of electricity for the week if 1 unit of electricity costs 7p.
- 30.** Calculate the power dissipated by the element of an electric fire of resistance 30 when a current of 10 A flows in it. If the fire is on for 30 hours in a week determine the energy used. Determine also the weekly cost of energy if electricity costs 7.2p per unit.
- 31.** A television set having a power rating of 120 W and electric lawnmower of power rating 1 kW are both connected to a 240 V supply. If 3 A, 5 A and 10 A fuses are available state which is the most appropriate for each appliance.

- 32.** For a heater rated at 4kW and 220V, calculate: (a) the current (b) the resistance of the heater (c) the energy consumed in 2 hours and (d) the cost if 1kWh is priced at Rs. 4.60
- 33.** A radio set of 60W runs for 50hrs. How much electrical energy consumed?
- 34.** A current of 4A flows through a 12V car headlight bulb for 10min. How much energy transfer occurs during this time?
- 35.** Calculate the energy transferred by a 5A current flowing through a resistor of  $2\Omega$  for 30min.
- 36.** A bulb is rated at 200V-100W. What is its resistance? 5 such bulbs burn for 4 hrs. What is the electrical energy consumed? Calculate the cost if the rate is Rs. 4.60 per unit.
- 37.** A refrigerator having a power rating of 350W operates for 10hours a day. Calculate the cost of electrical energy to operate it for a month of 30days. The rate of electrical energy is Rs. 3.40 per KWh.
- 38.** What will be the current drawn by an electric bulb of 40W when it is converted to a source of 220V?
- 39.** An electric bulb is rated 220V and 100W. When it is operated on 110V, find the power consumed.
- 40.** An electric heater draws a current of 10A from a 220V supply. What is the cost of using the heater for 5 hrs everyday for 30days if the cost of 1 unit is Rs. 5.20?
- 41.** In house two 60W electric bulbs are lighted for 4 hrs and three 100W bulbs for 5 hrs everyday. Calculate the electrical energy consumed in 30days.
- 42.** An electric motor takes 5A current from a 220V supply line. Calculate the power of the motor and electrical energy consumed by it in 2 hrs.
- 43.** An electric iron consumes energy at a rate of 840 W when heating is at the maximum rate and 360 W when the heating is at the minimum. The voltage is 220 V. What are the current and the resistance in each case?
- 44.** An electric refrigerator rated 400 W operates 8 hour/day. What is the cost of the energy to operate it for 30 days at Rs 3.00 per kW h?
- 45.** An electric motor takes 5 A from a 220 V line. Determine the power of the motor and the energy consumed in 2 h.
- 46.** Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

- 47.** Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?
- 48.** Two bulbs A and B are rated 100W – 120V and 10W – 120V respectively. They are connected across a 120V source in series. Which will consume more energy.
- 49.** Two bulbs A and B are rated 100W – 120V and 10W – 120V respectively. They are connected across a 120V source in series. Find the current in each bulb. Which will consume more energy.
- 50.** An electric kettle is rated at 230V, 1000W. What is the resistance of its element? What maximum current can pass through its element?
- 51.** An electric geyser has the rating 1000W, 220V marked on it. What should be the minimum rating in whole number of a fuse wire that may be required for safe use with this geyser?
- 52.** The mains power supply of a house is through a 5A fuse. How many 100W, 220V bulbs can be used in this house at the correct voltage?
- 53.** An electrician puts a fuse of rating 5A in that part of domestic electrical circuit in which an electrical heater of rating 1.5kW, 220V is operating. What is likely to happen in this case and why? What change if any needs to be made?
- 54.** Two bulbs of ratings 40W-220V and 60W-220V are connected in series and this combination is connected with a supply of 220V. Calculate the current from the supply line.
- 55.** Two bulbs have the ratings 40W-200V and 20W-110V. What is the ratio of their resistances?
- 56.** I can spend Rs. 9 per month (30days) on electric light. If power is 30paise per kWh and I use 5 identical bulbs for 5 hours a day, what should be the power of each bulb?
- 57.** Compute the number of electrons passing through per minute through an electric bulb of 60W, 220V.
- 58.** If electrical energy costs Rs.3 per unit, what is the total cost of leaving 4 light bulb rated at 100W each switched on for 8 hours.
- 59.** An electric heater of resistance  $8\Omega$  draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.
- 60.** 100 J of heat are produced each second in a  $4 \Omega$  resistance. Find the potential difference across the resistor.
- 61.** Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.

- 62.** An electric iron of resistance  $20\ \Omega$  takes a current of 5 A. Calculate the heat developed in 30 s.
- 63.** A p.d. of 250V is applied across a resistance of  $500\ \Omega$  in an electric iron. Calculate (i) current (ii) heat energy produced in joules in 10s.
- 64.** Calculate the heat produced when  $96000C$  of charge is transferred in 1 hour through a p.d. of 50V.
- 65.** A resistance of  $40\ \Omega$  and one of  $60\ \Omega$  are arranged in series across 220V supply. Find the heat in joules produced by this combination of resistances in half a minute?
- 66.** When a current of 4A passes through a certain resistor for 10min,  $2.88 \times 10^4$  J of heat are produced. Calculate (a) power of the resistor (b) the voltage across the resistor.
- 67.** A heating coil has a resistance of  $200\ \Omega$ . At what rate will heat be produced in it when a current of  $2.5\ \Omega$  flows through it.
- 68.** An electric heater of resistance  $8\ \Omega$  takes a current of 15A from the mains supply line. Calculate the rate at which heat is developed in the heater.
- 69.** A resistance of  $25\ \Omega$  is connected to a 12V battery. Calculate the heat energy in joule generated per minute.
- 70.** How much heat will an instrument of 12W produce in one minute if its is connected to a battery of 12V?

### **EXERCISE QUESTIONS PAGE NO. 221**

- 1.** A piece of wire of resistance  $R$  is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is  $R'$ , then the ratio  $R/R'$  is – (a)  $\frac{1}{25}$  (b)  $\frac{1}{5}$  (c) 5 (d) 25

**Ans.** (d) Resistance of a piece of wire is proportional to its length. A piece of wire has a resistance  $R$ . The wire is cut into five equal parts.

$$\text{Therefore, resistance of each part} = \frac{R}{5}$$

All the five parts are connected in parallel. Hence, equivalent resistance ( $R'$ ) is given as

$$\frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{5+5+5+5+5}{R} = \frac{25}{R}$$

$$\frac{1}{R'} = \frac{25}{R} \Rightarrow \frac{R}{R'} = 25$$

Therefore, the ratio  $\frac{R}{R'}$  is 25.

2. Which of the following terms does not represent electrical power in a circuit?

(a)  $I^2R$  (b)  $IR^2$  (c)  $VI$  (d)  $V^2/R$

**Ans.** (b) Electrical power is given by the expression,  $P = VI \dots$  (i)

According to Ohm's law,  $V = IR \dots$  (ii)

where,  $V$  = Potential difference,  $I$  = Current and  $R$  = Resistance

$$\therefore P = VI$$

From equation (i), it can be written

$$P = (IR) \times I$$

$$\therefore P = I^2R$$

From equation (ii), it can be written

$$I = \frac{V}{R}$$

$$\therefore P = V \times \frac{V}{R} \Rightarrow P = \frac{V^2}{R}$$

$$\therefore P = VI = I^2R = \frac{V^2}{R}$$

Power  $P$  cannot be expressed as  $IR^2$ .

3. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be – (a) 100 W (b) 75 W (c) 50 W (d) 25 W

**Ans.** (d) Energy consumed by an appliance is given by the expression,

$$P = VI = \frac{V^2}{R}$$

$$\Rightarrow R = \frac{V^2}{P}$$

where, Power rating,  $P = 100 \text{ W}$ , Voltage,  $V = 220 \text{ V}$

$$\text{Resistance, } R = \frac{(220)^2}{100} = 484\Omega$$

The resistance of the bulb remains constant if the supply voltage is reduced to 110 V. If the bulb is operated on 110 V, then the energy consumed by it is given by the expression for power as

$$\therefore P' = \frac{(V')^2}{R} = \frac{(110)^2}{484} = 25W$$

Therefore, the power consumed will be 25 W.

4. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be – (a) 1:2 (b) 2:1 (c) 1:4 (d) 4:1

**Ans.** (c) The Joule heating is given by,  $H = t^2Rt$

Let,  $R$  be the resistance of the two wires.

The equivalent resistance of the series connection is  $R_S = R + R = 2R$

If  $V$  is the applied potential difference, then it is the voltage across the equivalent resistance.

$$V = I_s \times 2R$$

$$\Rightarrow I_s = \frac{V}{2R}$$

The heat dissipated in time  $t$  is,

$$H = I_s^2 \times 2R \times t = \left( \frac{V}{2R} \right)^2 \times 2R \times t \Rightarrow H = \frac{V^2 t}{2R}$$

The equivalent resistance of the parallel connection is  $R_p = \frac{1}{\frac{1}{R} + \frac{1}{R}} = \frac{R}{2}$

$V$  is the applied potential difference across this  $R_p$ .

$$V = I_p \times \frac{R}{2}$$

$$\Rightarrow I_p = \frac{2V}{R}$$

The heat dissipated in time  $t$  is,

$$H' = I_p^2 \times \frac{R}{2} \times t = \left( \frac{2V}{R} \right)^2 \times \frac{R}{2} \times t \Rightarrow H' = \frac{2V^2 t}{R}$$

$$\text{So, the ratio of heat produced is, } \frac{H}{H'} = \frac{\frac{V^2 t}{2R}}{\frac{2V^2 t}{R}} = \frac{1}{4}$$

5. How is a voltmeter connected in the circuit to measure the potential difference between two points?
- Ans.** To measure the potential difference between two points, a voltmeter should be connected in parallel to the points.
6. A copper wire has diameter 0.5 mm and resistivity of  $1.6 \times 10^{-8} \Omega \text{ m}$ . What will be the length of this wire to make its resistance  $10 \Omega$ ? How much does the resistance change if the diameter is doubled?

**Ans.** Resistance ( $R$ ) of a copper wire of length  $l$  and cross-section  $A$  is given by the expression,

$$R = \rho \frac{l}{A}$$

Where,

Resistivity of copper,  $\rho = 1.6 \times 10^{-8} \Omega \text{ m}$

$$\text{Area of cross-section of the wire, } A = \pi \left( \frac{\text{diameter}}{2} \right)^2$$

Diameter = 0.5 mm = 0.0005 m

Resistance,  $R = 10 \Omega$

Hence, length of the wire,

$$l = \frac{RA}{\rho} = \frac{10 \times 3.14 \times \left( \frac{0.0005}{2} \right)^2}{1.6 \times 10^{-8}} = \frac{10 \times 3.14 \times 25}{4 \times 1.6} = 122.72 \text{ m}$$

If the diameter of the wire is doubled, new diameter =  $2 \times 0.5 = 1 \text{ mm} = 0.001 \text{ m}$   
Therefore, resistance  $R'$

$$R' = \rho \frac{l}{A} = \frac{1.6 \times 10^{-8} \times 122.72}{\pi \left( \frac{1}{2} \times 10^{-3} \right)^2}$$

$$\Rightarrow R' = \frac{1.6 \times 10^{-8} \times 122.72 \times 4}{3.14 \times 10^{-6}} = 250.2 \times 10^{-2} = 2.5 \Omega$$

Therefore, the length of the wire is 122.7 m and the new resistance is  $2.5 \Omega$

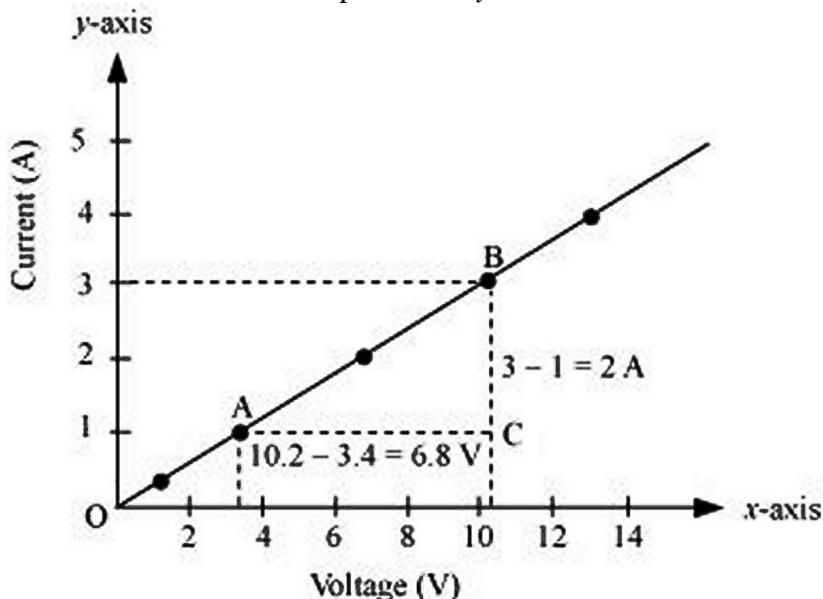
7. The values of current  $I$  flowing in a given resistor for the corresponding values of potential difference  $V$  across the resistor are given below –

$$I (\text{amperes}) \quad 0.5 \quad 1.0 \quad 2.0 \quad 3.0 \quad 4.0$$

$$V (\text{volts}) \quad 1.6 \quad 3.4 \quad 6.7 \quad 10.2 \quad 13.2$$

Plot a graph between  $V$  and  $I$  and calculate the resistance of that resistor.

**Ans.** The plot between voltage and current is called  $IV$  characteristic. The voltage is plotted on  $x$ -axis and current is plotted on  $y$ -axis.



The slope of the line gives the value of resistance ( $R$ ) as,

$$\text{Slope} = \frac{1}{R} = \frac{BC}{AC} = \frac{2}{6.8} \Rightarrow R = \frac{6.8}{2} = 3.4 \Omega$$

Therefore, the resistance of the resistor is  $3.4 \Omega$

8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

**Ans.** Resistance ( $R$ ) of a resistor is given by Ohm's law as,

$$V = IR \Rightarrow R = \frac{V}{I}$$

where, Potential difference,  $V = 12 \text{ V}$

Current in the circuit,  $I = 2.5 \text{ mA} = 2.5 \times 10^{-3} \text{ A}$

$$V = IR \Rightarrow R = \frac{12}{2.5 \times 10^{-3}} = 4.8 \times 10^3 \Omega = 4.8 k\Omega$$

Therefore, the resistance of the resistor is  $4.8 k\Omega$

9. A battery of 9 V is connected in series with resistors of  $0.2 \Omega$ ,  $0.3 \Omega$ ,  $0.4 \Omega$ ,  $0.5 \Omega$  and  $12 \Omega$ , respectively. How much current would flow through the  $12 \Omega$  resistor?

**Ans.** There is no current division occurring in a series circuit. Current flow through the component is the same, given by Ohm's law as

$$V = IR \Rightarrow I = \frac{V}{R} \text{ where, } R \text{ is the equivalent resistance of resistances } 0.2 \Omega, 0.3 \Omega, 0.4 \Omega, 0.5 \Omega \text{ and } 12 \Omega.$$

These are connected in series. Hence, the sum of the resistances will give the value of  $R$ .

$$R = 0.2 + 0.3 + 0.4 + 0.5 + 12 = 13.4 \Omega$$

Potential difference,  $V = 9 \text{ V}$

$$I = \frac{9}{13.4} = 0.671A$$

Therefore, the current that would flow through the  $12\Omega$  resistor is 0.671 A.

- 10.** How many  $176\Omega$  resistors (in parallel) are required to carry 5 A on a 220 V line?

**Ans.** For  $x$  number of resistors of resistance  $176\Omega$ , the equivalent resistance of the resistors connected in parallel is given by Ohm's law as

$$V = IR \Rightarrow R = \frac{V}{I}$$

where, Supply voltage,  $V = 220$  V, Current,  $I = 5$  A

Equivalent resistance of the combination =  $R$ , given as

$$\frac{1}{R} = x \times \frac{1}{176} \Rightarrow R = \frac{176}{x}$$

$$\text{From Ohm's law, } \frac{V}{I} = \frac{176}{x} \Rightarrow x = \frac{176 \times I}{V} = \frac{176 \times 5}{220} = 4$$

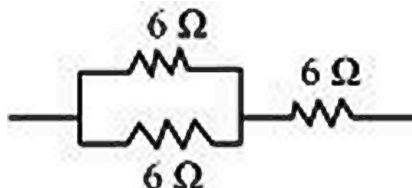
Therefore, four resistors of  $176\Omega$  are required to draw the given amount of current.

- 11.** Show how you would connect three resistors, each of resistance  $6\Omega$ , so that the combination has a resistance of (i)  $9\Omega$ , (ii)  $4\Omega$ .

**Ans.** If we connect the resistors in series, then the equivalent resistance will be the sum of the resistors, i.e.,  $6\Omega + 6\Omega + 6\Omega = 18\Omega$ , which is not desired. If we connect the resistors in parallel, then the equivalent resistance will be  $\frac{6}{2} = 3\Omega$ ,

which is also not desired. Hence, we should either connect the two resistors in series or parallel.

- (i) Two resistors in parallel

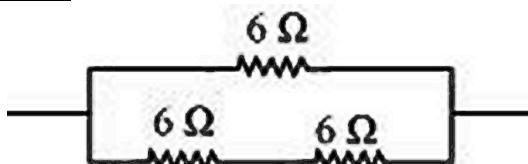


Two  $6\Omega$  resistors are connected in parallel. Their equivalent resistance will be

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{6} + \frac{1}{6}} = \frac{6 \times 6}{6 + 6} = 3\Omega$$

The third  $6\Omega$  resistor is in series with  $3\Omega$ . Hence, the equivalent resistance of the circuit is  $6\Omega + 3\Omega = 9\Omega$ .

