

PHYSICS

REFERENCE STUDY MATERIAL

for

Summative Assessment -II

CLASS – X

2013 – 14

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

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Kendriya Vidyalaya donimalai

PREFACE

It gives me great pleasure in presenting the Study Material in Physics for Summative Assessment (SA) - II. It is in accordance with the syllabus of the session 2013–14 for second term (CCE pattern).

Each chapter has a large number of Numerical Problems along with all concepts and descriptions of topics in such a simple style that even the weak students will be able to understand the topic very easily. The most important feature of this material is that **NCERT book questions(intext questions) and exercises** included along with answers.

All concepts and formulas based on Numericals and HOTS Numericals are also included in the material. It is also helpful to all the students for competitive examinations.

Keeping the mind the mental level of a child, every effort has been made to introduce simple Numerical Problems in starting before HOTS Numericals so that the child solve them easily and gets confidence.

I avail this opportunity to convey my sincere thanks to respected sir Shri Isampal, Deputy Commissioner, KVS RO Bangalore, respected sir Shri P. V. Sairanga Rao, Deputy Commissioner, KVS RO Varanasi, respected sir Shri. K. L. Nagaraju, Assistant Commissioner, KVS RO Bangalore and respected sir Shri.Gangadharaiah, Assistant Commissioner, KVS RO Bangalore for their blessings, motivation and encouragement in bringing out this notes in such an excellent form.

I also extend my special thanks to respected madam Smt. Nirmala Kumari M., Principal, KV Donimalai and respected Shri. M. Vishwanatham, Principal, KV Raichur for their kind suggestions and motivation while preparing this notes.

I would like to place on record my thanks to respected sir Shri. P. K. Chandran, Principal, presently working in KV Bambolim. I have started my career in KVS under his guidance, suggestions and motivation.

Inspite of my best efforts to make this notes error free, some errors might have gone unnoticed. I shall be grateful to the students and teacher if the same are brought to my notice. You may send your valuable suggestions, feedback or queries through email to kumarsir34@gmail.com that would be verified by me and the corrections would be incorporated in the next year Question Bank.

M. S. KUMARSWAMY

**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

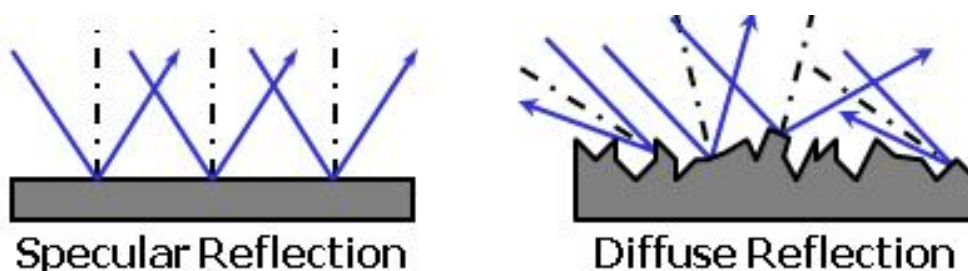
Reflection of light is the phenomenon of bouncing back of light in the same medium on striking the surface of any object.

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.

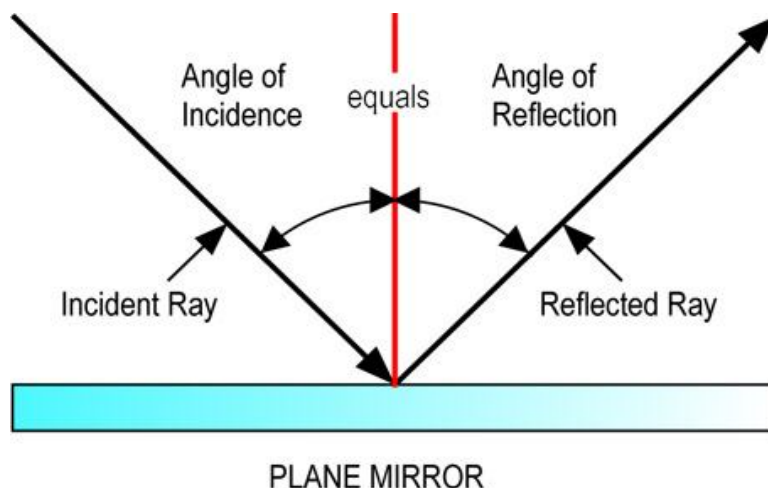
Irregular reflection: When the reflecting surface is rough, the parallel rays falling on it are reflected in different directions, as shown in below fig. Such a reflection is known as diffuse reflection or irregular reflection.



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 actresses on the screen. So, the images formed on a cinema screen is an example of real images.