- (ii) Two resistors in series



Two  $6\Omega$  resistors are in series. Their equivalent resistance will be the sum  $6 + 6 = 12\Omega$

The third  $6\Omega$  resistor is in parallel with  $12\Omega$ . Hence, equivalent resistance will be

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{12} + \frac{1}{6}} = \frac{12 \times 6}{12 + 6} = 4\Omega$$

Therefore, the total resistance is  $4\Omega$

- 12.** Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

**Ans.** Resistance  $R_1$  of the bulb is given by the expression,

$$P_1 = \frac{V^2}{R_1} \Rightarrow R_1 = \frac{V^2}{P_1} \text{ where, Supply voltage, } V = 220 \text{ V; Maximum allowable}$$

current,  $I = 5 \text{ A}$

Rating of an electric bulb ,  $P_1=10\text{W}$

$$R_1 = \frac{(220)^2}{5} = 4840\Omega$$

According to Ohm's law,  $V = I R$

where,  $R$  is the total resistance of the circuit for  $x$  number of electric bulbs

$$R = \frac{V}{I} = \frac{220}{5} = 44\Omega$$

Resistance of each electric bulb,  $R_1 = 4840 \Omega$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \text{upto } x \text{ times} \Rightarrow \frac{1}{R} = \frac{1}{R_1} \times x$$

$$\Rightarrow x = \frac{R_1}{R} = \frac{4840}{44} = 110$$

Therefore, 110 electric bulbs are connected in parallel.

- 13.** A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of  $24 \Omega$  resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

**Ans.** Supply voltage,  $V = 220 \text{ V}$

Resistance of one coil,  $R =$

(i) Coils are used separately

According to Ohm's law,  $V_1 = I_1 R_1$  where,  $I_1$  is the current flowing through the coil

$$I_1 = \frac{V}{R_1} = \frac{220}{24} = 9.166A$$

Therefore, 9.16 A current will flow through the coil when used separately.

(ii) Coils are connected in series

Total resistance,  $R_2 = 24 \Omega + 24 \Omega = 48 \Omega$

According to Ohm's law,  $V_2 = I_2 R_2$  where,  $I_2$  is the current flowing through the coil

$$I_2 = \frac{V}{R_2} = \frac{220}{48} = 4.58A$$

Therefore, 4.58 A current will flow through the circuit when the coils are connected in series.

(iii) Coils are connected in parallel

$$\text{Total resistance, } R_3 = \frac{1}{\frac{1}{24} + \frac{1}{24}} = \frac{24}{2} = 12\Omega$$

According to Ohm's law,  $V_3 = I_3 R_3$  where,  $I_3$  is the current flowing through the coil

$$I_3 = \frac{V}{R_3} = \frac{220}{12} = 18.33A$$

Therefore, 18.33 A current will flow through the circuit when coils are connected in parallel.

14. Compare the power used in the  $2\ \Omega$  resistor in each of the following circuits: (i) a 6 V battery in series with  $1\ \Omega$  and  $2\ \Omega$  resistors, and (ii) a 4 V battery in parallel with  $12\ \Omega$  and  $2\ \Omega$  resistors.

**Ans.** (i) Potential difference,  $V = 6\text{ V}$

$1\ \Omega$  and  $2\ \Omega$  resistors are connected in series. Therefore, equivalent resistance of the circuit,  $R = 1 + 2 = 3\ \Omega$

According to Ohm's law,  $V = IR$  where,  $I$  is the current through the circuit

$$I = \frac{6}{3} = 2\text{ A}$$

This current will flow through each component of the circuit because there is no division of current in series circuits. Hence, current flowing through the  $2\ \Omega$  resistor is 2A. Power is given by the expression,

$$P = (I)^2 R = (2)^2 2 = 8\text{ W}$$

(ii) Potential difference,  $V = 4\text{ V}$

$12\ \Omega$  and  $2\ \Omega$  resistors are connected in parallel. The voltage across each component of a parallel circuit remains the same. Hence, the voltage across  $2\ \Omega$  resistor will be 4 V.

Power consumed by  $2\ \Omega$  resistor is given by

$$P = \frac{V^2}{R} = \frac{4^2}{2} = 8\text{ W}$$

Therefore, the power used by  $2\ \Omega$  resistor is 8 W.

15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

**Ans.** Both the bulbs are connected in parallel. Therefore, potential difference across each of them will be 220 V, because no division of voltage occurs in a parallel circuit.

Current drawn by the bulb of rating 100 W is given by,

$$\text{Power} = \text{Voltage} \times \text{Current}$$

$$\Rightarrow \text{Current} = \frac{\text{Power}}{\text{Voltage}} = \frac{110}{220}\text{ A}$$

Similarly, current drawn by the bulb of rating 100 W is given by,

$$\text{Power} = \text{Voltage} \times \text{Current}$$

$$\Rightarrow \text{Current} = \frac{\text{Power}}{\text{Voltage}} = \frac{60}{220}\text{ A}$$

$$\text{Hence, current drawn from the line} = \frac{110}{220} + \frac{60}{220} = 0.727\text{ A}$$

16. Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?

**Ans.** Energy consumed by an electrical appliance is given by the expression,

$$H = P \times t$$

where, Power of the appliance =  $P$ , Time =  $t$

$$\text{Energy consumed by a TV set of power } 250\text{ W in } 1\text{ h} = 250 \times 3600 = 9 \times 10^5\text{ J}$$

Energy consumed by a toaster of power 1200 W in 10 minutes =  $1200 \times 600$   
=  $7.2 \times 10^5$  J

Therefore, the energy consumed by a 250 W TV set in 1 h is more than the energy consumed by a toaster of power 1200 W in 10 minutes.

- 17.** An electric heater of resistance  $8\ \Omega$  draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

**Ans.** Rate of heat produced by a device is given by the expression for power as  $P = I^2R$

where, Resistance of the electric heater,  $R = 8\ \Omega$

Current drawn,  $I = 15\text{ A}$

$$P = 15^2 \times 8 = 225 \times 8 = 1800\ \text{J/s}$$

Therefore, heat is produced by the heater at the rate of 1800 J/s.

- 18.** Explain the following.

- (a) Why is the tungsten used almost exclusively for filament of electric lamps?
- (b) Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?
- (c) Why is the series arrangement not used for domestic circuits?
- (d) How does the resistance of a wire vary with its area of cross-section?
- (e) Why are copper and aluminium wires usually employed for electricity transmission?

**Ans.** (a) The melting point and resistivity of tungsten are very high. It does not burn readily at a high temperature. The electric lamps glow at very high temperatures. Hence, tungsten is mainly used as heating element of electric bulbs.

(b) The conductors of electric heating devices such as bread toasters and electric irons are made of alloy because resistivity of an alloy is more than that of metals. It produces large amount of heat.

(c) There is voltage division in series circuits. Each component of a series circuit receives a small voltage for a large supply voltage. As a result, the amount of current decreases and the device becomes hot. Hence, series arrangement is not used in domestic circuits.

(d) Resistance ( $R$ ) of a wire is inversely proportional to its area of cross-section

$$(A), \text{ i.e., } R \propto \frac{1}{A}$$

(e) Copper and aluminium wires have low resistivity. They are good conductors of electricity. Hence, they are usually employed for electricity transmission.

## **ASSIGNMENT QUESTIONS** **ELECTRICITY**

### **VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)**

1. Define Electrostatic potential.
2. What is potential difference?
3. Define 1 volt.
4. Name the SI unit of potential difference.
5. Is potential difference a scalar or a vector quantity?
6. Name the instrument used to measure potential difference.
7. Does a voltmeter have a high or low resistance?
8. Write the other name of Joule/Coulomb?
9. How much work is done when one coulomb of charge moves against a potential difference of 1 volt?
10. Name the SI unit of electric current.
11. Is electric current a scalar or vector quantity?
12. Name the instrument used to measure electric current.
13. Does an ammeter have low or a high resistance?
14. Write the other name of variable resistance.
15. How do we connect an ammeter in a circuit?
16. Write the unit of electrical resistance.
17. State the factors on which the resistance of a conductor depends.
18. What is the term for the reciprocal of resistance?
19. What is the nature of the graph between I and V for a metallic conductor?
20. Does Ohm's law hold for a copper wire?

- 21.** Does Ohm's law hold for a liquid electrolyte?
- 22.** Does Ohm's law hold for a vacuum tube?
- 23.** Following are the I vs V graphs for a (a) metallic conductor (b) liquid electrolyte and (c) vacuum tube. In which case does the Ohm's law hold good?
- 24.** What do you mean by resistance?
- 25.** Does the resistance of a metal change when we raise the temperature of the metal?
- 26.** Name the substance having the largest and smallest electrical resistance amongst the following: Silver, copper, nichrome, rubber, acidulated water.
- 27.** Name the best conductor of electricity.
- 28.** Name an excellent insulator.
- 29.** Is wood a good conductor of electricity?
- 30.** When are two resistances said to be in series?
- 31.** When are two resistances said to be in parallel?
- 32.** How many different resistance-combinations are possible with two equal resistors, taking both of them together?
- 33.** The unit of resistance is ohm. What is the unit of conductance?
- 34.** Define electric power.
- 35.** What is the SI unit of electrical power?
- 36.** Name the quantity which is the product of potential difference and current.
- 37.** Express power P in terms of I and R.
- 38.** Write various formulae for electric power.
- 39.** What does 220V, 100W written on an electrical appliance mean? What do you mean by power rating?

- 40.** Which of the following electrical appliances usually has the (a) highest (b) least, power ratings? Tube light, Electric fan, Electric heater, Immersion heater.
- 41.** Which of the following electrical appliances usually draws the (a) highest and (b) least, current when operated at 220V? Tube light, Electrical fan, Electrical heater, Immersion heater.
- 42.** What do you mean by electrical energy being consumed by an electrical appliance?
- 43.** Write the SI unit of electrical energy.
- 44.** Write the commercial unit of energy.
- 45.** Define one Kilowatt-hour.
- 46.** Convert 1 Kwh to MJ.
- 47.** What is the ratio of SI units to C.G.S. unit of electrical energy?
- 48.** What are the factors on which electrical energy consumed by an eletrcial appliance depends?
- 49.** What do you mean by one unit of electrical energy?
- 50.** How many joules are in one watt-hour?
- 51.** List some important effects of electric current.
- 52.** Name the quantity whose role in mechanics is similar to the role of resistance in electrical circuits.
- 53.** Write a formula for calculating the amount of heat (H) produced in a resistor of resistance R when current I is passed through it for time t.
- 54.** List of factors on which heating effect of electric current depends.
- 55.** How is the heat produced by a current passing through a constant resistance related to the strength of the current?
- 56.** Name the Scientist who gave the formula for finding the heating produced in a conductor.

- 57.** Is joule's heating a reversible effect?
- 58.** How much can be Joule's heating produced in an ideal insulator?
- 59.** Name three electrical appliances that involve the heating effect of electric current.
- 60.** Is electric fuse an application of heating effect of current?
- 61.** Out of 5A fuse and 15A fuse which will you prefer to use for the lighting circuit?
- 62.** In domestic wiring do we connect various distribution circuits in series?
- 63.** Usually three insulated wires of different colours are used in electrical appliance. Name the three colours.
- 64.** What do you mean by short circuiting?
- 65.** What do you mean by a fuse?
- 66.** Should a fuse wire be connected in series or in parallel in the main circuit?
- 67.** Can we use a copper wire as a fuse wire?
- 68.** Name the instrument used to measure current in a circuit.
- 69.** Name the instrument used to detect weak currents in a circuit.
- 70.** Is ammeter connected in series or parallel in a circuit?
- 71.** What does the potential of a charged body determine?
- 72.** Is potential difference between two points in an electric field a vector quantity?
- 73.** What does a voltmeter measure?
- 74.** Is a voltmeter same as a voltameter?
- 75.** What are the conditions under which charges can move in a conductor?
- 76.** How will you maintain a potential difference between the ends of a conductor?
- 77.** Name the quantity that determines the rate of flow of charge through a conductor.

- 78.** What determines the direction of flow of charge: Potential of a body or Quantity of charge on a body?
- 79.** When the two ends of copper wire are connected to the two terminals of a battery some potential difference is created between its ends. Do electrons start flowing from high potential end to low potential end?
- 80.** In the question above, does current flow from the low potential end to the high potential end of the wire?
- 81.** What is the difference between a cell and a battery?
- 82.** What do you mean by an electric circuit?
- 83.** What do you mean by a circuit diagram?
- 84.** How does a cell maintain some constant potential difference across its terminals?
- 85.** Do all substances have the same resistivity?
- 86.** Give two substances having very low resistivities.
- 87.** Give two substances having moderate resistivities.
- 88.** Give two substances having high resistivities.
- 89.** What is the name given to substances which are used for making heating soils?
- 90.** Why do electricians wear rubber shoes or sandals or rubber hand gloves while working?
- 91.** What are the two ways in which the resistances are combined?
- 92.** What is meant by an equivalent resistance?
- 93.** Name the SI unit of electrical energy.
- 94.** Name the commercial unit of energy.
- 95.** Name the property of a conductor by virtue of which it opposes the flow of electric current through it.

- 96.** Is resistance a scalar or a vector quantity?
- 97.** Name the property of a conductor by virtue of which it allows the flow of charge through it.
- 98.** Is conductance a scalar or a vector quantity?
- 99.** Which has a greater resistance: thin wire or thick wire of the same material?
- 100.** What happens to the resistance of a copper wire when its temperature is raised?
- 101.** What happens to the conductance of a copper wire when its temperature is raised?
- 102.** What happens to the resistance of the following substances when its temperature is raised?  
(i) Aluminium (ii) Silicon (iii) Silver (iv) Germanium
- 103.** Define 1KWh.
- 104.** Name the quantity that represents the electric work done per unit time.
- 105.** Express electric power (P) in terms of current (I) and resistance (R).
- 106.** Express electric power (P) in terms of current (I) and potential difference (V).
- 107.** Name the quantity that represents the product of power rating and time.
- 108.** What voltage for the electrical appliance is kept in India?
- 109.** What voltage is kept for the domestic electric supply in USA?
- 110.** An electric heater is rated as 220V, 1KW. What does it mean?
- 111.** Name the term used to represent the values of the voltage and wattage(power) of an electrical appliance taken together.
- 112.** Which bulb has the lesser resistance: 100W or 60W?
- 113.** Which electrical appliance generally draws more current for the same applied voltage: Electric iron or Electric bulb?
- 114.** What do you understand by the heating effect of electric current?

- 115.** A number of bulbs are to be connected to a single source. Will they provide more illumination if connected in parallel, or in series?
- 116.** What do you mean by the overloading of the electrical circuit?
- 117.** All electrical circuits consist of three wires: a live wire, a neutral wire and an earth wire, what colours are assigned to these wires?
- 118.** What do you understand by short circuiting?
- 119.** What will happen when the live and the neutral wires in a circuit touch each other due to defective wiring?
- 120.** What is the use of electrical fuse in an electrical circuit?
- 121.** Name the effect of current on which a fuse works.
- 122.** Where do we connect a fuse in an electrical circuit?
- 123.** By what symbol is earthing represented?
- 124.** Why do we do the earthing of an electrical appliance?
- 125.** What does an electric meter in the house hold electric circuit measure?
- 126.** Are distribution circuits connected to each other in series or in parallel?
- 127.** Are switches connected in the neutral wire?
- 128.** What do you mean by earthing of an electrical appliance?

#### **SHORT ANSWER TYPE – I QUESTIONS (2 MARKS)**

- 1.** Why can't we use a copper wire as a fuse wire?
- 2.** What is usual colour code followed for connecting live, neutral and earth wires? Why is it so important?
- 3.** Define Electric current. How can you measure the magnitude of electric current?
- 4.** What is the direction of conventional current?
- 5.** State the law, which relates the current in a conductor to the potential difference across its ends.

6. Differentiate between conductors and insulators.
7. What is the law of combination of resistances in series?
8. What is the law of combination of resistances in parallel?
9. What do you mean when we say that the electric appliance is earthed? What is its importance?
10. What causes electric resistance? What is the physical significance of resistance?
11. What are the limitations of Ohm's law? What are ohmic conductors?
12. A graph is plotted between  $V$ (potential difference) and  $I$ (current) for a metal at two different temperatures  $T_1$  and  $T_2$ . What is the relationship between  $T_1$  and  $T_2$ ?
13. How many different resistances are possible with two equal resistors?
14. Draw a diagram used for a fuse to be used in an electrical appliance. Write the symbol for an electrical fuse in circuit diagram.
15. One billion electrons pass from a point A towards another point B in  $10^{-4}$  s. What is the current in amperes? What is its direction?

#### **SHORT ANSWER TYPE – II QUESTIONS (3 MARKS)**

1. Given five equal resistances; each of the value 5 ohms. (a) What is the maximum resistance that can be obtained from them? (b) What is the minimum resistance that can be obtained from them?
2. How many different resistance combinations are possible with three equal resistors taken all of them together?
3. Write symbols for the following:
  - (a) Cell (b) Battery (c) Fixed resistance (d) Wires crossing without contact
  - (e) Variable resistance (f) A wire joint
4. Write symbols for the following: (a) Ammeter (b) Voltmeter (c) Galvanometer  
(d) Open switch (e) Closed switch

5. Draw a labelled circuit diagram for the verification of Ohm's law. Plot a I-V graph for an ohmic conductor.
6. With the help of a diagram, derive the formula for the equivalent resistance of three resistances connected in series.
7. With the help of a diagram, derive the formula for the equivalent resistance of three resistances connected in parallel.
8. Write the SI and commercial unit of energy. Derive the relation between them.
9. What do you mean by resistivity of a conductor? What are the factors on which the resistance of a conductor depends?
10. State Joule's law of heating. Derive the formula for the Heat produced due to current flowing in a conductor.

#### **LONG ANSWER TYPE QUESTIONS (5 MARKS)**

1. Discuss series and parallel combinations of resistors with their salient features.
2. What is electric energy and electric power? Derive their expressions and define their units.
3. What is Ohm's law? How is it represented graphically? Derive an expression for the resultant resistance of series combinations of resistors.
4. State Ohm's law? Derive an expression for the equivalent resistance of parallel combinations of resistors.
5. What is Joule's heating effect? How can it be demonstrated experimentally? List its four applications in daily life.
6. What is electrical resistivity of a material? What is its unit? Describe an experimentally to study the factors on which the resistance of conducting wire depends?

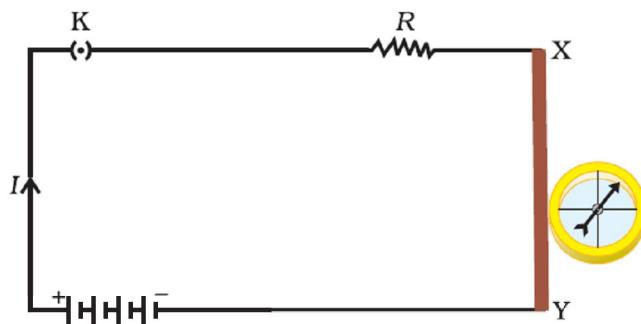
**All Numerical based on series and parallel combinations of resistances come under this section. Please refer page no. 16 – 26.**

## CHAPTER – 13

### MAGNETIC EFFECT OF CURRENT

The term magnetic effect of electric current means that an electric current flowing in a wire produces a magnetic field around it.

A current flowing in a wire always gives rise to a magnetic field around it. The magnetic effect of current is also called electromagnetism which means electricity produces magnetism. In figure, the deflection of compass needle by the current carrying wire in the below experiment show that an electric current produces a magnetic field around it.



#### **MAGNET**

A magnet is an object, which attracts pieces of iron, steel, nickel and cobalt. It has two poles at ends – South and North Pole.

- Like magnetic poles repel each other.
- Unlike magnetic poles attract each other.

#### **MAGNETIC FIELD**

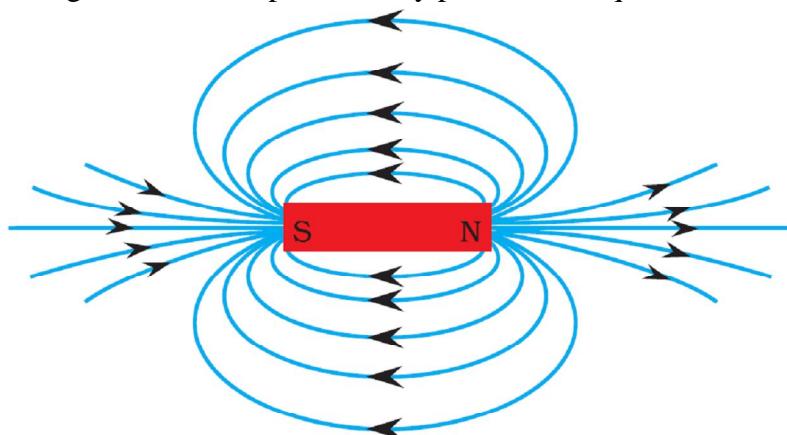
The space surrounding a magnet in which the force of attraction and repulsion is exerted is called a magnetic field.

#### **MAGNETIC FIELD LINES**

The magnetic field lines are the lines drawn in a magnetic field along which a north magnetic pole would move. These are also known as magnetic lines of forces.

#### **PROPERTIES OF MAGNETIC FIELD LINES**

1. A magnetic field lines originate from north pole and end at its south pole.
2. A magnetic field line is a closed and continuous curve.
3. The magnetic field lines are closer near the poles of a magnet where the magnetic field is strong and farther apart where the magnetic field is weak.
4. The magnetic field lines never intersect each other.
5. A uniform magnetic field is represented by parallel and equidistant field lines.



## **INTEXT QUESTIONS PAGE NO. 224**

1. Why does a compass needle get deflected when brought near a bar magnet?

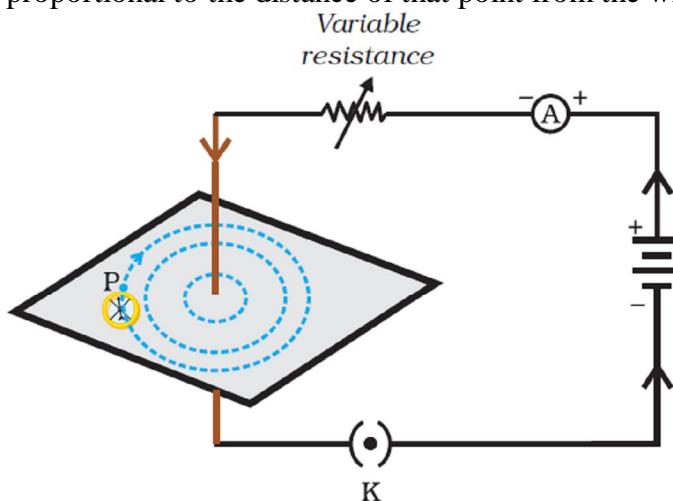
**Ans.** A compass gets deflected due to the forces acting on its poles due to the magnetic field of the bar magnet.

## **MAGNETIC FIELD DUE TO A CURRENT THROUGH A STRAIGHT CONDUCTOR**

The magnetic field lines around a straight conductor carrying current are concentric circles whose centres lies on the wire.

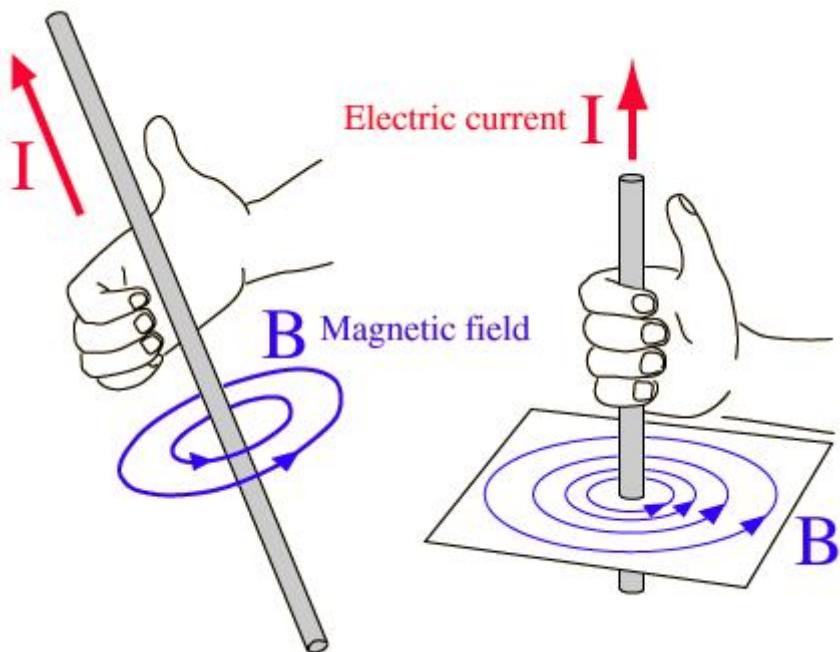
The magnitude of magnetic field produced by a straight current carrying wire at a point-

- directly proportional to current passing in the wire.
- inversely proportional to the distance of that point from the wire.



### **RIGHT-HAND THUMB RULE**

When a current-carrying straight conductor is held in right hand such that the thumb points towards the direction of current. Then fingers will wrap around the conductor in the direction of the field lines of the magnetic field, as shown in below figure. This is known as the right-hand thumb rule

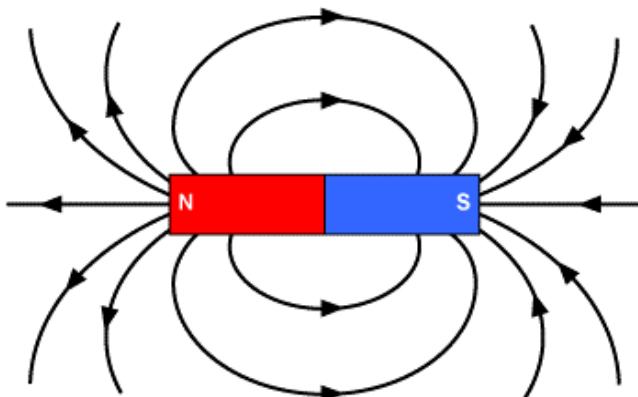


Thumb-points in the direction of current then direction of fingers encircle the wire give the direction of magnetic field around the wire.

### **INTEXT QUESTIONS PAGE NO. 228**

1. Draw magnetic field lines around a bar magnet.

**Ans.**



2. List the properties of magnetic lines of force.

**Ans.** Refer in page no. 1

3. Why don't two magnetic lines of force intersect each other?

**Ans.** If two magnetic lines of force intersect then there would be two directions of magnetic field at that point, which is absurd. That is why they never intersect.

### **MAGNETIC FIELD DUE TO A CURRENT THROUGH A CIRCULAR LOOP**

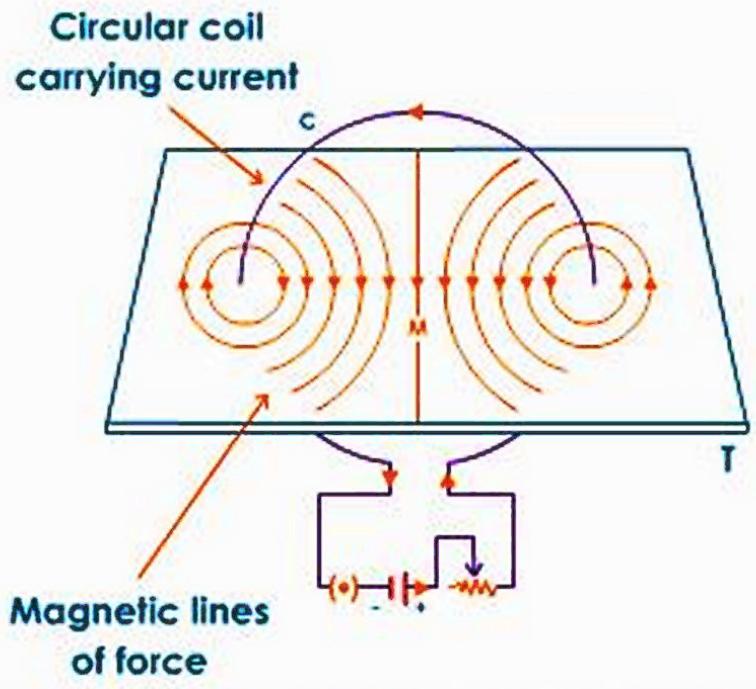
The magnetic field lines are circular near the current carrying loop. As we move away, the concentric circles becomes bigger and bigger. At the centre, the lines are straight.

At the centre, all the magnetic field lines are in the same direction due to which the strength of magnetic field increase.

The magnitude of magnetic field produced by a current carrying circular loop at its centre is

- directly proportional to the current passing
- inversely proportional to the radius of the circular loop

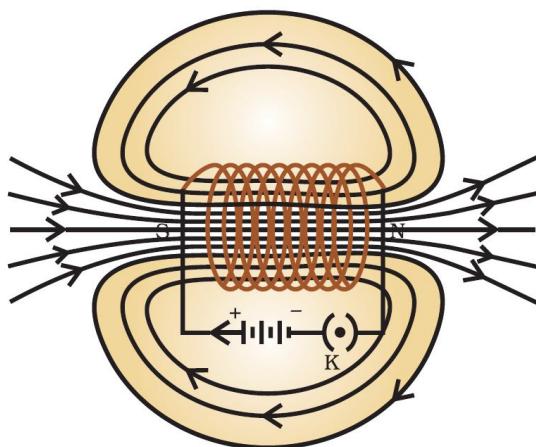
The strength of magnetic field produced by a circular coil carrying current is directly proportional to both number of turns( $n$ ) and current( $I$ ) but inversely proportional to its radius( $r$ ).



### MAGNETIC FIELD DUE TO A CURRENT IN A SOLENOID

The insulated copper wire wound on a cylindrical tube such that its length is greater than its diameter is called a solenoid. The solenoid is from greek word for channel.

- The solenoid is a long coil containing a large number of close turns of insulated copper wire.
- The magnetic field produced by a current carrying solenoid is similar to the magnetic field produced by a bar magnet.
- The current in each turn of a current carrying solenoid flows in the same direction due to which the magnetic field produced by each turn of the solenoid adds up, giving a strong magnetic field inside the solenoid.



The strong magnetic field produced inside a current-carrying solenoid can be used to magnetise a piece of magnetic material like soft iron, when placed inside the solenoid. The magnet thus formed is called an electromagnet.

So, a solenoid is used for making electromagnets.

The strength of magnetic field produced by a carrying current solenoid depends on

- number of turns(n)
- strength of current(I)
- nature of core material used in solenoid – use of soft iron as core in a solenoid produces the strongest magnetism.

## ELECTROMAGNETS AND PERMANENT MAGNETS

An electromagnet is a temporary strong magnet and is just a solenoid with its winding on soft iron core.

A permanent magnet is made from steel. As steel has more retentivity than iron, it does not lose its magnetism easily.

*Difference between Electromagnet and permanent magnet*

Electromagnet	Permanent magnet
1. An electromagnet is a temporary magnet as it can readily demagnetized by stopping the current through the solenoid.	1. A permanent magnet cannot be readily demagnetized.
2. Strength can be changed.	2. Strength cannot be changed.
3. It produces very strong magnetic forces.	3. It produces weak forces of attraction.
4. Polarity can be changed by changing the direction of the current.	4. Polarity is fixed and cannot be changed.

### **O. Why soft iron is used for making the core of an electromagnet?**

Soft iron is used for making the core of an electromagnet because soft iron loses all of its magnetism when current in the coil is switched off.

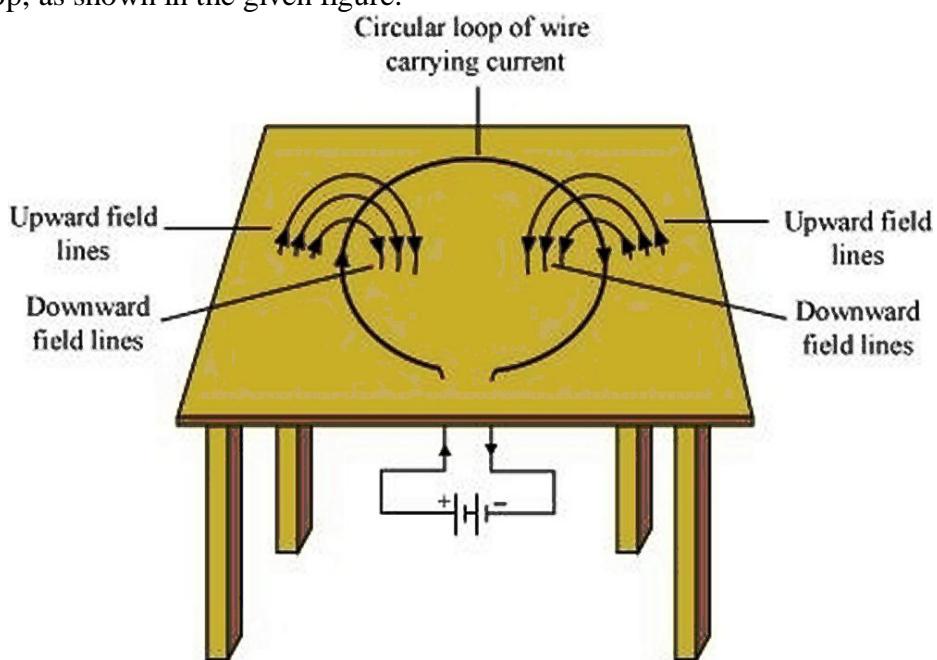
### **O. Why steel is not used for making the core of an electromagnet?**

Steel is not used for making the core of an electromagnet because steel does not loses all of its magnetism when current in the coil is switched off.

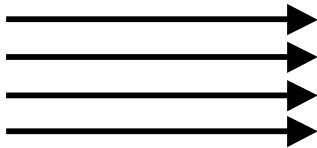
### **INTEXT QUESTIONS PAGE NO. 229 and 230**

1. Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right-hand rule to find out the direction of the magnetic field inside and outside the loop.

For downward direction of current flowing in the circular loop, the direction of magnetic field lines will be as if they are emerging from the table outside the loop and merging in the table inside the loop. Similarly, for upward direction of current flowing in the circular loop, the direction of magnetic field lines will be as if they are emerging from the table outside the loop and merging in the table inside the loop, as shown in the given figure.



2. The magnetic field in a given region is uniform. Draw a diagram to represent it.



3. Choose the correct option: The magnetic field inside a long straight solenoid-carrying current (a) is zero. (b) decreases as we move towards its end. (c) increases as we move towards its end. (d) is the same at all points.

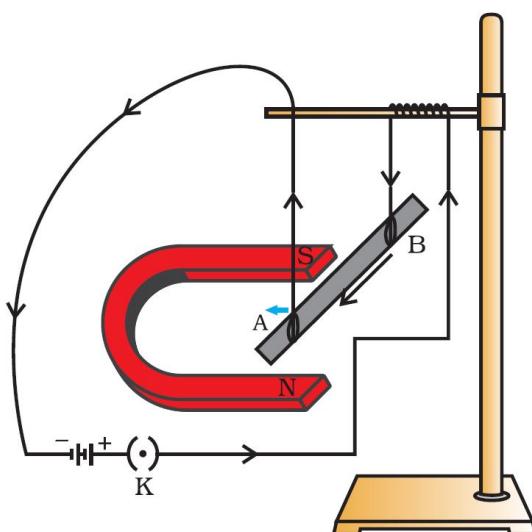
The magnetic field for a point inside a long straight solenoid carrying current is double than for a point situated at one of its ends. Thus, the correct option is (b).

### **FORCE ON A CURRENT-CARRYING CONDUCTOR IN A MAGNETIC FIELD**

When a current carrying conductor is placed in a magnetic field it experiences a force, except when it is placed parallel to the magnetic field.

The force acting on a current carrying conductor in a magnetic field is due to interaction between:

1. Magnetic force due to current-carrying conductor and
2. External magnetic field in which the conductor is placed.



In the above figure, a current-carrying rod, AB, experiences a force perpendicular to its length and the magnetic field.

The displacement of the rod in the above activity suggests that a force is exerted on the current-carrying aluminium rod when it is placed in a magnetic field. It also suggests that the direction of force is also reversed when the direction of current through the conductor is reversed. Now change the direction of field to vertically downwards by interchanging the two poles of the magnet. It is once again observed that the direction of force acting on the current-carrying rod gets reversed. It shows that the direction of the force on the conductor depends upon the direction of current and the direction of the magnetic field. We considered the direction of the current and that of the magnetic field perpendicular to each other and found that the force is perpendicular to both of them.