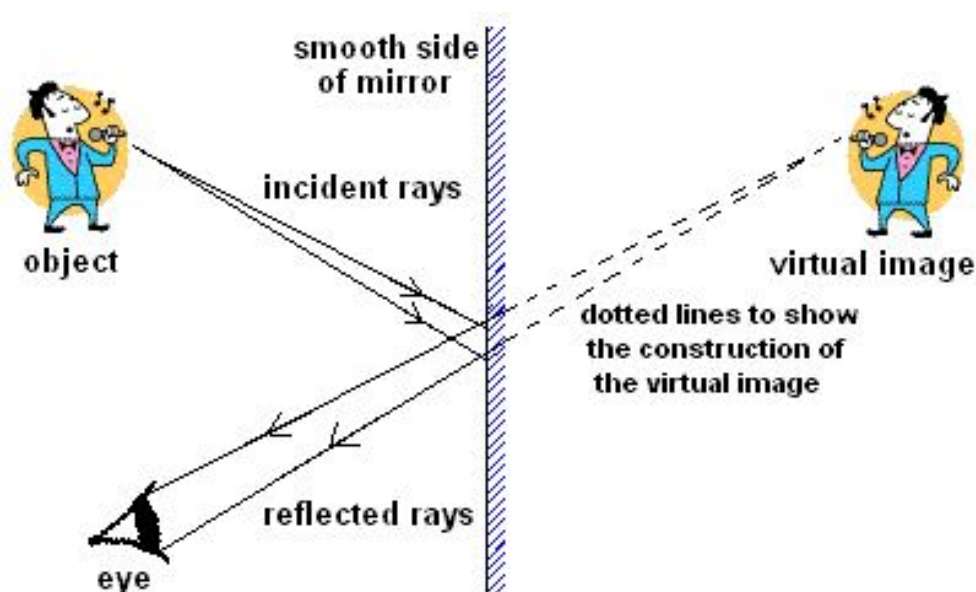
VIRTUAL IMAGE

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:

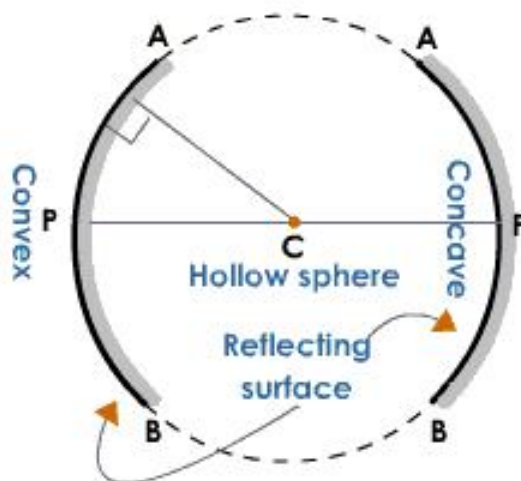
1. The image of real object is always virtual. Such image cannot be taken on a screen.
2. The image formed in a plane mirror is always erect.
3. The size of the image in a plane mirror is always the same as the size of the object.
4. The image formed in a plane mirror is as far behind the mirror, as 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'.

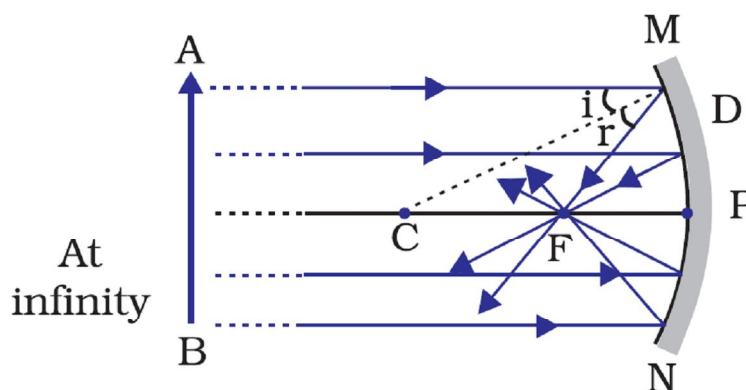
Radius of Curvature(R): The radius of curvature of a spherical mirror is the radius of the hollow sphere of glass of which the spherical is a part. It is represented by the letter 'R'.

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.

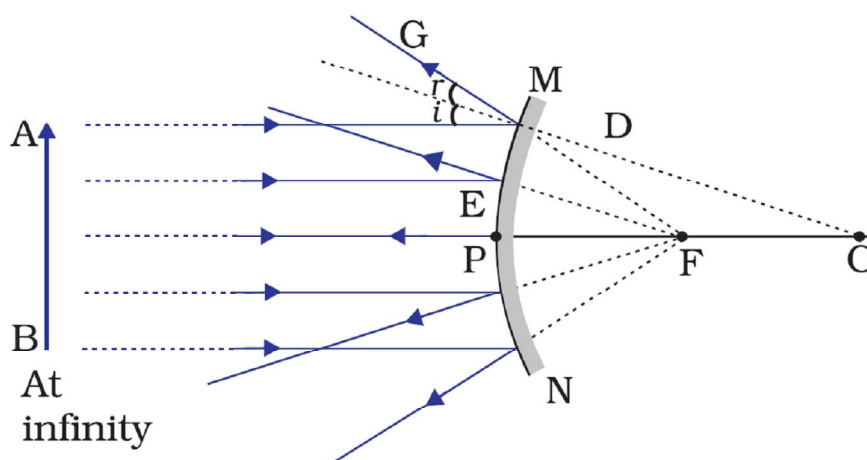
Aperture: The aperture of a spherical mirror is the diameter of the reflecting surface of the mirror.

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.