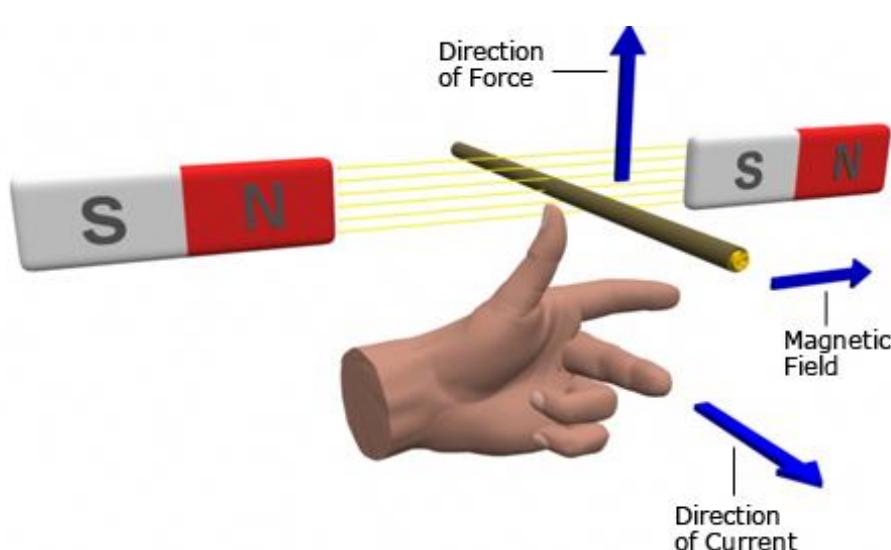
### **FLEMING'S LEFT HAND RULE**

Fleming's left hand rule (for electric motors) shows the direction of the thrust on a conductor carrying a current in a magnetic field. The left hand is held with the thumb, index finger and middle finger mutually at right angles.

The First finger represents the direction of the magnetic Field. (north to south)

The Second finger represents the direction of the Current (the direction of the current is the direction of conventional current; from positive to negative).

The Thumb represents the direction of the Thrust or resultant Motion.



### FLEMING'S RIGHT HAND RULE

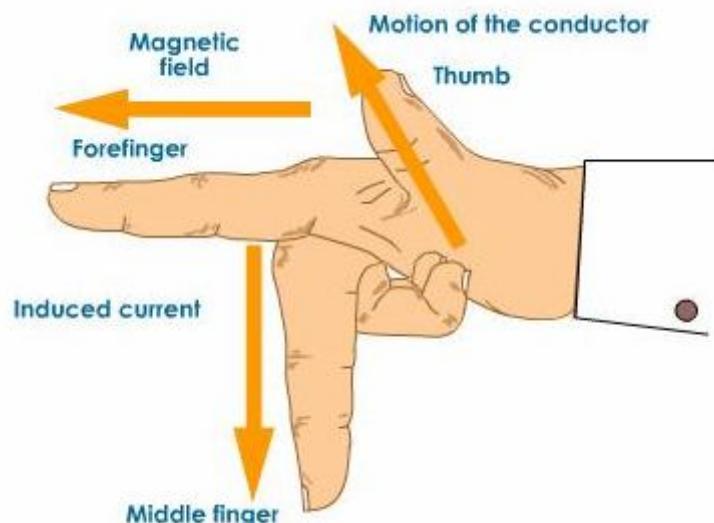
Fleming's right hand rule (for generators) shows the direction of induced current when a conductor moves in a magnetic field.

The right hand is held with the thumb, first finger and second finger mutually perpendicular to each other {at right angles}, as shown in the diagram .

The Thumb represents the direction of Motion of the conductor.

The First finger represents the direction of the Field. (north to south)

The Second finger represents the direction of the induced or generated Current (the direction of the induced current will be the direction of conventional current; from positive to negative).



### INTEXT QUESTIONS PAGE NO. 231 AND 232

- Which of the following property of a proton can change while it moves freely in a magnetic field? (There may be more than one correct answer.) (a) mass (b) speed (c) velocity (d) momentum

Whenever a charged proton moves in a magnetic field, its velocity changes and as a result of this its momentum change. Thus (c) and (d) are the properties which change when a proton moves freely in a magnetic field.

2. In Activity 13.7, how do we think the displacement of rod AB will be affected if
  - (i) current in rod AB is increased; (ii) a stronger horse-shoe magnet is used; and (iii) length of the rod AB is increased?
  - (i) If the current in the rod AB is increased, force also increases.
  - (ii) When a stronger horse-shoe magnet is used, magnetic field increases as a result force also increases.
  - (iii) If the length of the rod AB is increased, force also increased.
3. A positively-charged particle (alpha-particle) projected towards west is deflected towards north by a magnetic field. The direction of magnetic field is (a) towards south (b) towards east (c) downward (d) upward  
The direction of the motion of proton is the direction of current. The direction of force on the proton is towards north. Applying Fleming's left hand rule, the direction of magnetic field is upward. The correct option is (d).

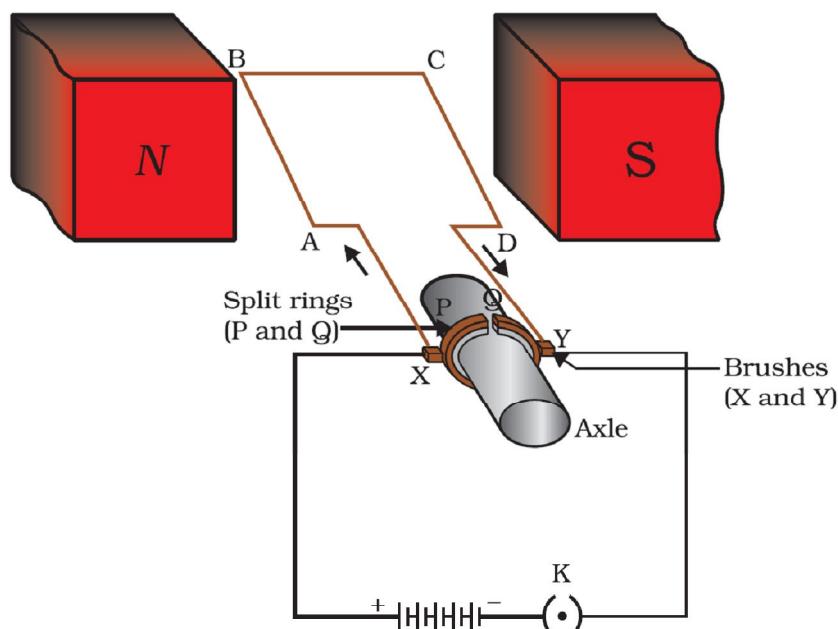
## ELECTRIC MOTOR

An electric motor is a rotating device that converts electrical energy to mechanical energy. Electric motor is used as an important component in electric fans, refrigerators, mixers, washing machines, computers, MP3 players etc.

**Principle:** When a coil carrying current is placed in a magnetic field, it experiences a torque. As a result of this torque, the coil begins to rotate.

### Construction:

It consists of a rectangular coil ABCD of insulated copper wire. The coil is placed between the two poles of a magnetic field such that the arm AB and CD are perpendicular to the direction of the magnetic field. The ends of the coil are connected to the two halves P and Q of a split ring. The inner sides of these halves are insulated and attached to an axle. The external conducting edges of P and Q touch two conducting stationary brushes X and Y, respectively, as shown in the below figure



### Working:

Current in the coil ABCD enters from the source battery through conducting brush X and flows back to the battery through brush Y.

Notice that the current in arm AB of the coil flows from A to B. In arm CD it flows from C to D, that is, opposite to the direction of current through arm AB.

On applying Fleming's left hand rule for the direction of force on a current-carrying conductor in a magnetic field.. We find that the force acting on arm AB pushes it downwards while the force acting on arm CD pushes it upwards. Thus the coil and the axle O, mounted free to turn about an axis, rotate anti-clockwise.

At half rotation, Q makes contact with the brush X and P with brush Y. Therefore the current in the coil gets reversed and flows along the path DCBA. A device that reverses the direction of flow of current through a circuit is called a commutator. In electric motors, the split ring acts as a commutator.

The reversal of current also reverses the direction of force acting on the two arms AB and CD. Thus the arm AB of the coil that was earlier pushed down is now pushed up and the arm CD previously pushed up is now pushed down. Therefore the coil and the axle rotate half a turn more in the same direction. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil and to the axle.

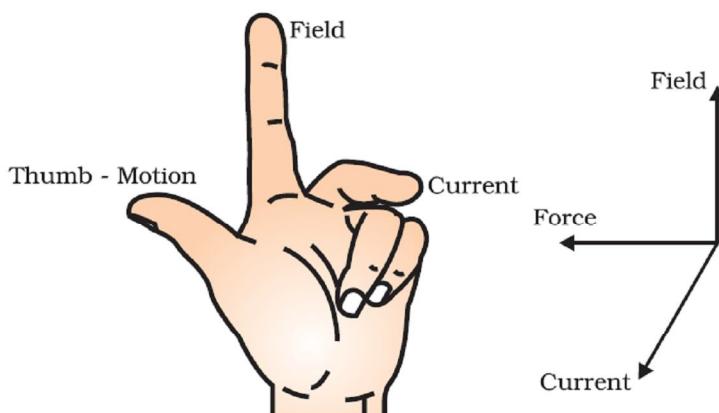
#### Uses of electric motor:

The commercial motors use (i) an electromagnet in place of permanent magnet; (ii) large number of turns of the conducting wire in the current-carrying coil; and (iii) a soft iron core on which the coil is wound. The soft iron core, on which the coil is wound, plus the coils, is called an armature. This enhances the power of the motor.

#### **INTEXT QUESTIONS PAGE NO. 231 AND 232**

1. State Fleming's left-hand rule.

**Ans.** Fleming's left hand rule states that if we arrange the thumb, the centre finger, and the forefinger of the left hand at right angles to each other, then the thumb points towards the direction of the magnetic force, the centre finger gives the direction of current, and the forefinger points in the direction of magnetic field.



2. What is the principle of an electric motor?

**Ans.** The working principle of an electric motor is based on the magnetic effect of current. A current-carrying loop experiences a force and rotates when placed in a magnetic field. The direction of rotation of the loop is given by the Fleming's left-hand rule.

3. What is the role of the split ring in an electric motor?

**Ans.** The split ring in the electric motor acts as a commutator. The commutator reverses the direction of current flowing through the coil after each half rotation of

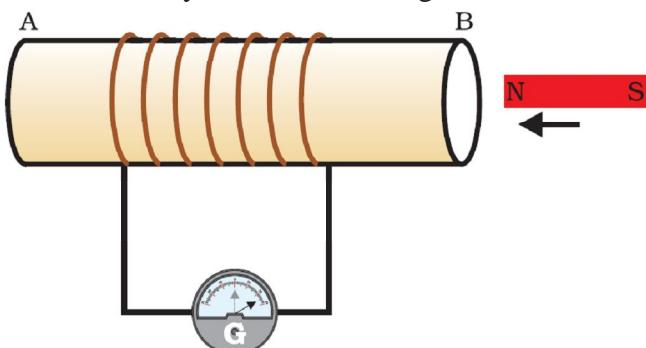
the coil. Due to this reversal of the current, the coil continues to rotate in the same direction.

### ELECTROMAGNETIC INDUCTION

The production of electricity from magnetism is called Electromagnetic induction. When a straight wire is moved up and down rapidly between the poles of magnet, then an electric current is produced in the wire. This is an example of electromagnetic induction

The process of electromagnetic induction has led to the construction of generators for producing electricity at power stations

The current produced by moving a straight wire in a magnetic field is called an induced current. In the below figure, moving a magnet towards a coil sets up a current in the coil circuit, as indicated by deflection in the galvanometer needle.



If the bar magnet moved towards south pole of the magnet towards the end B of the coil, the deflections in the galvanometer would just be opposite to the previous case. When the coil and the magnet are both stationary, there is no deflection in the galvanometer. It is, thus, clear from this activity that motion of a magnet with respect to the coil produces an induced potential difference, which sets up an induced electric current in the circuit.

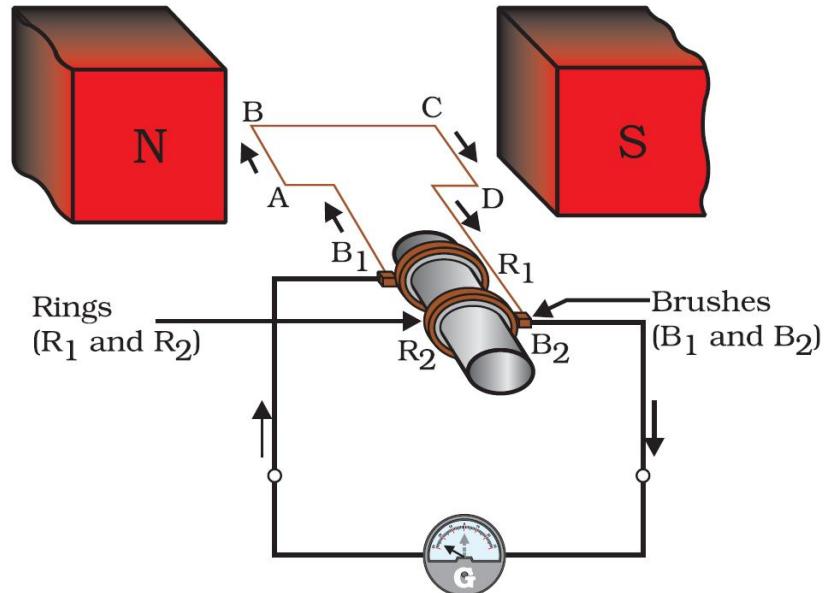
### ELECTRIC GENERATOR

In an electric generator, mechanical energy is used to rotate a conductor in a magnetic field to produce electricity.

**Principle:** Whenever in a closed circuit, the magnetic field lines change, an induced current is produced.

#### Construction:

- An electric generator, as shown in the below figure, consists of a rotating rectangular coil ABCD placed between the two poles of a permanent magnet.
- The two ends of this coil are connected to the two rings R1 and R2.
- The inner side of these rings are made insulated.
- The two conducting stationary brushes B1 and B2 are kept pressed separately on the rings R1 and R2, respectively.
- The two rings R1 and R2 are internally attached to an axle.
- The axle may be mechanically rotated from outside to rotate the coil inside the magnetic field.
- Outer ends of the two brushes are connected to the galvanometer to show the flow of current in the given external circuit.



### **Working:**

When the axle attached to the two rings is rotated such that the arm AB moves up (and the arm CD moves down) in the magnetic field produced by the permanent magnet. Let us say the coil ABCD is rotated clockwise in the arrangement shown in the above figure.

By applying Fleming's right-hand rule, the induced currents are set up in these arms along the directions AB and CD. Thus an induced current flows in the direction ABCD. If there are larger numbers of turns in the coil, the current generated in each turn adds up to give a large current through the coil. This means that the current in the external circuit flows from B2 to B1.

After half a rotation, arm CD starts moving up and AB moving down. As a result, the directions of the induced currents in both the arms change, giving rise to the net induced current in the direction DCBA. The current in the external circuit now flows from B1 to B2. Thus after every half rotation the polarity of the current in the respective arms changes. Such a current, which changes direction after equal intervals of time, is called an alternating current (abbreviated as AC). This device is called an AC generator.

To get a direct current (DC, which does not change its direction with time), a split-ring type commutator must be used. With this arrangement, one brush is at all times in contact with the arm moving up in the field, while the other is in contact with the arm moving down. We have seen the working of a split ring commutator in the case of an electric motor. Thus a unidirectional current is produced. The generator is thus called a DC generator. The difference between the direct and alternating currents is that the direct current always flows in one direction, whereas the alternating current reverses its direction periodically.

### **INTEXT QUESTIONS PAGE NO. 236**

1. Explain different ways to induce current in a coil.

The different ways to induce current in a coil are as follows:

- (a) If a coil is moved rapidly between the two poles of a horse-shoe magnet, then an electric current is induced in the coil.
- (b) If a magnet is moved relative to a coil, then an electric current is induced in the coil

## **INTEXT QUESTIONS PAGE NO. 237**

1. State the principle of an electric generator.

An electric generator works on the principle of electromagnetic induction. It generates electricity by rotating a coil in a magnetic field.

2. Name some sources of direct current.

Some sources of direct current are cell, DC generator, etc

3. Which sources produce alternating current?

AC generators, power plants, etc., produce alternating current

4. Choose the correct option: A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each (a) two revolutions (b) one revolution (c) half revolution (d) one-fourth revolution

(c) When a rectangular coil of copper is rotated in a magnetic field, the direction of the induced current in the coil changes once in each half revolution. As a result, the direction of current in the coil remains the same

## **DOMESTIC ELECTRIC CIRCUITS**

### When does an electric short circuit occur?

If the resistance of an electric circuit becomes very low, then the current flowing through the circuit becomes very high. This is caused by connecting too many appliances to a single socket or connecting high power rating appliances to the light circuits. This results in a short circuit.

When the insulation of live and neutral wires undergoes wear and tear and then touches each other, the current flowing in the circuit increases abruptly. Hence, a short circuit occurs.

### What is the function of an earth wire? Why is it necessary to earth metallic appliances?

The metallic body of electric appliances is connected to the earth by means of earth wire so that any leakage of electric current is transferred to the ground. This prevents any electric shock to the user. That is why earthing of the electrical appliances is necessary.

### What is Electric fuse? What is the important of electric fuse?

Electric Fuse consists of a piece of wire made of a metal or an alloy of appropriate melting point, for example aluminium, copper, iron, lead etc. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit. Fuse is the most important safety device, used for protecting the circuits due to short-circuiting or overloading of the circuits. The use of an electric fuse prevents the electric circuit and the appliance from a possible damage by stopping the flow of unduly high electric current. The fuses used for domestic purposes are rated as 1 A, 2 A, 3 A, 5 A, 10 A, etc.

## **INTEXT QUESTIONS PAGE NO. 238**

1. Name two safety measures commonly used in electric circuits and appliances.

Two safety measures commonly used in electric circuits and appliances are as follows:

(i) Each circuit must be connected with an electric fuse. This prevents the flow of excessive current through the circuit. When the current passing through the wire exceeds the maximum limit of the fuse element, the fuse melts to stop the flow of current through that circuit, hence protecting the appliances connected to the circuit.

- (ii) Earthing is a must to prevent electric shocks. Any leakage of current in an electric appliance is transferred to the ground and people using the appliance do not get the shock.
2. An electric oven of 2 kW power rating is operated in a domestic electric circuit (220 V) that has a current rating of 5 A. What result do you expect? Explain. Current drawn by the electric oven can be obtained by the expression,

$$P=VI$$

$$I = \frac{P}{V}$$

Where, current = I. Power of the oven, P = 2 kW = 2000W

Voltage supplied, V = 220V

$$I = \frac{2000}{220} = 9.09A$$

Hence, the current drawn by the electric oven is 9.09 A, which exceeds the safe limit of the circuit. Fuse element of the electric fuse will melt and break the circuit.

3. What precaution should be taken to avoid the overloading of domestic electric circuits?
- The precautions that should be taken to avoid the overloading of domestic circuits are as follows:
- (a) Too many appliances should not be connected to a single socket.
  - (b) Too many appliances should not be used at the same time.
  - (c) Faulty appliances should not be connected in the circuit
  - (d) Fuse should be connected in the circuit.

## MAGNETISM IN MEDICINE

An electric current always produces a magnetic field. Even weak ion currents that travel along the nerve cells in our body produce magnetic fields. When we touch something, our nerves carry an electric impulse to the muscles we need to use. This impulse produces a temporary magnetic field. These fields are very weak and are about one-billionth of the earth's magnetic field. Two main organs in the human body where the magnetic field produced is significant, are the heart and the brain. The magnetic field inside the body forms the basis of obtaining the images of different body parts. This is done using a technique called ***Magnetic Resonance Imaging (MRI)***. Analysis of these images helps in medical diagnosis. Magnetism has, thus, got important uses in medicine.

## EXERCISE QUESTIONS PAGE NO. 240

1. Which of the following correctly describes the magnetic field near a long straight wire?
- (a) The field consists of straight lines perpendicular to the wire
  - (b) The field consists of straight lines parallel to the wire
  - (c) The field consists of radial lines originating from the wire
  - (d) The field consists of concentric circles centred on the wire
- Ans.** (d) The magnetic field lines, produced around a straight current-carrying conductor, are concentric circles. Their centres lie on the wire.
2. The phenomenon of electromagnetic induction is

- (a) the process of charging a body

- (b) the process of generating magnetic field due to a current passing through a coil
- (c) producing induced current in a coil due to relative motion between a magnet and the coil
- (d) the process of rotating a coil of an electric motor

**Ans.** (c) When a straight coil and a magnet are moved relative to each other, a current is induced in the coil. This phenomenon is known as electromagnetic induction.

3. The device used for producing electric current is called a  
(a) generator. (b) galvanometer. (c) ammeter. (d) motor.

**Ans.** (a) An electric generator produces electric current. It converts mechanical energy into electricity.

4. The essential difference between an AC generator and a DC generator is that  
(a) AC generator has an electromagnet while a DC generator has permanent magnet.

(b) DC generator will generate a higher voltage.  
(c) AC generator will generate a higher voltage.  
(d) AC generator has slip rings while the DC generator has a commutator.

**Ans.** (d) An AC generator has two rings called slip rings. A DC generator has two half rings called commutator. This is the main difference between both the types of generators.

5. At the time of short circuit, the current in the circuit  
(a) reduces substantially. (b) does not change.  
(c) increases heavily. (d) vary continuously.

**Ans.** (c) When two naked wires of an electric circuit touch each other, the amount of current that is flowing in the circuit increases abruptly. This causes short-circuit.

6. State whether the following statements are true or false.

(a) An electric motor converts mechanical energy into electrical energy.  
(b) An electric generator works on the principle of electromagnetic induction.  
(c) The field at the centre of a long circular coil carrying current will be parallel straight lines.  
(d) A wire with a green insulation is usually the live wire of an electric supply.

**Ans.** (a) False

An electric motor converts electrical energy into mechanical energy.

(b) True

A generator is an electric device that generates electricity by rotating a coil in a magnetic field. It works on the principle of electromagnetic induction.

(c) True

A long circular coil is a long solenoid. The magnetic field lines inside the solenoid are parallel lines.

(d) False

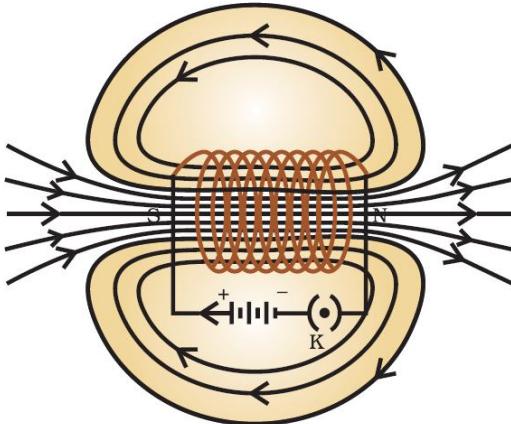
Live wire has red insulation cover, whereas earth wire has green insulation colour in the domestic circuits.

7. List three sources of magnetic fields.

**Ans.** Three sources of magnetic fields are as follows:

- (a) Current-carrying conductors
- (b) Permanent magnets
- (c) Electromagnets

8. How does a solenoid behave like a magnet? Can you determine the north and south poles of a current-carrying solenoid with the help of a bar magnet? Explain.
- Ans.** A solenoid is a long coil of circular loops of insulated copper wire. Magnetic field lines are produced around the solenoid when a current is allowed to flow through it. The magnetic field produced by it is similar to the magnetic field of a bar magnet. The field lines produced in a current-carrying solenoid is shown in the following figure.



In the above figure, when the north pole of a bar magnet is brought near the end connected to the negative terminal of the battery, the solenoid repels the bar magnet. Since like poles repel each other, the end connected to the negative terminal of the battery behaves as the north pole of the solenoid and the other end behaves as a south pole. Hence, one end of the solenoid behaves as a north pole and the other end behaves as a south pole.

9. When is the force experienced by a current-carrying conductor placed in a magnetic field largest?

**Ans.** The force experienced by a current-carrying conductor is the maximum when the direction of current is perpendicular to the direction of the magnetic field.

10. Imagine that you are sitting in a chamber with your back to one wall. An electron beam, moving horizontally from back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of magnetic field?

**Ans.** The direction of magnetic field is given by Fleming's left hand rule. Magnetic field inside the chamber will be perpendicular to the direction of current (opposite to the direction of electron) and direction of deflection/force i.e., either upward or downward. The direction of current is from the front wall to the back wall because negatively charged electrons are moving from back wall to the front wall. The direction of magnetic force is rightward. Hence, using Fleming's left hand rule, it can be concluded that the direction of magnetic field inside the chamber is downward.

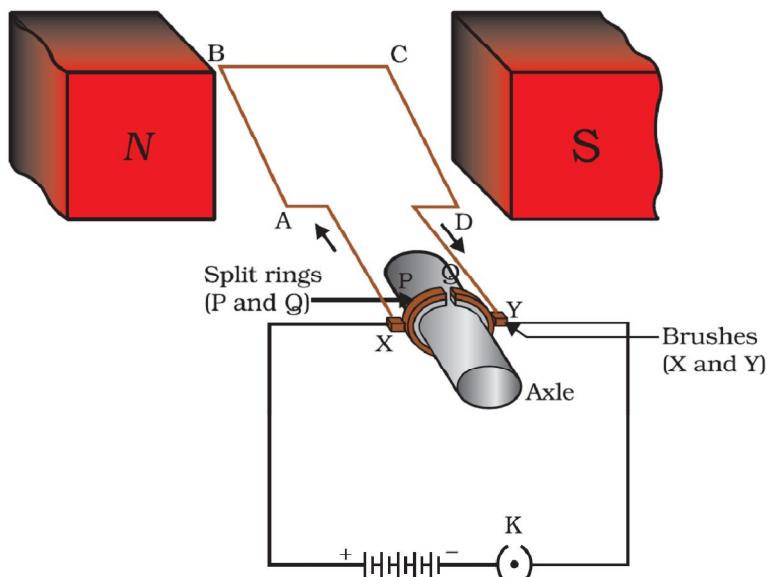
11. Draw a labelled diagram of an electric motor. Explain its principle and working. What is the function of a split ring in an electric motor?

**Ans.** An electric motor is a rotating device that converts electrical energy to mechanical energy. Electric motor is used as an important component in electric fans, refrigerators, mixers, washing machines, computers, MP3 players etc.

**Principle:** When a coil carrying current is placed in a magnetic field, it experiences a torque. As a result of this torque, the coil begins to rotate.

### **Construction:**

It consists of a rectangular coil ABCD of insulated copper wire. The coil is placed between the two poles of a magnetic field such that the arm AB and CD are perpendicular to the direction of the magnetic field. The ends of the coil are connected to the two halves P and Q of a split ring. The inner sides of these halves are insulated and attached to an axle. The external conducting edges of P and Q touch two conducting stationary brushes X and Y, respectively, as shown in the below figure



### **Working:**

Current in the coil ABCD enters from the source battery through conducting brush X and flows back to the battery through brush Y.

Notice that the current in arm AB of the coil flows from A to B. In arm CD it flows from C to D, that is, opposite to the direction of current through arm AB.

On applying Fleming's left hand rule for the direction of force on a current-carrying conductor in a magnetic field.. We find that the force acting on arm AB pushes it downwards while the force acting on arm CD pushes it upwards. Thus the coil and the axle O, mounted free to turn about an axis, rotate anti-clockwise.

At half rotation, Q makes contact with the brush X and P with brush Y. Therefore the current in the coil gets reversed and flows along the path DCBA. A device that reverses the direction of flow of current through a circuit is called a commutator. In electric motors, the split ring acts as a commutator.

The reversal of current also reverses the direction of force acting on the two arms AB and CD. Thus the arm AB of the coil that was earlier pushed down is now pushed up and the arm CD previously pushed up is now pushed down. Therefore the coil and the axle rotate half a turn more in the same direction. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil and to the axle.

**12.** Name some devices in which electric motors are used.

**Ans.** Some devices in which electric motors are used are as follows:

- (a) Water pumps (b) Electric fans (c) Electric mixers (d) Washing machines

**13.** A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil, (ii) withdrawn from inside the coil, (iii) held stationary inside the coil?

**Ans.** A current induces in a solenoid if a bar magnet is moved relative to it. This is the principle of electromagnetic induction.

(i) When a bar magnet is pushed into a coil of insulated copper wire, a current is induced momentarily in the coil. As a result, the needle of the galvanometer deflects momentarily in a particular direction.

(ii) When the bar magnet is withdrawn from inside the coil of the insulated copper wire, a current is again induced momentarily in the coil in the opposite direction. As a result, the needle of the galvanometer deflects momentarily in the opposite direction.

(iii) When a bar magnet is held stationary inside the coil, no current will be induced in the coil. Hence, galvanometer will show no deflection.

- 14.** Two circular coils A and B are placed closed to each other. If the current in the coil A is changed, will some current be induced in the coil B? Give reason.

**Ans.** Two circular coils A and B are placed closed to each other. When the current in coil A is changed, the magnetic field associated with it also changes. As a result, the magnetic field around coil B also changes. This change in magnetic field lines around coil B induces an electric current in it. This is called electromagnetic induction.

- 15.** State the rule to determine the direction of a (i) magnetic field produced around a straight conductor-carrying current, (ii) force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular to it, and (iii) current induced in a coil due to its rotation in a magnetic field.

**Ans.** (i) Maxwell's right hand thumb rule

(ii) Fleming's left hand rule

(iii) Fleming's right hand rule

- 16.** Explain the underlying principle and working of an electric generator by drawing a labelled diagram. What is the function of brushes?

**Ans.** In an electric generator, mechanical energy is used to rotate a conductor in a magnetic field to produce electricity.

**Principle:** Whenever in a closed circuit, the magnetic field lines change, an induced current is produced.

**Construction:**

- An electric generator, as shown in the below figure, consists of a rotating rectangular coil ABCD placed between the two poles of a permanent magnet.
- The two ends of this coil are connected to the two rings R1 and R2.
- The inner side of these rings are made insulated.
- The two conducting stationary brushes B1 and B2 are kept pressed separately on the rings R1 and R2, respectively.
- The two rings R1 and R2 are internally attached to an axle.
- The axle may be mechanically rotated from outside to rotate the coil inside the magnetic field.
- Outer ends of the two brushes are connected to the galvanometer to show the flow of current in the given external circuit.

**Working:**

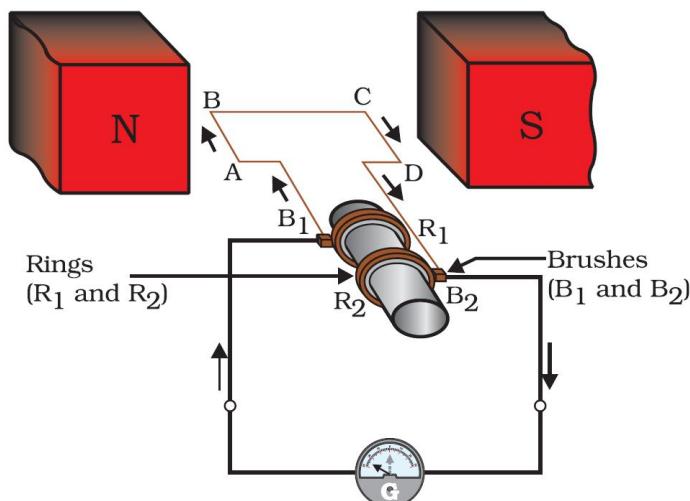
When the axle attached to the two rings is rotated such that the arm AB moves up (and the arm CD moves down) in the magnetic field produced by the permanent magnet. Let us say the coil ABCD is rotated clockwise in the arrangement shown in the above figure.

By applying Fleming's right-hand rule, the induced currents are set up in these arms along the directions AB and CD. Thus an induced current flows in the direction ABCD. If there are larger numbers of turns in the coil, the current

generated in each turn adds up to give a large current through the coil. This means that the current in the external circuit flows from B<sub>2</sub> to B<sub>1</sub>.

After half a rotation, arm CD starts moving up and AB moving down. As a result, the directions of the induced currents in both the arms change, giving rise to the net induced current in the direction DCBA. The current in the external circuit now flows from B<sub>1</sub> to B<sub>2</sub>. Thus after every half rotation the polarity of the current in the respective arms changes. Such a current, which changes direction after equal intervals of time, is called an alternating current (abbreviated as AC). This device is called an AC generator.

To get a direct current (DC, which does not change its direction with time), a split-ring type commutator must be used. With this arrangement, one brush is at all times in contact with the arm moving up in the field, while the other is in contact with the arm moving down. We have seen the working of a split ring commutator in the case of an electric motor. Thus a unidirectional current is produced. The generator is thus called a DC generator. The difference between the direct and alternating currents is that the direct current always flows in one direction, whereas the alternating current reverses its direction periodically.



**17. When does an electric short circuit occur?**

**Ans.** If the resistance of an electric circuit becomes very low, then the current flowing through the circuit becomes very high. This is caused by connecting too many appliances to a single socket or connecting high power rating appliances to the light circuits. This results in a short circuit.

When the insulation of live and neutral wires undergoes wear and tear and then touches each other, the current flowing in the circuit increases abruptly. Hence, a short circuit occurs.

**18. What is the function of an earth wire? Why is it necessary to earth metallic appliances?**

**Ans.** The metallic body of electric appliances is connected to the earth by means of earth wire so that any leakage of electric current is transferred to the ground. This prevents any electric shock to the user. That is why earthing of the electrical appliances is necessary.

## **ASSIGNMENT QUESTIONS FOR PRACTICE** **MAGNETIC EFFECTS OF ELECTRIC CURRENT**

### **VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)**

1. Name the scientist who discovered the magnetic effect of current.
2. Does a current flowing in a wire always give rise to a magnetic field around it?
3. State any two properties of magnetic field lines.
4. Why does a compass needle get deflected when brought near a bar magnet?
5. Name the effect of current on which an electromagnetic works.
6. What name is given to the combination of a solenoid and a soft iron core?
7. Can steel be used for making electromagnets?
8. Name the scientist who discovered that a current carrying conductor when placed in a magnetic field experiences a mechanical force.
9. When is the maximum force exerted on a current carrying conductor while it is kept in a magnetic field?
10. Does a current carrying conductor experience some force when kept parallel to the magnetic field?
11. Which rule is employed to find the direction of force on a current carrying conductor when kept in a magnetic field? State the rule and explain it by a diagram.
12. Name the transformation of energy involved in the electric motor.
13. What is the function of commutator rings in the electric motor?
14. What is the function of carbon brushes in the electric motor?
15. Name one application of electromagnetic induction.
16. What is the other name of electric generator?
17. Name the transformation of energy in an electric generator.

- 18.** What is a turbine used for?
- 19.** Name the different types of electric power plants for generating electricity on large scale.
- 20.** Name the fuel used in a thermal power plant.
- 21.** Name the fuel used in an atomic power plant.
- 22.** What do you understand by magnetic field?
- 23.** What do you mean by electromagnetism?
- 24.** What is meant by magnetic effect of current?
- 25.** Can you observe the magnetic field?
- 26.** What do you mean by a magnetic line of force?
- 27.** Is a magnetic line of force always a straight line?
- 28.** What do you conclude from Oersted's experiment?
- 29.** Can you magnetic line of force ever intersect each other?
- 30.** What kind of magnetic field is produced by a straight current carrying conductor?
- 31.** What kind of magnetic field is produced by a current carrying circular field?
- 32.** What do you mean by a solenoid?
- 33.** State the clock rule for a current carrying solenoid.
- 34.** How does a current carrying solenoid behave?
- 35.** What is the nature of magnetic field produced by a current carrying solenoid?
- 36.** What is the magnitude and direction of the magnetic field inside a current carrying solenoid?
- 37.** Name the effect of current upon which electromagnets are based?
- 38.** Are electromagnets permanent magnets?
- 39.** Name the material used for making the core of an electromagnet.