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

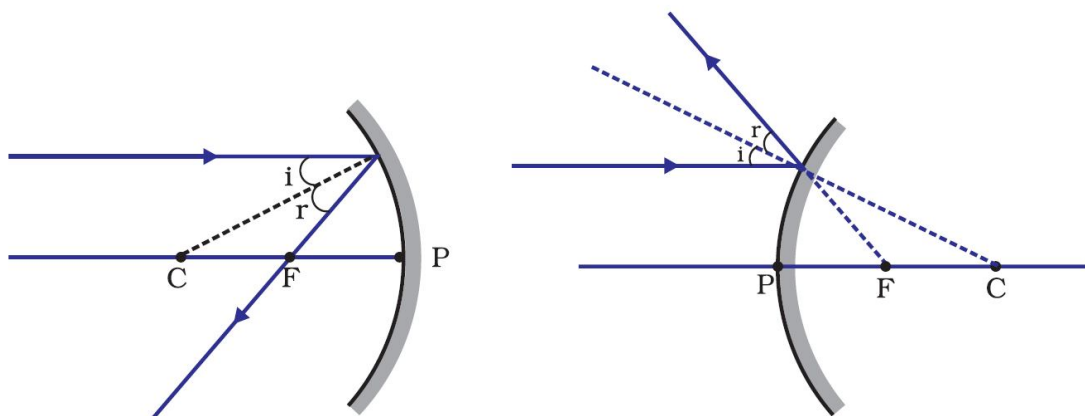
In other words, for spherical mirrors of small apertures, the radius of curvature is found to be equal to twice the focal length.

$$R = 2f$$

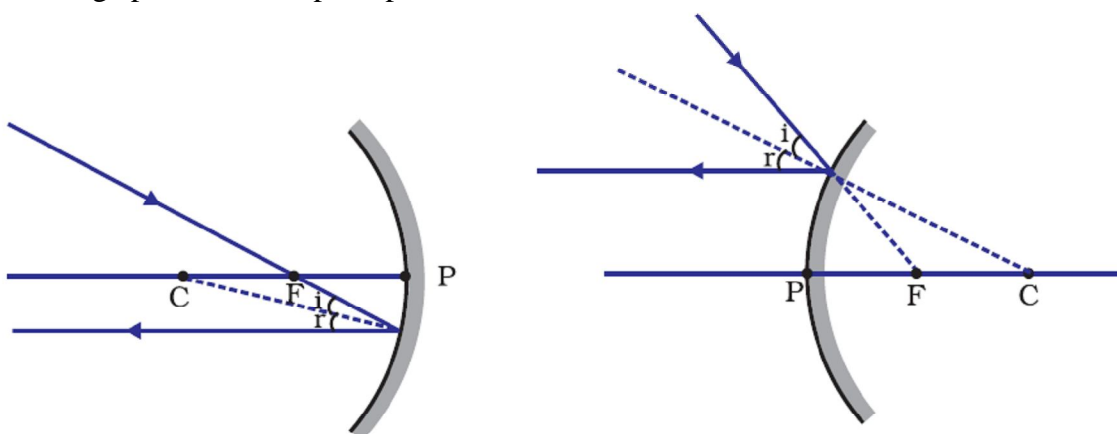
RULES FOR OBTAINING IMAGES FORMED BY SPHERICAL MIRRORS

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.

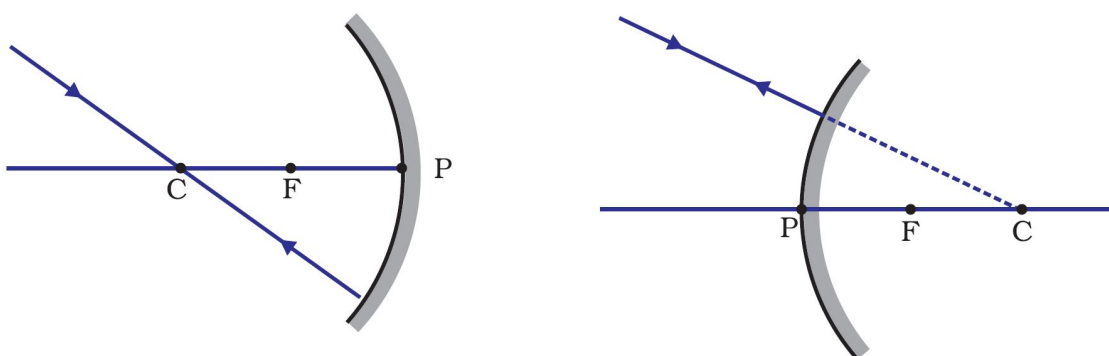
1. A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.



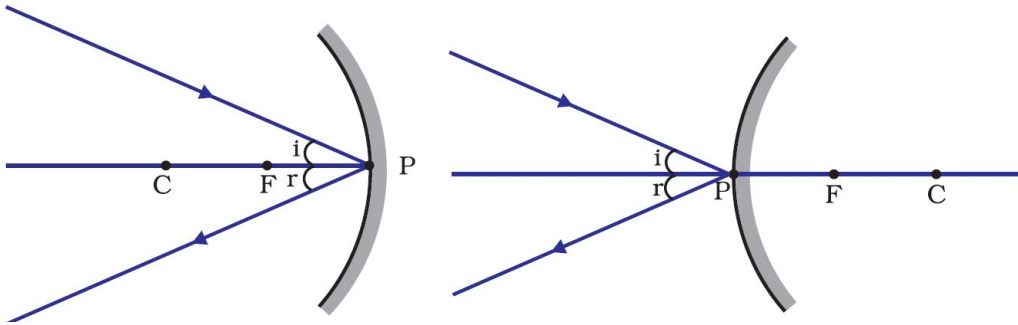
2. A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, after reflection, will emerge parallel to the principal axis.