**40.** Can we use steel, instead of soft iron, for making the core of an electromagnet?

Why?

**41.** Can we change the polarity of a permanent magnet?

**42.** Can we change the polarity of an electromagnet?

**43.** Is the strength of an electromagnet always constant?

**44.** Name the rule applied to know direction of the force acting on a current carrying conductor when placed in a magnetic field.

**45.** Name the transformations of energies takes place in an electric motor.

**46.** Name the two kinds of motors.

**47.** Which kind of motor is used in a fan?

**48.** Which kind of motor used in a battery-operated toy?

**49.** Name the experiment which formed the basis of an electric motor.

**50.** What forms the commutator of an electric motor?

**51.** State quantitatively, the effect of inserting an iron core into a current carrying solenoid.

**52.** Name the types of electromagnets commonly used.

**53.** What happens to the strength of an electromagnet when the magnitude of current decreases?

**54.** What will you prefer, soft iron or steel to make an electromagnet?

**55.** Can we produce electricity from magnetism?

**56.** Name the phenomenon in which an electric current could be produced in a circuit by changing the magnetic field.

**57.** What do you mean by electromagnetic induction?

**58.** What is e.m.i. or E.M.I.?

**59.** What do you understand by electric motor effect?

**60.** What is the cause of electromagnetic induction?

- 61.** Does the AC generator have any slip ring?
- 62.** Does the DC generator have two slip rings?
- 63.** What is the frequency DC?
- 64.** Name the fuel used by nuclear power station.
- 65.** Name the device which converts electrical energy into kinetic energy.
- 66.** What is the SI unit of induced emf?
- 67.** State two factors on which the strength of induced current depends.
- 68.** What is the SI unit of induced current?
- 69.** What is electromagnetic induction?
- 70.** What do you mean by a solenoid?

**SHORT ANSWER TYPE – I QUESTIONS (2 MARKS)**

- 1.** Draw a labeled diagram of an electric motor.
- 2.** State and explain Fleming's right hand rule for the direction of induced current.
- 3.** What do you mean by DC? Show by a diagram.
- 4.** What do you mean by AC? Show by a diagram.
- 5.** Draw a labeled to show the magnetic field pattern due to a straight wire carrying current.
- 6.** With the help of a diagram, indicate the direction of magnetic field produced by a current carrying conductor. Name the rule employed and state it.
- 7.** With the help of a diagram, indicate the direction of magnetic field produced due to a circular wire carrying current.
- 8.** Indicate the direction of the magnetic field produced in a solenoid when some current is passed through it.
- 9.** How can we increase the strength of magnetic field produced by a circular coil carrying conductor?

10. What are the factors on which the strength of magnetic field produced by a current carrying solenoid depends?
11. List the factors affecting the strength of an electromagnet.
12. Show that magnetic lines of force due to a bar magnet.

#### **SHORT ANSWER TYPE – II QUESTIONS (3 MARKS)**

1. Briefly describe Oersted's experiment to demonstrate the magnetic effect of current.
2. What are magnetic field lines? Give their important properties.
3. How will you experimentally show the magnetic field produced by a straight current carrying conductor? Also state Maxwell's right hand grip rule.
4. What kind of magnetic field is produced by a current carrying circular coil? Show it with the help of a labeled diagram.
5. What do you mean by a solenoid? With the help of a labeled, show the magnetic field due to a current carrying solenoid.
6. What do you mean by an electromagnet? With the help of diagram show the two types of electromagnets. Give two uses of electromagnets.
7. How does AC differ from DC? What are the advantages and disadvantages of AC over DC?
8. What is the basic difference between an AC generator and a DC generator?
9. Briefly explain the phenomenon of earthing using examples.
10. Describe the salient features of tree system of wiring.

#### **LONG ANSWER TYPE QUESTIONS (5 MARKS)**

1. Why does a magnetic compass needle pointing North and South in the absence of a nearby magnet get deflected when a bar magnet or a current carrying loop is brought near it. Describe some salient features of magnetic lines if field concept.

2. With the help of a labeled circuit diagram, illustrate the pattern of field lines of the magnetic field around a current carrying straight long conducting wire. How is the right hand thumb rule useful to find the direction of magnetic field associated with a current carrying conductor?
  3. Explain with the help of a labeled diagram the distribution of magnetic field due to a current through a circular loop. Why is it that if a current carrying coil has 'n' turn, the field produced at any point is n times as large as that produced by a single turn?
  4. (a) State the factors on which the strength of an electromagnet depends. (b) How does an electromagnet differ from a bar magnet or permanent magnet?
  5. How will you experimentally show that a current carrying conductor experiences a force when kept in a magnetic field?
  6. What is the principle of an electric motor? Briefly explain the construction and working of an electric motor using a labeled diagram. State the factors on which the strength of a motor depends.
  7. What is meant by electromagnetic induction? How will you demonstrate this phenomenon with the help of an experiment? State the factors on which the strength of the induced current depends.
  8. Briefly describe the principle, construction and working of an AC generator or dynamo.
  9. (a) How are electrical installations carried out in a house? (b) What is the main function of electric fuse? Briefly explain it.
  10. What safety measures do you employ in the use of electricity?
- .....

## **CHAPTER – 14** **SOURCES OF ENERGY**

**ENERGY:** - Whenever a body is capable of doing work, the body is said to possess energy. Thus energy is defined as the ability of a body to do work and the amount of energy possessed by a body is equal to the amount of work it can do when its energy is released.

Energy comes in different forms and one form can be converted to another. For example, if we drop a plate from a height, the potential energy of the plate is converted mostly to sound energy when it hits the ground.

**Units of energy:** - On S.I. system, energy is measured in the units of joules or in calories, and on C.G.S. system in ergs. However, the commercial unit of energy is kilowatt-hour. The energy is said to be one kilowatt-hour, when a body consumes one kilowatt of energy in one hour.

**Sources of energy :** a source of energy is that which is capable of providing enough useful energy at a steady rate over a long period of time.

A good source of energy should be :

- i) Safe and convenient to use, e.g., nuclear energy can be used only by highly trained engineers with the help of nuclear power plants. It cannot be used for our household purposes.
- ii) Easy to transport, e.g., coal, petrol, diesel, LPG etc. Have to be transported from the places of their production to the consumers.
- iii) Easy to store, e.g., huge storage tanks are required to store petrol, diesel, LPG etc.

**Characteristics of an ideal or a good fuel:**

- It should have a high calorific or a heat value, so that it can produce maximum energy by low fuel consumption.
- It should have a proper ignition temperature, so that it can burn easily.
- It should not produce harmful gases during combustion.
- It should be cheap in cost and easily available in plenty for everyone.
- It should be easily and convenient to handle
- e, store and transport from one place to another.
- It should not be valuable to any other purpose than as a fuel.
- It should burn smoothly and should not leave much residue after its combustion.

### **INTEXT QUESTIONS PAGE NO. 243**

**1. What is a good source of energy?**

**Ans.** A good source of energy fulfills the following criteria:

- It produces a lot of heat per unit mass.
- It does a huge amount of work per unit mass.
- It is easily accessible.
- It is easy to store and transport.
- It is economical.
- It produces less amount of smoke.

**2. What is a good fuel?**

**Ans.** A good fuel produces a huge amount of heat on burning, does not produce a lot of smoke, and is easily available.

3. If you could use any source of energy for heating your food, which one would you use and why?

**Ans.** Natural gas can be used for heating and cooking food because it is a clean source of energy. It does not produce huge amount of smoke on burning. Although it is highly inflammable, it is easy to use, transport, and it produces a huge amount of heat on burning.

### **CLASSIFICATION OF SOURCES ENERGY :**

The sources of energy can be classified as follows :

- (i) Renewable
- (ii) Non-Renewable.

#### **1. Renewable sources of energy :-**

Renewable sources of energy are those which are inexhaustible, i.e., which can be replaced as we use them and can be used to produce energy again and again. These are available in an unlimited amount in nature and develop within a relatively short period of time.

#### **Examples of Renewable Sources of Energy.**

- (i) Solar energy, (ii) Wind Energy, (iii) water energy (hydro-energy), (iv) geothermal energy,
- (v) ocean energy, (vi) biomass energy (firewood, animal dung and biodegradable waste from cities and crop residues constitute biomass).

#### **Advantages of Renewable Sources of Energy :**

- (i) These sources will last as long as the Earth receives light from the sun.
- (ii) These sources are freely available in nature.
- (iii) These sources do not cause any pollution.

#### **2. Non-Renewable Sources of Energy :**

Non-renewable sources of energy are those which are exhaustible and cannot be replaced once they have been used. These sources have been accumulated in nature over a very long period of million of years.

#### **Examples of Non-renewable sources of Energy :**

- (i) Coal (ii) Oil and (iii) Natural gas.
- All these fuels are called fossil fuels.

#### **Disadvantages of Non-renewable sources of Energy :**

- (i) Due to their extensive use, these sources are fast depleting.
- (ii) It is difficult to discover and exploit new deposits of these sources.
- (iii) These sources are a major cause of environmental pollution.

### **CONVENTIONAL AND NON-CONVENTIONAL SOURCES OF ENERGY :**

Sources of energy are also classified as :

- (i) Conventional sources of energy
- (ii) Nonconventional sources of energy.

## CONVENTIONAL SOURCES OF ENERGY

### FOSSIL FUELS

Fossil fuels are the remains of prehistoric plants and animals which got buried deep inside the early millions of years ago due to some natural processes.

The energy of fossil fuels is in fact, that solar energy which was trapped by natural processes a very long time ago. Coal, petroleum and natural gas are fossil fuels.

**Formation of Fossil Fuels:** During its formation, an entire organism or its parts often get buried in sand or mud. These, then decay and disintegrate leaving no signs of their existence. Infact, the harder parts of organisms after their death, settle down and are covered by sediments and subjected to extreme pressure and temperature of the earth converts them into fossil fuels, the process being referred to as fossilization.

### Disadvantages of Fossil Fuels:

1. The fossil fuels are non-renewable sources of energy and once used cannot be renewed.
2. Burning of fossil fuels causes air pollution.
3. The fossil fuels reserves in the earth are limited and may get exhausted soon.

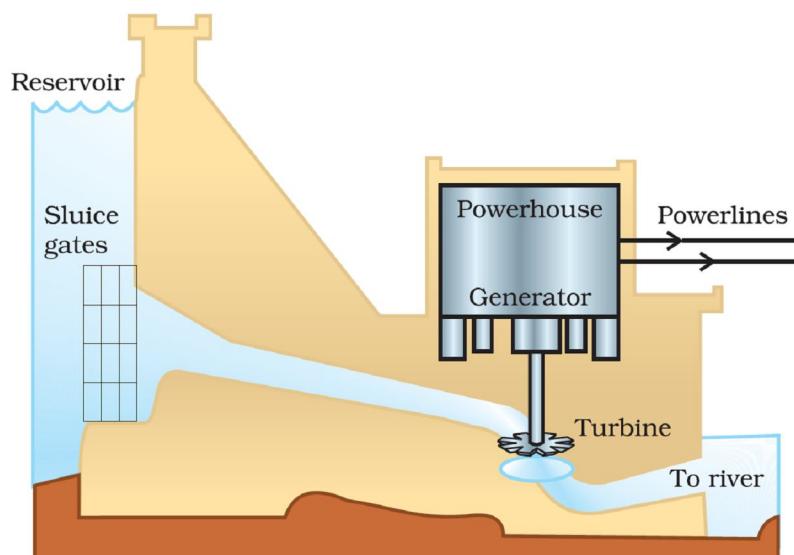
### THERMAL POWER PLANT

The term thermal power plant is used since fuel is burnt to produce heat energy which is converted into electrical energy.

Large amount of fossil fuels are burnt every day in power stations to heat up water to produce steam which further runs the turbine to generate electricity. The transmission of electricity is more efficient than transporting coal or petroleum over the same distance. Therefore, many thermal power plants are set up near coal or oil fields.

### HYDRO POWER PLANTS

Hydro power plants convert the potential energy of falling water into electricity. Since there are very few water-falls which could be used as a source of potential energy, hydro power plants are associated with dams.



In order to produce hydel electricity, high-rise dams are constructed on the river to obstruct the flow of water and thereby collect water in larger reservoirs. The water level rises and in this process the kinetic energy of flowing water gets transformed into potential energy. The water from the high level in the dam is carried through

pipes, to the turbine, at the bottom of the dam (see the above Fig.). Since the water in the reservoir would be refilled each time it rains (hydro power is a renewable source of energy) we would not have to worry about hydroelectricity sources getting used up the way fossil fuels would get finished one day.

**Advantages of generating hydro electricity :-** The main advantages of using water energy for the generation of hydro electricity are listed as under :

1. It is readily and abundantly available everywhere free of cost.
2. It is eco-friendly and does not produce any kind of environmental pollution.
3. It is a renewable source as water itself is a renewable and inexhaustible resource.
4. It is a cheap source of energy, as it does not involve any costly investment.

## **BIO-MASS**

Biomass is defined as living matter or its residue and is a renewable sources of energy.

The biomass includes (i) all the new plant growth (ii) agricultural and forest residues (like biogases, bark, saw dust, wood shavings, roots, animal droppings etc.) (iii) Carbonaceous wastes (like sewage, garbage, night-soil, etc.) (iv) Biodegradable organic affluent from industries.

**Biogas:-** Biogas is a mixture of gases produced by anaerobic degradation of biomass in the presence of water but in the absence of oxygen. It is a renewable source of energy on account of its production from vastly and continuously available organic wastes.

### **Advantages of Biogas:-**

- i) A biogas plant, being quite simple, can easily be built in rural areas. A small plant using dung from 3 to 4 heads of cattle is capable of supplying biogas for 6 hours daily for cooking purposes.
- ii) Biogas is a clean fuel that burns without smoke and leaves no ash.
- iii) The main constituent of biogas, i.e., ethane has a higher calorific value (55kj/g) than that of petrol (50kj/g).
- iv) The spent slurry, being rich in nitrogen and phosphorus, is good manure.
- v) By using biogas, firewood is saved and deforestation is reduced.

**Composition of Biogas:-** Biogas is mainly composed methane (up to 75%), CO<sub>2</sub> (25%) and traces of other gases such as nitrogen and hydrogen. Whereas methane is a high value calorific fuel, carbon dioxide is an inert gas.

Biogas is prepared in biogas plants which are of two types: (i) Fixed Dome Type (ii) Floating Gas Holder Type.

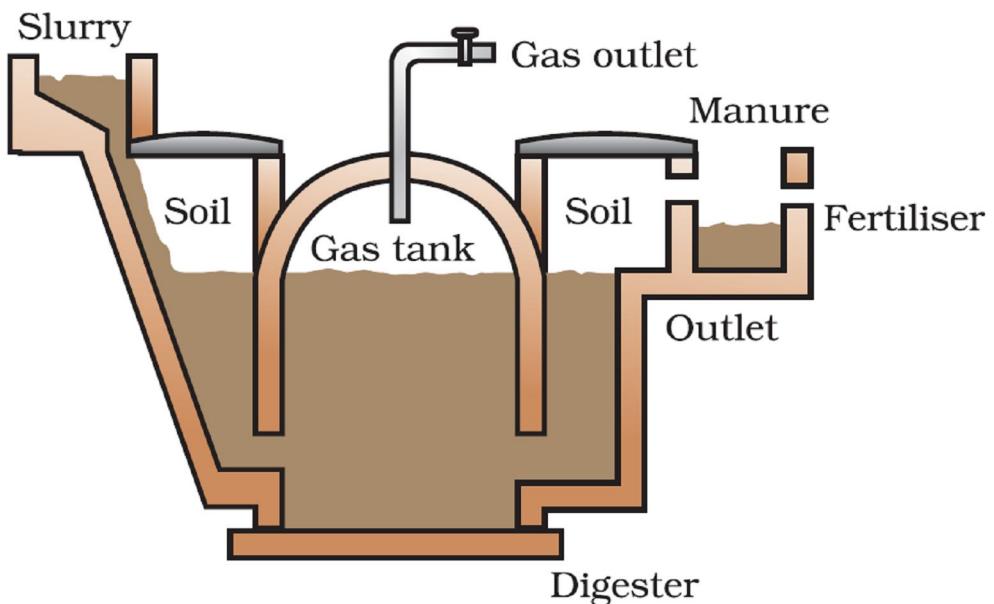
### **Fixed Dome Type Biogas Plant:-**

The main parts of fixed dome type of biogas plants are:

1. Digester. It is well shaped underground tank made of bricks. Its roof is some-shaped which acts as a storage tank for biogas.
2. Mixing tank. It is constructed on the ground level where cattle dung and water are mixed.
3. Inlet tank. It is constructed underground below the mixing tank.
4. Overflow tank. It is constructed slightly below the level of mixing tank.
5. Outlet tank. It is constructed below the overflow tank.

### **Working of Biogas Plant:-**

Cattle dung and water are mixed in equal proportion in the mixing tank to form slurry. This slurry is fed into the digester tank through inlet tank when the digester tank is filled about 2/3rd of its capacity, the dome is left free for collection of biogas. The slurry undergoes anaerobic fermentation and biogas is produced after 50 to 60 days. As biogas is collected in the dome it exerts pressure due to which spent slurry go to the overflow tank through outlet tank and fresh slurry is fed into the digester and continuous supply of biogas is obtained spent slurry is used as manure.



### **WIND ENERGY**

**Wind Energy:** -When large masses of air move from one place to another it is referred to as wind. During this process kinetic energy gets associated with it which is referred to as wind energy.

#### **Principle of utilisation of wind energy: -**

Wind energy is efficiently converted into electrical energy with the aid of a windmill. A windmill is a large fan having big blades, which rotate by the force exerted by moving wind on them. These blades remain continuously rotating as long as wind is blowing and can be used to drive a large number of machines like water pumps, flour mills etc. But these days a windmill is used to generate electric current which is used for various purposes and therefore wind power stations are established all over the world which convert wind energy directly into electrical energy.

#### **Uses of wind energy: -**

The important uses of wind energy are;

1. It is used to drive windmills, water lifting pumps and flour mills etc.
2. It is used to propel sail boats.
3. It is used to fly engine less aeroplanes or gliders in the air.
4. It is used to generate electricity used for various purposes like lightening, heating etc.



### **Advantages of generating wind energy: -**

The chief advantages of using wind energy are;

1. It is readily and abundantly available at every place of the earth free of cost.
2. It is eco-friendly and does not produce any kind of environmental pollution.
3. It is a renewable source as air itself is a renewable and inexhaustible resource.
4. It is a cheap source of energy, as it does not involve any costly investment.

### **INTEXT QUESTIONS PAGE NO. 248**

1. What are the disadvantages of fossil fuels?

**Ans.** The disadvantages of fossil fuels are as follows:

- (a) Burning of coal and petroleum produces a lot of pollutants causing air pollution.
- (b) Fossil fuels release oxides of carbon, nitrogen, sulphur, etc. that cause acid rain, which affects the soil fertility and potable water.
- (c) Burning of fossil fuels produce gases such as carbon dioxide that causes global warming.

2. Why are we looking at alternate sources of energy?

**Ans.** Fossil fuels, which have been traditionally used by human beings as an energy sources, are non-renewable sources of energy. These sources of energy are limited and cannot replenish on their own. They are being consumed at a large rate. If this rate of consumption continues, then the fossil fuels would be exhausted from the Earth. Therefore, we have to conserve the energy sources. Hence, we should look for alternate sources of energy.

How has the traditional use of wind and water energy been modified for our convenience?

Traditionally, waterfalls were used as a source of potential energy which was converted to electricity with the help of turbines. Since waterfalls are few in number, water dams have been constructed in large numbers. Nowadays, hydro-dams are used in order to harness potential energy of stored water. In water dams, water falls from a height on the turbine, which produces electricity.

Earlier, the windmills were used to harness wind energy to do mechanical work such as lifting/drawing water from a well. Today, windmills are used to generate electricity. In windmills, the kinetic energy of wind is harnessed and converted into electricity. The rotatory motion of the blades turns the turbine of the electric generator to generate electricity.

### **ALTERNATIVE OR NON-CONVENTIONAL SOURCES OF ENERGY**

**Non-conventional sources of energy :** Non-conventional source of energy are those which are not used as extensively as the conventional ones and meet our energy requirement only on a limited scale. Solar energy, ocean energy (tidal energy, wave energy, ocean thermal energy, OTE), Geothermal energy and nuclear energy belong to this category. These sources of energy which have been tapped with the aid of advances in technology to meet our growing energy needs are also called alternative sources of energy.

### **SOLAR ENERGY**

The energy produced by the sun in the form of heat and light energy is called as solar energy.

**Principles of utilisation of Solar Energy:** - Solar energy is utilised by the involvement of two main principles:

(i). In the appliances requiring a moderate temperature, the incident sun rays are reflected by a plain mirror on a black container which absorbs the solar energy and gets heated .

(ii). In the appliances requiring a high temperature, the incident sun rays are reflected and concentrated by using a large concave reflector which focuses all the sun rays at a single point called focus and any object kept at the focus gets strongly heated.

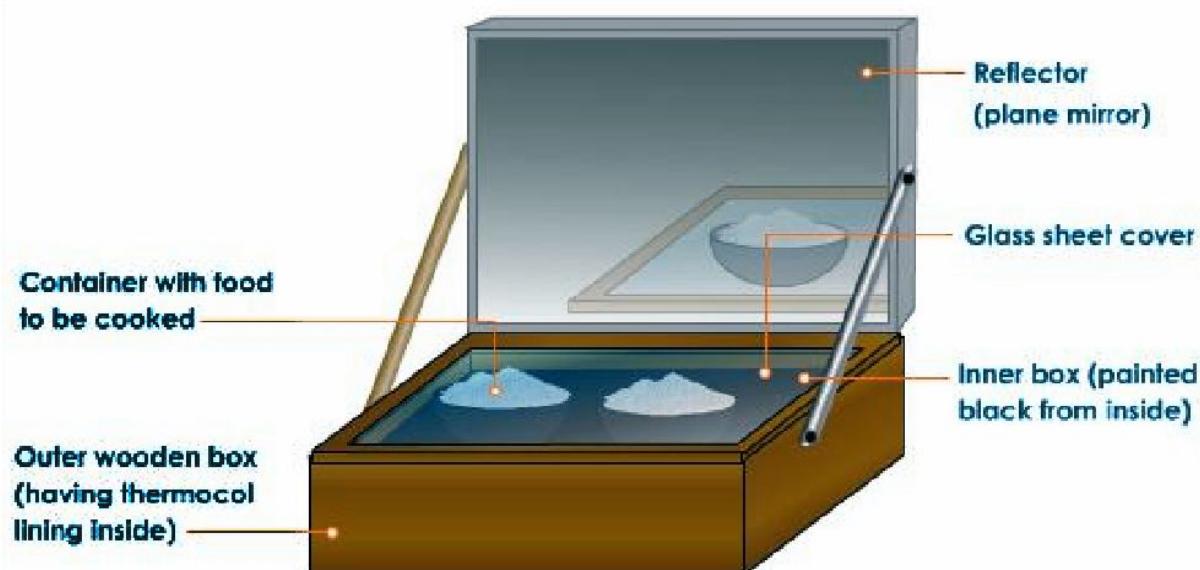
**Harnessing or utilisation of Solar energy:-** The sun is the ultimate source of energy having a remarkable capacity to produce energy in the form of heat and light. The energy produced by the sun in one day is about 50,000 times more than the energy consumed in the whole world in one year. But solar energy has certain limitations, which does not facilitate its large-scale utilisation. However, solar energy can be put to use in two differ ways Viz.

**1) Direct utilization:** - Directly the solar energy can be used either by collecting it as heat energy or by converting it into electricity.

**2) Indirect utilization:** - Indirectly the solar energy can be utilized by converting it into chemical energy like biomass or by utilising the energy obtained from wind, sea waves, tides etc.

**Solar Heating Devices:** - A device that gets heated by absorbing solar energy radiated by the sun in the form of heat and light energy is called a solar heating device. For eg. Solar cooker, solar water heater, solar furnace and solar cells are solar heating devices.

**Solar cooker:** - A solar cooker is a device which utilises solar energy for cooking food material. It consists of an insulated wooden box (B) painted with black from inner side. The lid of the box is provided with a plane mirror reflector (R) and a glass sheet (G). The food to be cooked is placed in a metal container (C) painted with black from outer side and kept in the box .The container is covered with the glass sheet. The box is then kept in direct sunlight and its reflector is adjusted in such away that a strong beam of sun light falls over it.



**Working:** - When the solar cooker is kept in direct sunlight, the reflector (R) reflects both visible and infrared rays of the sunlight on to the top of the box in the form of a strong beam of light. The black surface of the box and the vessel absorbs it. When the inner black surface becomes quite hot, it also starts radiating heat energy in the form of infrared rays, but the upper glass sheet (G) does not allow these rays to pass through it and go outside the box. As a result, these infrared rays get absorbed in the box, which increases its internal temperature up to about 1000C. This high temperature cooks the food material kept in the metallic container inside the box.

#### **Limitations of solar Cooker:-**

1. It can not be used during night.
2. On a cloudy day, it can not be used.
3. The direction of the reflector has to be adjusted according to the position of the sun.
4. It can not be used for making 'chappatis'.
5. It can not be used for frying.

**Solar cell:** - A solar cell is a device which converts solar energy (light energy) directly into electricity. It is made of semi-conducting material like silicon, germanium, selenium or gallium. A modern solar cell is made from wafers of semi conducting materials containing impurities in such away that a potential difference gets generated when light falls on them. A 4 cm<sup>2</sup> solar cells produces a potential difference of about 0.4--0.5volts and generate about 60 milli-amperes of current. To generate a large amount of current a number of solar cells are arranged together in a definite pattern in a solar panel. The energy (electric current) generated in a solar panel is stored in a battery connected to it and can be used for various purposes.

**Uses of a solar cell:** - The solar cells are used effectively in various fields, but some of its important uses are:

Solar cells are used for production of electricity for lighting, houses, streets etc. Solar cells are used for production of electricity to run electronic appliances like televisions, radios, watches, calculators, toys, toy games etc. Solar cells are used to develop electricity for offshore oil drilling platforms etc. Solar cells are used to generate electricity in artificial satellites, rockets, and space vehicles etc.

## **ENERGY FROM THE SEA**

**Energy from Oceans :** - The oceans acquire almost 71% of the surface of the earth and the enormous amount of water present in them not only act as a big collector of solar heat energy, but also store large amount of it due to its high specific heat. Thus ocean water can be used as a renewable resource of energy. The main forms of ocean energy are described as under;

**i) Ocean Thermal energy :** - The energy available due to the temperature difference between the deeper levels and surface of an ocean is called as ocean thermal energy.

**ii) Ocean Tidal energy :** - The rise of ocean water due to attraction of the moon is referred to as high tide and its fall as low tide. The enormous movement of water due to high and low tide provide a large amount of energy known as ocean tidal energy. This tidal energy can be utilised by constructing a tidal barrage or dam.

**iii) Sea wave energy:** - The energy obtained from the high speed sea waves is referred to as sea wave energy. Infact these high speed sea waves have a lot of kinetic energy associated with them, which can be used to drive dynamos which convert kinetic energy into electrical energy.

**iv) Energy from Nuclear deuterium of oceans:** - The ocean water contains unlimited amount of heavy hydrogen isotope called deuterium which is isotope hydrogen having one proton and one neutron in its nucleus. Scientists are working hard to produce energy by carrying out controlled nuclear fission of deuterium isotope. The process is still in its experimental stage.

**v) Energy from Salinity gradient in seas:** - The difference in the concentration of salts in the water of the two or more seas is called as salinity gradient. This salinity gradient is now a day used to obtain energy with the involvement of suitable techniques.

**vi) Energy from sea vegetation or biomass:** - Sea vegetation or biomass is another direct source of energy because the enormous amount of sea weeds present in the sea water provides an endless supply of methane fuel.

#### **Limitations of Energy from Oceans :-**

The limitations of energy that can be obtained from the oceans are:

- i) Tidal Energy for which very few suitable sites are available for construction of dams and the power generation is intermittent and not very large.
- ii) Wave Energy where power output is variable and the presently available technologies are very expensive.
- iii) Ocean Thermal Energy where the conversion efficiency is low (3% - 4%) and a lot of capital investment is required.

## **GEOTHERMAL ENERGY**

Geothermal energy is the heat of the earth and is the naturally occurring thermal energy found within rock formations and the fluids held within those formations.

Geothermal energy is one of those few sources of energy that do not come directly or indirectly from the solar energy.

The underground hot water in contact with hot spots changes into steam. As the steam is trapped between the rocks, it gets compressed to high pressure. At some places, hot water and steam gush out from the Earth's surface after making their way through large cracks between the rocks and form natural geysers. Geothermal energy carried by natural geysers is utilized for generating electricity.

#### **Merits if geothermal Energy:-**

1. Geothermal energy is the most versatile and least polluting renewable source of energy.
2. It can be harnessed for 24 hours throughout the year.
3. Geothermal energy is relatively inexpensive.
4. As compared to solar energy and wind energy, the power generation level of geothermal energy is higher.
5. Geothermal energy can be used for power generation as well as direct heating. In USA, water is pumped from underground hot water deposits and is used to heat houses.

#### **Limitations of Geothermal Energy:**

1. Geothermal hot spots are scattered and usually some distance away from the areas that need energy.

2. The overall power production has a lower efficiency (about 15%) as compared to that of fossil fuels (35% to 40%).
3. Though as a whole, geothermal energy is inexhaustible, a single by ore has a limited life span of about 10 years.
4. Noise pollution is caused by drilling operations at geothermal sites.

## NUCLEAR ENERGY

**A reaction in which the nucleus of an atom undergoes a change to form a new atom and releases an enormous amount of energy is called as nuclear energy. There are two distinct ways of obtaining nuclear energy. a) Nuclear fission b) Nuclear fusion.**

### Nuclear Fission reaction:

This type of nuclear reaction was first of all reported by Otto Hahn in 1938. He stated that when an unstable heavy nucleus is bombarded with slow speed thermal neutrons, it splits into two small stable nuclei liberates an enormous amount of heat and light energy.

### Nuclear Fusion reaction:

This type of nuclear reaction was first of all reported by Hans Bethe in 1939. The word ‘fusion’ means ‘to combine together’. So, nuclear fusion means combining together of two or more nuclei to form a single nucleus. Thus, a process in which two lighter nuclei fuse (combine) together to form a stable heavier nucleus with a simultaneous release of a very large amount of energy is called nuclear fusion. The energy produced in a fusion reaction is much higher than that produced in a nuclear fission reaction.

### Advantages of Nuclear Energy:-

The advantages of nuclear energy are that:

1. It produces a large amount of useful energy from a very small amount of a nuclear fuel (like uranium-235).
2. Once the nuclear fuel (like uranium-235) is loaded into the reactor, the nuclear power plant can go on producing electricity for two to three years at a stretch. There is no need for putting in nuclear fuel again and again.
3. It does not produce gases like carbon dioxide which contributes to greenhouse effect or sulphur dioxide which causes acid rain.

### Disadvantages of Nuclear Energy :-

1. The major hazard of nuclear power generation is the storage and disposal of spent or used fuels – the uranium still decaying into harmful subatomic particles (radiations).
2. Improper nuclear-waste storage and disposal result in environmental contamination.
3. **There is a risk of accidental leakage of nuclear radiation.**
4. The high cost of installation of a nuclear power plant, high risk of environmental contamination and limited availability of uranium makes large-scale use of nuclear energy prohibitive

## INTEXT QUESTIONS PAGE NO. 253

1. What kind of mirror – concave, convex or plain – would be best suited for use in a solar cooker? Why?

**Ans.** A solar cooker uses heat of the sunlight to cook and heat food. A mirror is used in order to reflect and focus sunlight at a point. A concave mirror is used in a solar cooker for this purpose. The mirror focuses all the incident sunlight at a point. The temperature at that point increases, thereby cooking and heating the food placed at that point.

**2.** What are the limitations of the energy that can be obtained from the oceans?

**Ans.** The forms of energy that can be obtained from the ocean are tidal energy, wave energy, and ocean thermal energy. There are several limitations in order to harness these energies.

(i) Tidal energy depends on the relative positioning of the Earth, moon, and the Sun.

(ii) High dams are required to be built to convert tidal energy into electricity.

(iii) Very strong waves are required to obtain electricity from wave energy.

(iv) To harness ocean thermal energy efficiently, the difference in the temperature of surface water (hot) and the water at depth (cold) must be 20°C or more.

**3.** What is geothermal energy?

**Ans.** Geothermal power plants use heat of the Earth to generate electricity. This heat energy of the Earth is known as geothermal energy.

When there are geological changes, the molten rocks present in the core of the earth are pushed to the earth's crust. This forms regions of hot spot. Steam is generated when the underground water comes in contact with these hot spots forming hot springs. This trapped steam is used to generate electricity in the geothermal power plants.

**4.** What are the advantages of nuclear energy?

**Ans.** The advantages of nuclear energy are as follows:

(a) Large amount of energy is produced per unit mass.

(b) It does not produce smoke. It is a clean energy.

(c) Fission of one atom of uranium produces 10 million times the energy released by burning of one atom of carbon.

(d) Fusion of four hydrogen atoms produces huge amount of energy approximately equal to 27 MeV.

### **ENVIRONMENTAL CONSEQUENCES**

1. The combustion for fossil fuels is producing acid rain and damaging plants (crops), soil and aquatic life.
2. The burning of fossil fuels is increasing the amount of greenhouse gas carbon dioxide in the atmosphere.
3. The cutting down of trees from the forest (deforestation) for obtaining fire-wood is causing soil erosion and destroying wild life.
4. The construction of hydro-power plants is disturbing ecological balance.
5. Nuclear power plants are increasing radioactivity in the environment.

### **INTEXT QUESTIONS PAGE NO. 253**

**1.** Can any source of energy be pollution-free? Why or why not?

**Ans.** No source of energy can be pollution-free. It is considered that solar cells are pollution-free. However, even their making causes environmental damage indirectly.

Also, in the case of nuclear energy, there is no waste produced after the fusion reactions. However, it is not totally pollution-free. To start the fusion reactions, approximately  $10^7$  K temperature is required, which is provided by fission reactions. The wastes released from fission reactions are very hazardous. Hence, no source of energy is pollution-free.

2. Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?

**Ans.** Hydrogen is cleaner than CNG. CNG contains hydrocarbons. Therefore, it has carbon contents. Carbon is a form of pollutant present in CNG. On the other hand, hydrogen is waste-free. The fusion of hydrogen does not produce any waste. Hence, hydrogen is cleaner than CNG.

### INTEXT QUESTIONS PAGE NO. 254

1. Name two energy sources that you would consider to be renewable. Give reasons for your choices.

**Ans.** Two renewable sources of energy are as follows:

(a) Sun: The energy derived from the Sun is known as solar energy. Solar energy is produced by the fusion of hydrogen into helium, fusion of helium into other heavy elements, and so on. A large amount of hydrogen and helium is present in the Sun. Therefore, solar energy can replenish on its own. The Sun has 5 billion years more to burn. Hence, solar energy is a renewable source of energy.

(b) Wind: Wind energy is derived from air blowing with high speed. Wind energy is harnessed by windmills in order to generate electricity. Air blows because of uneven heating of the Earth. Since the heating of the Earth will continue forever, wind energy will also be available forever.

2. Give the names of two energy sources that you would consider to be exhaustible. Give reasons for your choices.

**Ans.** Two exhaustible energy sources are as follows:

(a) Coal: It is produced from dead remains of plants and animals that remain buried under the earth's crust for millions of years. It takes millions of years to produce coal. Industrialization has increased the demand of coal. However, coal cannot replenish within a short period of time. Hence, it is a non-renewable or exhaustible source of energy.