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.



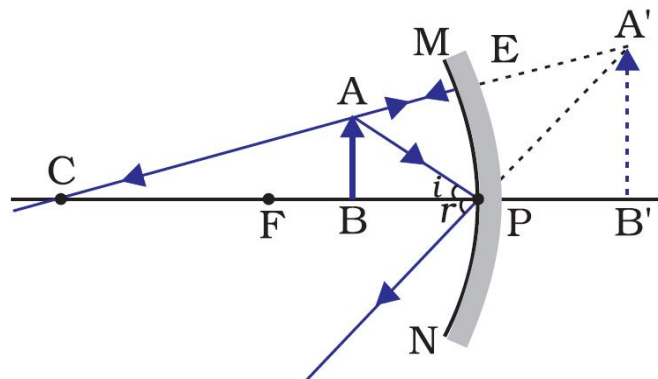
FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONCAVE MIRROR

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

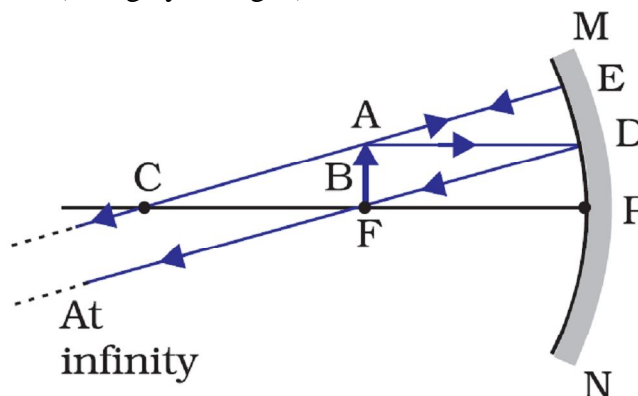
- (i) behind the mirror
- (ii) virtual and erect and
- (iii) larger than the object (or magnified)



Case-2: Object is at the focus(F).

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

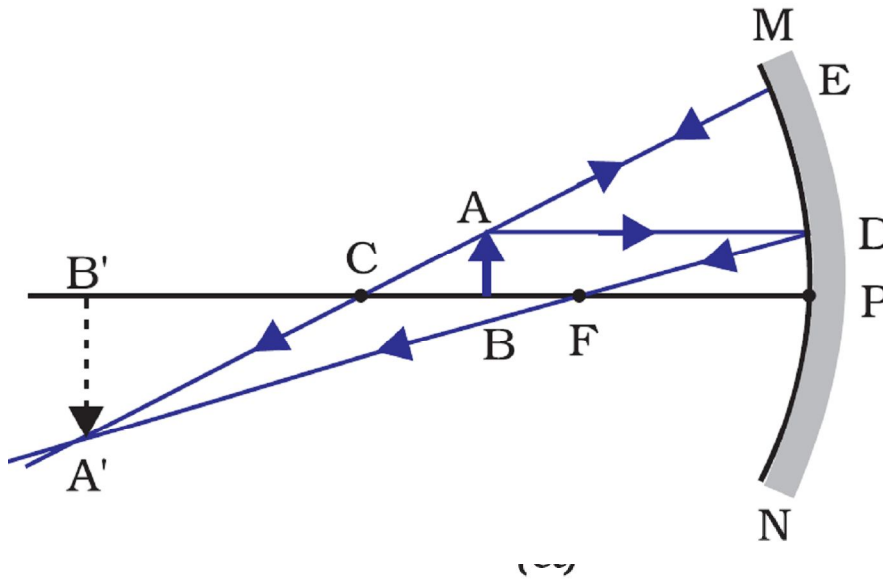
- (i) at infinity
- (ii) real and inverted, and
- (iii) highly magnified (or highly enlarged)



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

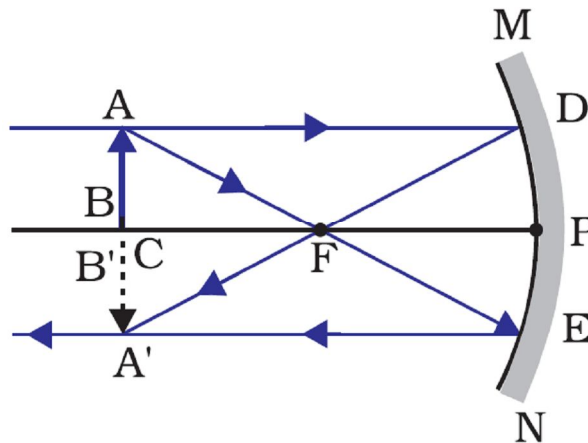
- (i) beyond the centre of curvature
- (ii) real and inverted, and
- (iii) larger than the object (or magnified)



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

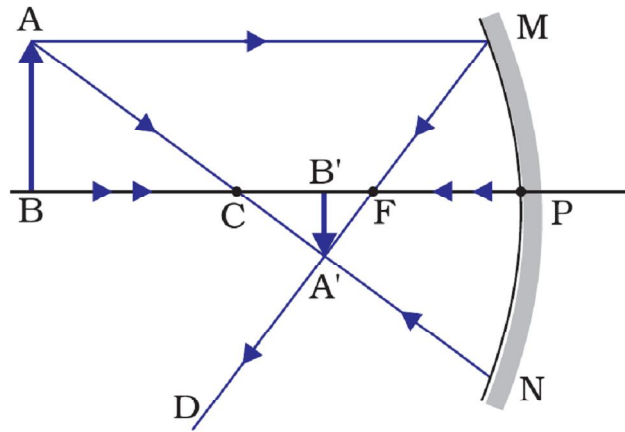
- (i) at the centre of curvature
- (ii) real and inverted, and
- (iii) same size as the object