(b) Wood: It is obtained from forests. Deforestation at a faster rate has caused a reduction in the number of forests on the Earth. It takes hundreds of years to grow a forest. If deforestation is continued at this rate, then there would be no wood left on the Earth. Hence, wood is an exhaustible source of energy.

### EXERCISE QUESTIONS PAGE NO. 254

1. A solar water heater cannot be used to get hot water on

(a) a sunny day    (b) a cloudy day    (c) a hot day    (d) a windy day

**Ans.** (b) A solar water heater uses solar energy to heat water. It requires bright and intense sunlight to function properly. On a cloudy day, the sunlight reflects back in the sky from the clouds and is unable to reach the ground. Therefore, solar energy is not available for the solar heater to work properly. Hence, solar water heater does not function on a cloudy day.

2. Which of the following is not an example of a bio-mass energy source?

(a) wood    (b) gobar gas    (c) nuclear energy    (d) coal

**Ans.** (c) Bio-mass is a source of energy that is obtained from plant materials and animal wastes. Nuclear energy is released during nuclear fission and fusion. In nuclear fission, uranium atom is bombarded with low-energy neutrons. Hence, uranium atom splits into two relatively lighter nuclei. This reaction produces huge amount of energy. In nuclear fusion reaction, lighter nuclei are fused together to form a relatively heavier nuclei. This reaction produces tremendous amount of energy. Hence, nuclear energy is not an example of bio-mass energy source.

Wood is a plant material, *gobar* gas is formed from animal dung, and coal is a fossil fuel obtained from the buried remains of plants and animals. Hence, these are bio-mass products.

3. Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the Sun's energy?

(a) Geothermal energy  
(b) Wind energy  
(c) Nuclear energy  
(d) Bio-mass

**Ans.** (c) Nuclear energy is released during nuclear fission and fusion. In nuclear fission, uranium atom is bombarded with low-energy neutrons. Hence, uranium atom splits into two relatively lighter nuclei. This reaction produces huge amount of energy. In nuclear fusion reaction, lighter nuclei are fused together to form a relatively heavier nuclei. The energy required to fuse the lighter nuclei is provided by fission reactions. This reaction produces tremendous amount of energy. These reactions can be carried out in the absence or presence of sunlight. There is no effect of sunlight on these reactions. Hence, nuclear energy is not ultimately derived from Sun's energy.

Geothermal energy, wind energy, and bio-mass are all ultimately derived from solar energy. Geothermal energy is stored deep inside the earth's crust in the form of heat energy. The heating is caused by the absorption of atmospheric and oceanic heat. It is the sunlight that heats the atmosphere and oceans.

Wind energy is harnessed from the blowing of winds. The uneven heating of the earth's surface by the Sun causes wind.

Bio-mass is derived from dead plants and animal wastes. Chemical changes occur in these dead plants and animal wastes in the presence of water and sunlight. Hence, bio-mass is indirectly related to sunlight.

4. Compare and contrast fossil fuels and the Sun as direct sources of energy.

**Ans.**

Fossil fuels are energy sources, such as coal and petroleum, obtained from underneath the Earth's crust. They are directly available to human beings for use. Hence, fossil fuels are the direct source of energy. These are limited in amount. These are non-renewable sources of energy because these cannot be replenished in nature. Fossil fuels take millions of years for their formation. If the present fossil fuel of the Earth gets exhausted, its formation will take several years. Fossil fuels are also very costly.

On the other hand, solar energy is a renewable and direct source of energy. The Sun has been shining for several years and will do so for the next five billion years. Solar energy is available free of cost to all in unlimited amount. It replenishes in the Sun itself.

- 5.** Compare and contrast bio-mass and hydro electricity as sources of energy.

**Ans.**

Bio-mass and hydro-electricity both are renewable sources of energy. Bio-mass is derived from dead plants and animal wastes. Hence, it is naturally replenished. It is the result of natural processes. Wood, *gobar* gas, etc. are some of the examples of bio-mass.

Hydro-electricity, on the other hand, is obtained from the potential energy stored in water at a height. Energy from it can be produced again and again. It is harnessed from water and obtained from mechanical processes.

- 6.** What are the limitations of extracting energy from –

(a) the wind? (b) waves? (c) tides?

**Ans.**

(a) Wind energy is harnessed by windmills. One of the limitations of extracting energy from wind is that a windmill requires wind of speed more than 15 km/h to generate electricity. Also, a large number of windmills are required, which covers a huge area.

(b) Very strong ocean waves are required in order to extract energy from waves.

(c) Very high tides are required in order to extract energy from tides. Also, occurrence of tides depends on the relative positions of the Sun, moon, and the Earth.

- 7.** On what basis would you classify energy sources as

(a) renewable and non-renewable?

(b) exhaustible and inexhaustible?

Are the options given in (a) and (b) the same?

**Ans.**

(a) The source of energy that replenishes in nature is known as renewable source of energy. Sun, wind, moving water, bio-mass, etc. are some of the examples of renewable sources of energy.

The source of energy that does not replenish in nature is known as non-renewable source of energy. Coal, petroleum, natural gas, etc. are some of the examples of non-renewable sources of energy.

(b) Exhaustible sources are those sources of energy, which will deplete and exhaust after a few hundred years. Coal, petroleum, etc. are the exhaustible sources of energy.

Inexhaustible resources of energy are those sources, which will not exhaust in future. These are unlimited. Bio-mass is one of the inexhaustible sources of energy.

Yes. The options given in (a) and (b) are the same.

- 8.** What are the qualities of an ideal source of energy?

**Ans.**

An ideal source of energy must be:

- (i) Economical
- (ii) Easily accessible
- (iii) Smoke/pollution free
- (iv) Easy to store and transport
- (v) Able to produce huge amount of heat and energy on burning

- 9.** What are the advantages and disadvantages of using a solar cooker? Are there places where solar cookers would have limited utility?

**Ans.**

Solar cooker uses Sun's energy to heat and cook food. It is inexhaustible and clean renewable source of energy. It is free for all and available in unlimited amount. Hence, operating a solar cooker is not expensive.

Disadvantage of a solar cooker is that it is very expensive. It does not work without sunlight. Hence, on cloudy day, it becomes useless.

The places where the days are too short or places with cloud covers round the year, have limited utility for solar cooker.

- 10.** What are the environmental consequences of the increasing demand for energy?  
What steps would you suggest to reduce energy consumption?

**Ans.**

Industrialization increases the demand for energy. Fossil fuels are easily accessible sources of energy that fulfil this demand. The increased use of fossil fuels has a harsh effect on the environment. Too much exploitation of fossil fuels increases the level of green house gas content in the atmosphere, resulting in global warming and a rise in the sea level.

It is not possible to completely reduce the consumption of fossil fuels. However, some measures can be taken such as using electrical appliances wisely and not wasting electricity. Unnecessary usage of water should be avoided. Public transport system with mass transit must be adopted on a large scale. These small steps may help in reducing the consumption of natural resources and conserving them.

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## **ASSIGNMENT QUESTIONS FOR PRACTICE** **SOURCES OF ENERGY**

### **VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)**

1. Define energy.
2. What is good source of energy?
3. What is good fuel?
4. Name the physical quantity associated with the capacity to perform work.
5. Write the two forms of mechanical energy.
6. Define kinetic energy of a body.
7. Define potential energy of a body.
8. Write the formula for kinetic and potential energies.
9. What is the common name for radiant energy?
10. State four different forms of energy?
11. Do kinetic energy and potential energy have the same units?
12. Which form of energy is associated with the deflating of a balloon?
13. Name a source of radiant energy.
14. Name the natural and man made sources of radiant energy.
15. What is the chemical energy? Is it a form of potential energy?
16. What do you mean by a muscular energy?
17. Name the form of energy that gives us warmth.
18. What type of energy that gives us while climbing a staircase?
19. A torch cell converts one form of energy into another form. Name these two forms of energy.
20. Which form of energy is stored in a compressed spring?

- 21.** Give an example where potential energy is acquired by a body due to a change in its shape.
  - 22.** Why do you feel exhausted after doing laborious work?
  - 23.** Name the form of energy that man has been using over the ages. How does he get this energy?
  - 24.** What is wind? Does it possess energy?
  - 25.** What is the source of energy in the sun?
  - 26.** Does wind possess kinetic or potential energy?
  - 27.** What is a windmill?
  - 28.** Mention two uses of windmills.
  - 29.** Can we produce electricity by using a cluster of windmills?
  - 30.** What kind of energy transformation takes place when wind moves a sailboat?
  - 31.** Name one place in India where a wind energy power station has been established.
  - 32.** Does moving water possess energy?
  - 33.** What is a turbine?
  - 34.** What is hydro-electricity generation?
  - 35.** What is a water wheel?
  - 36.** Name the device that converts mechanical energy in the turbine into electrical energy.
  - 37.** What is a dam?
  - 38.** What kind of energy is possessed by water stored in dams?
  - 39.** Name the device that converts the kinetic energy of flowing water into mechanical energy.
  - 40.** In a water wheel, which form of energy is transformed into work?
- 41. What is the name given to moving air?**

- 42.** Why are the inner walls and bottom of the box-type solar cookers painted black?
- 43.** What is the use of glass sheet cover in solar heating device?
- 44.** What is the use of a reflector in the solar heating device?
- 45.** Name the two types of commonly used reflectors in a solar heating device.
- 46.** What is the maximum temperature attainable in case of box type solar cooker?
- 47.** Can we use the box type solar cooker for a quick heating?
- 48.** Out of box-type and spherical reflector type solar cookers, which (i) produces a higher temperature (ii) produces slow heating?
- 49.** What is meant by a solar furnace?
- 50.** What is the order of temperature that can be attained by a solar furnace?
- 51.** Name the device which converts solar energy directly into electricity.
- 52.** When was first practical solar cell made?
- 53.** Which material is used for connecting the solar cells in a solar panel?
- 54.** Name the type of semiconductor used in a modern solar cell.
- 55.** What do you mean by a solar cell panel?
- 56.** State two uses of solar cells.
- 57.** Name the type of cell used for operating electronic watches and calculators.
- 58.** Does wind energy produce environmental pollution?
- 59.** What do wind-energy maps indicate?
- 60.** Name any two wind-energy regions of India.
- 61.** What is the first step in utilizing wind energy on a commercial scale?
- 62.** What do you mean by hydro energy?
- 63.** What is geothermal energy?

- 64.** Is hydro energy a direct or an indirect source of energy?
- 65.** Is water energy a non-renewable source of electric energy?
- 66.** Name the property of water which enables the oceans to act as a storehouse of solar heat energy.
- 67.** Which kind of mirror-concave, convex or plane – would be best suited for use in a solar cooker? Why?
- 68.** What is the full form of OTE?
- 69.** What do you mean by ocean thermal energy?
- 70.** What do you mean by tidal energy?
- 71.** Give one important way of trapping heat inside the solar cooker?
- 72.** Name the most important green house gas in the earth's atmosphere.
- 73.** What should be the temperature difference between surface water and water at depth in an ocean, to tap ocean thermal energy?
- 74.** A student constructed a model of box-type solar cooker. He used a transparent plastic sheet to cover the open face of the box. He found that this cooker does not function well. What modification should he make to enhance its efficiency? Give reason?
- 75.** Can we use a box-type solar cooker for baking and frying?
- 76.** What are the substances used for producing heat known as?
- 77.** Name three important sources of modern fuels.
- 78.** What are propellants?
- 79.** What is the value of solar constant?
- 80.** Name two gaseous fuels.
- 81.** What are processed fuels? Give one example.
- 82.** What is biomass?
- 83.** Name the ultimate source of fossil fuel.

- 84.** What is the composition of coal?
- 85.** Name the places in India where coal is mainly found.
- 86.** Name the coal which has a high carbon content.
- 87.** Why are sources of energy required inspite of law of conservation of energy?
- 88.** Name two acidic oxides released on burning fossil fuels.
- 89.** What is LPG?
- 90.** What is the composition of petroleum gas? Give one of its uses.
- 91.** Why is ethyl hydrogen sulphide added in the LPG cylinders?
- 92.** Give two uses of natural gas.
- 93.** Name two gas pipelines in India which have been installed to supply natural gas to the industries and homes.
- 94.** Name the acidic oxide released by burning fossil fuel which causes green house effect.
- 95.** Which gas is released by anaerobic decomposition of submerged vegetation in dams?
- 96.** Define calorific value of fuel.
- 97.** “The calorific value of cooking gas (LPG) is 50kJ/g”. What does it mean?
- 98.** Define ignition temperature of a fuel.
- 99.** What do you understand by nuclear wastes?
- 100.** Out of alpha, beta and gamma radiations, name the radiations that are most dangerous for human beings?
- 101.** What is the name given to a slow moving neutron?
- 102.** Which type of bomb was used in the second world war in 1945?
- 103.** In case of an atom bomb, is it controlled or uncontrolled chain reaction which takes place during explosion?

- 104.** Name any two non-conventional sources of energy.
- 105.** What are renewable sources of energy?
- 106.** What are non-renewable sources of energy?
- 107.** What is the chemical name of marsh gas?
- 108.** Name the device in which nuclear fusion reaction is controlled and maintained.
- 109.** What is a controlled chain reaction?
- 110.** Which isotope of uranium is used in nuclear fission in nuclear reactors?
- 111.** What is nuclear reactor?
- 112.** Name the fuel used in atomic reactors.
- 113.** What is the importance of cadmium rods in nuclear reactor?
- 114.** What is meant by the critically of a reaction?
- 115.** Name the process that forms the principle of a nuclear (i) atom bomb (ii) hydrogen bomb.
- 116.** Which of the two processes is carried out at a higher temperature: nuclear fission or nuclear fusion?
- 117.** Name the main constituent of biogas?
- 118.** What do you understand by dry distillation of wood?
- 119.** What are fossil fuels?
- 120.** Why are fossil fuels called ‘depletable’ sources of energy?
- 121.** Describe in brief how petroleum is formed inside the earth.
- 122.** Explain why the fuels containing oxygen have a low calorific value?
- 123.** A tremendous amount of energy is released during a nuclear fission reaction.  
Why?
- 124.** What would happen if all the hydrogen present in the sun is converted into helium?

- 125.** It is said that the energy produced from nuclear fusion would create fewer pollution problems than the energy produced by nuclear fission. Explain. Why?

**SHORT ANSWER TYPE – I QUESTIONS (2 MARKS)**

- 1.** What are primary and secondary fuels? Give two examples of each.
- 2.** Why is charcoal considered a better fuel than wood?
- 3.** Coal is said to be formed from the wood of trees. Why then coal considered to be a non-renewable source of energy whereas wood is renewable source of energy?
- 4.** Name all the products obtained by the fractional distillation of petroleum.
- 5.** What is LPG? Give one advantage and one disadvantage of LPG.
- 6.** Why is LPG considered a good fuel?
- 7.** Why is LPG considered a better fuel than coal?
- 8.** Define calorific value of a fuel. Which has a high calorific value: wood or charcoal?
- 9.** Explain why a match stick can light a splinter of wood but not a log of wood?
- 10.** Explain why one can boil water in a paper cup without burning it?
- 11.** What do you mean by transformation of energy? Give some examples.
- 12.** What do you mean by conservation of energy? Briefly explain the statement.
- 13.** How can energy crisis be averted?
- 14.** Write four functions performed by the sun's energy.
- 15.** Give two applications of nuclear fission.
- 16.** What constitutes nuclear reactions? How is the problem of disposal of nuclear waste being tackled at present?
- 17.** State two differences between nuclear reactions and chemical reactions.
- 18.** Mention four uses of wind energy.

19. Write two limitations of wind energy.
20. Write two advantages of wind energy.
21. What is the difference between a thermal power plant and a hydro power plant?
22. Give two advantages of liquid and gaseous fuels over solid fuels.
23. Give two advantages of smokeless chulhas over traditional chulhas.
24. Give four examples of renewable sources of energy.
25. Give four examples of non-renewable sources of energy.

#### **SHORT ANSWER TYPE – II QUESTIONS (3 MARKS)**

1. Define combustion. What are the various conditions required for combustion to take place?
2. What are the various characteristics of an ideal fuel?
3. Give examples to explain the transformation of potential energy into kinetic energy and vice versa.
4. Mention any three harmful effects of nuclear radiation on our body.
5. What is solar constant? What is the value of solar constant? If the energy received by  $5\text{m}^2$  area in 10 minutes is 4200kJ, calculate the value of solar constant.
6. What is a solar cell? Draw the labeled diagram of a solar cell.
7. What is biogas? Name the major component of biogas.
8. What is the origin of biomass energy? Briefly explain it.
9. What are environmental consequences of increasing demand for energy? What steps would you suggest to reduce energy consumption?
10. State two differences between nuclear fission and nuclear fusion. Also give examples. How is the sun able to liberate such a large amount of energy without getting cooled?

### **LONG ANSWER TYPE QUESTIONS (5 MARKS)**

1. What is hydroelectric power? Draw a schematic diagram of a hydroelectric power plant.
  2. What is geothermal energy? What is the source of heat contained in geothermal energy? Explain how geothermal energy is used to generate electricity. State two advantages and disadvantages of geothermal energy.
  3. What is biogas? Describe the construction and working of a biogas plant with the help of a labeled diagram. Write any two uses of biogas.
  4. What is solar energy? What are the various devices based on solar energy? Briefly describe the construction and working of a solar cooker.
  5. What are solar cells? How are they designed? Does solar energy cause any environmental pollution? State important uses of solar cells.
  6. Which property of water in oceans enables it to act as a storehouse of solar energy? Name some important forms of energy which could be harnessed from the oceans. What is meant by OTE? Name three important potential sites in India which have been identified for harnessing tidal energy.
  7. Give the principle, construction and operation of a Box type solar cooker.
  8. States three advantages and three limitations of a box type solar cooker. What are the main differences between box-type solar cooker and spherical reflector type solar cooker?
  9. What is solar energy? How do we form a solar panel cell? What are the uses of solar cells?
  10. What is a nuclear reactor? What is the fuel used in a nuclear reactor? With the help of a labeled diagram, describe the working of a nuclear power plant.
- .....