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

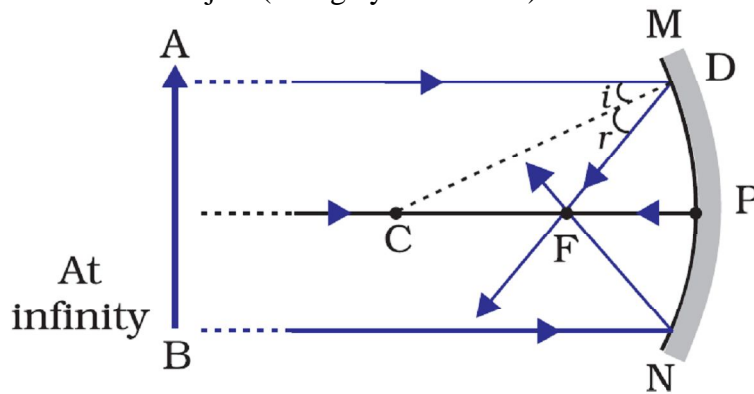
- (i) between the focus and centre of curvature
- (ii) real and inverted, and
- (iii) smaller than the object (or diminished)



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.

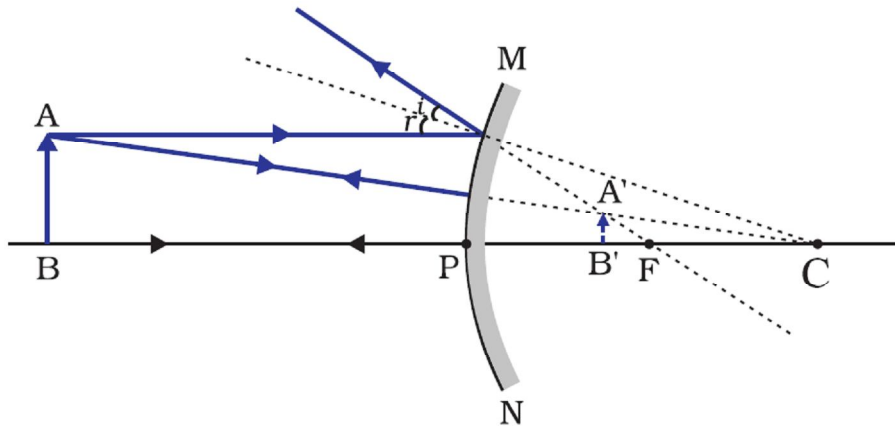
FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONVEX MIRROR

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

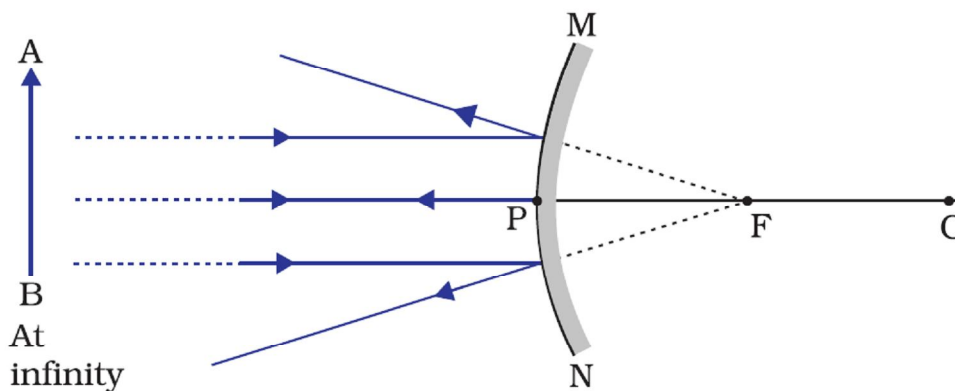
- (i) between the pole and focus
- (ii) virtual and erect, and
- (iii) smaller than the object (or diminished)



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 $R = 20\text{ cm}$

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:

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

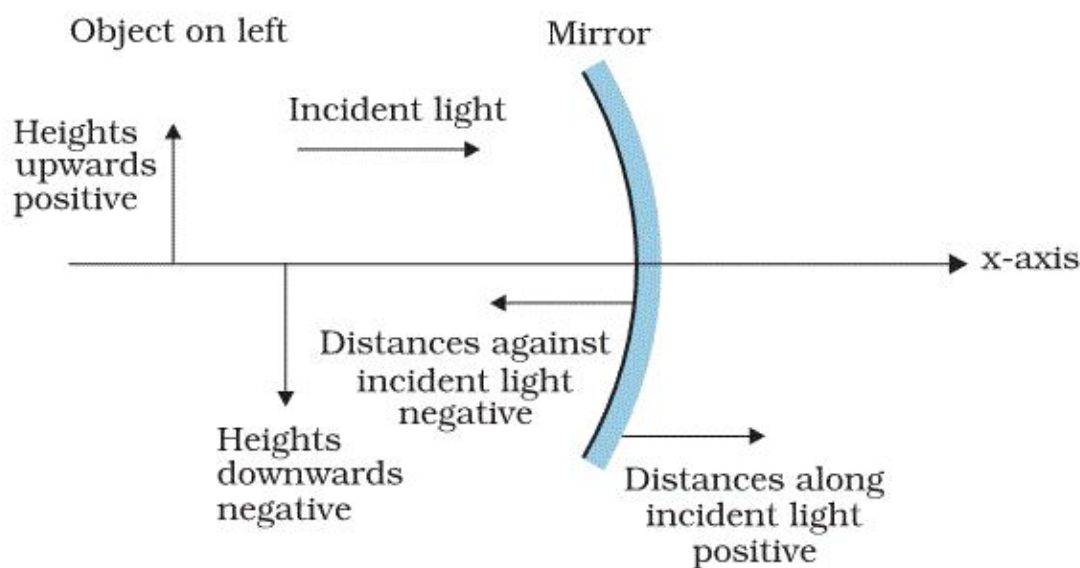
Points to be remembered:

- 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 $R = 32$ cm

We know that $f = \frac{R}{2} \Rightarrow f = \frac{32}{2} = 16$ 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, $u = -10$ cm and
image distance, $v = ?$

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

$$m = -\frac{v}{u} \Rightarrow -3 = -\frac{v}{-10}$$
$$\Rightarrow v = -30$$

cm

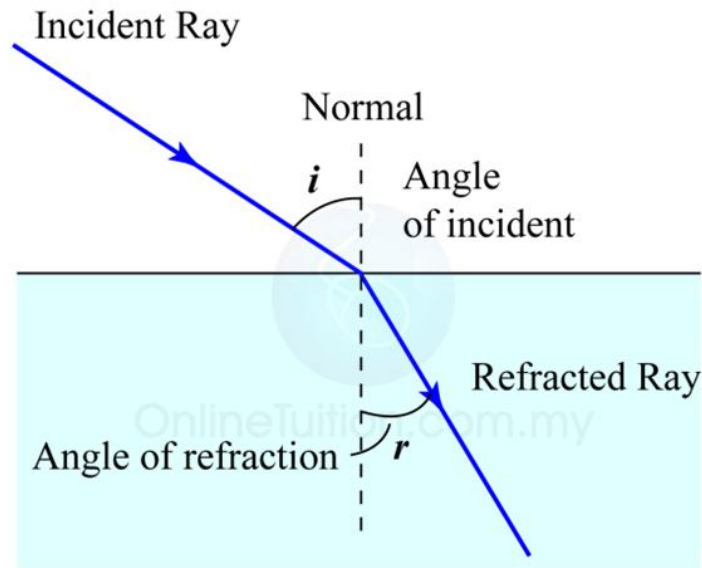
NUMERICALS BASED ON CONVEX AND CONCAVE MIRROR

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 $\frac{1}{2}$. Where should the object be placed to get a magnification of $\frac{1}{3}$?
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. An 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 $\frac{1}{3}$. 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 move 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

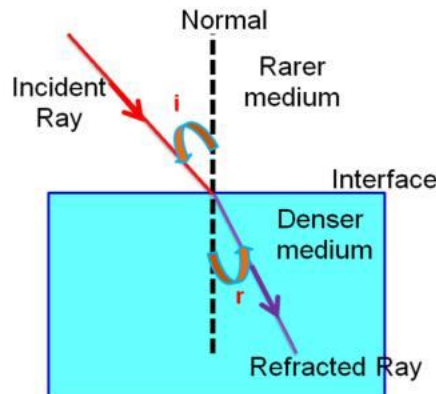
A transparent substance in which light travels is known as a medium. Medium can be divided into two types:

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)

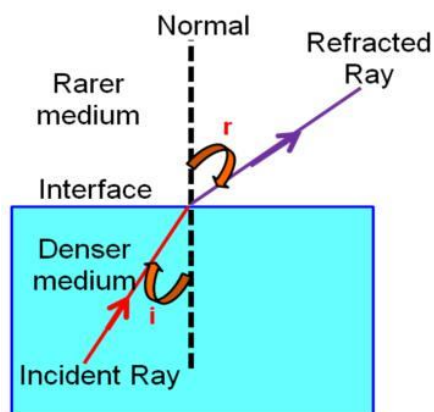
Glass is an optically denser medium than air and water.

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.

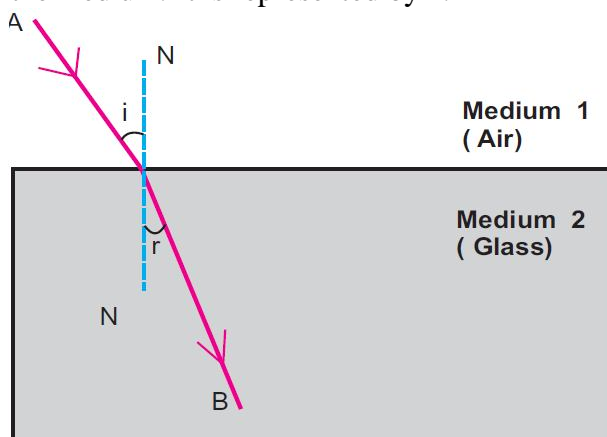
(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(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

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

- ${}^a n_w = \frac{\text{real depth}(x)}{\text{apparent depth}(a)}$

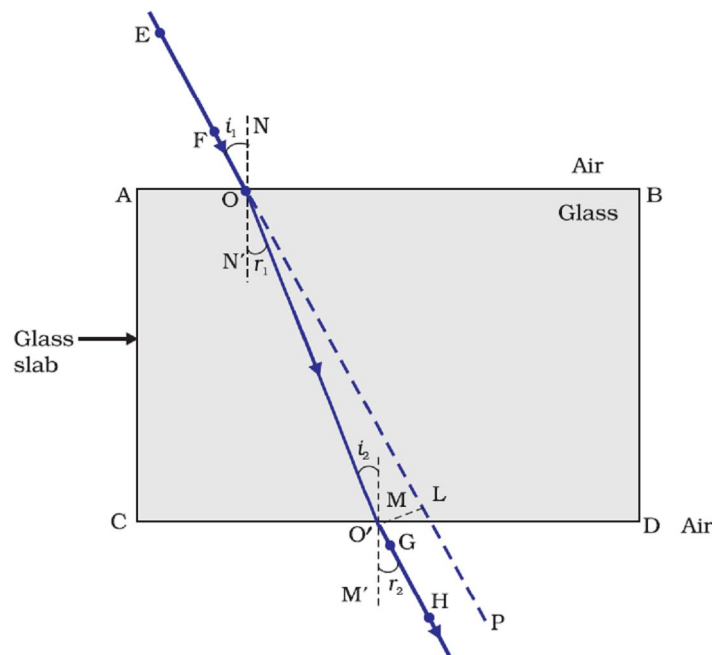
Both x and y are in metre or in cm.

- 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 not 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.

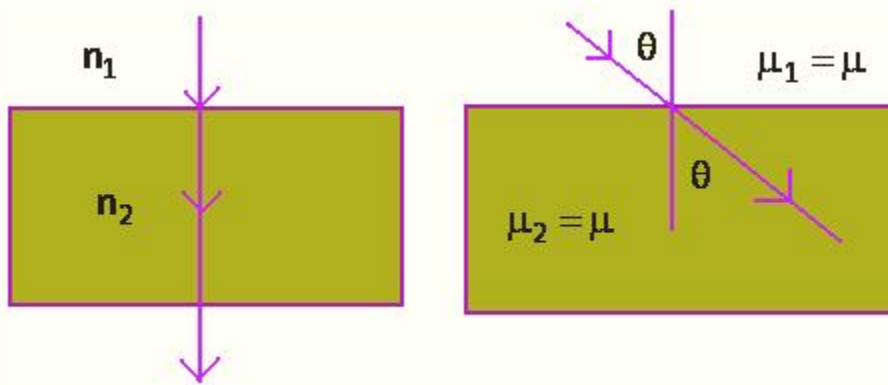
$n_1 = n_2$, then according to Snell's law

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

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

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

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 3×10^8 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, $n_g = 1.50$

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

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 2.25×10^8 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° and 30° . 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 $\frac{4}{3}$.
6. A ray of light passes from air to glass ($n = 1.5$) at an angle of 30° . Calculate the angle of refraction.
7. A ray of light is incident on a glass slab at an angle of 45° . 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 in air if its speed in glycerine is 2.05×10^8 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° and angle of refraction in air is 60° . 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° ? 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 $\frac{4}{3}$, 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 $\frac{4}{3}$.
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.

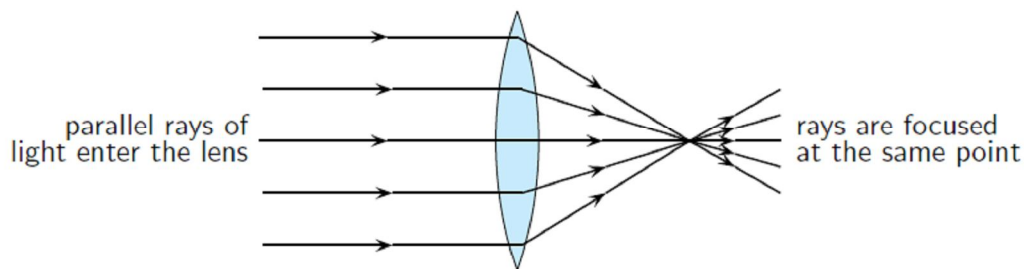
A transparent material bound by two surfaces, of which one or both surfaces are spherical, forms a lens.

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

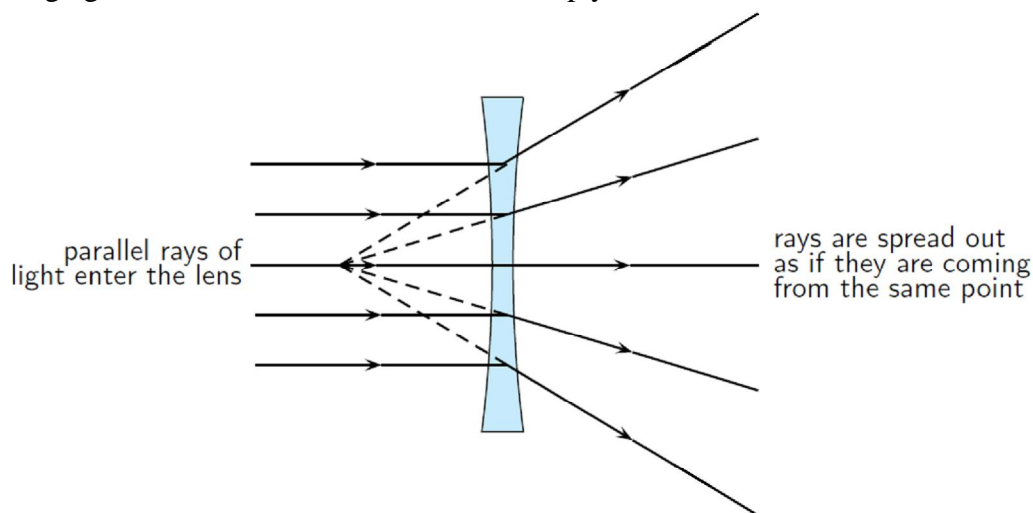
A lens may have two spherical surfaces, bulging outwards. Such a lens is called a double convex lens. It is simply called a convex lens. It is thicker at the middle as

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



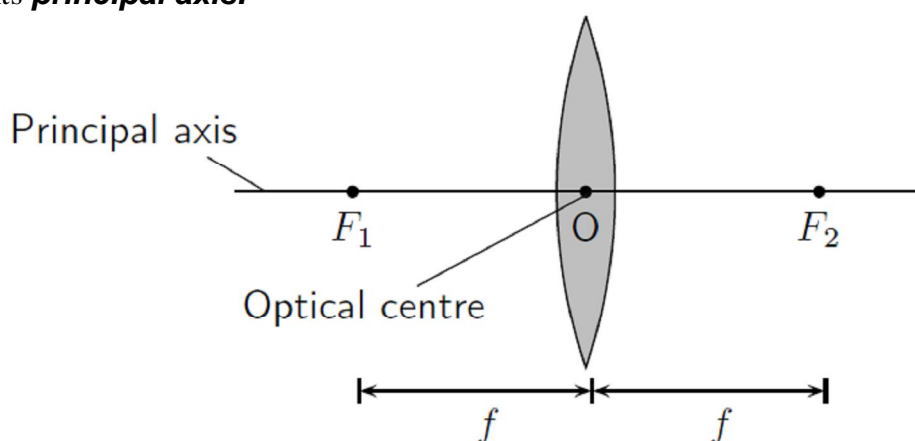
CONCAVE LENS

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

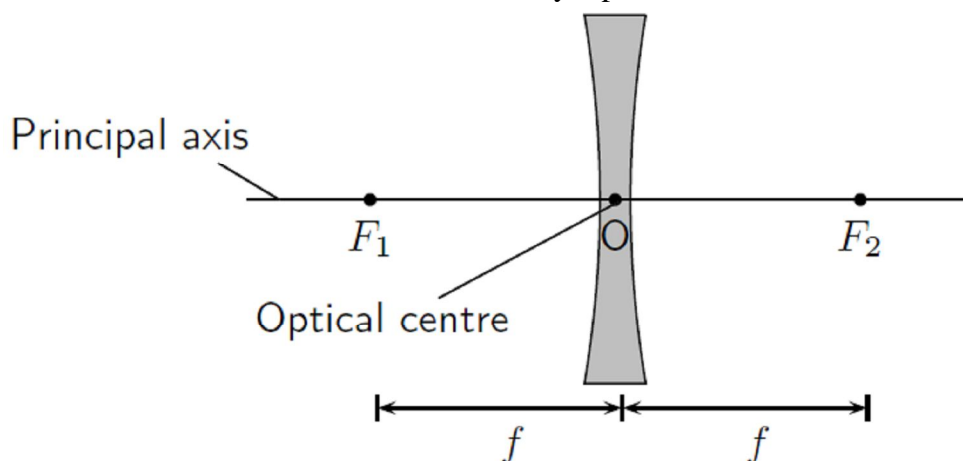
Principal Axis: The principal axis is the line which runs horizontally straight through the optical centre of the lens. It is also sometimes called the optic axis. In other words, an imaginary straight line passing through the two centres of the curvature of a lens is called its **principal axis**.



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.

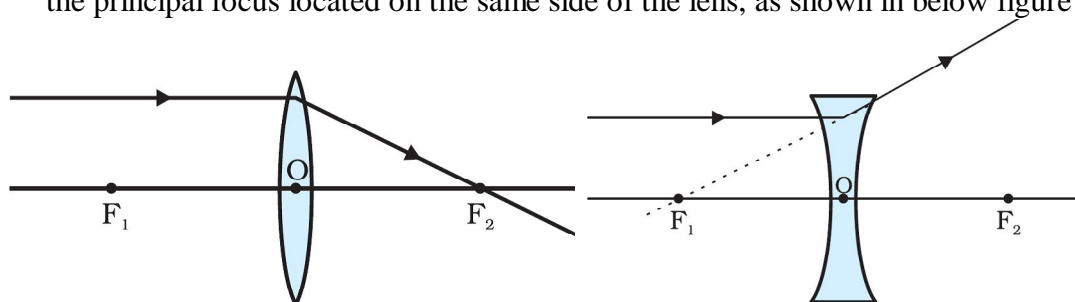
Focus: The focus or focal point of the lens is the position on the principal axis where all light rays that run parallel to the principal axis through the lens converge (come together) at a point. Since light can pass through the lens either from right to left or left to right, there is a focal point 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.

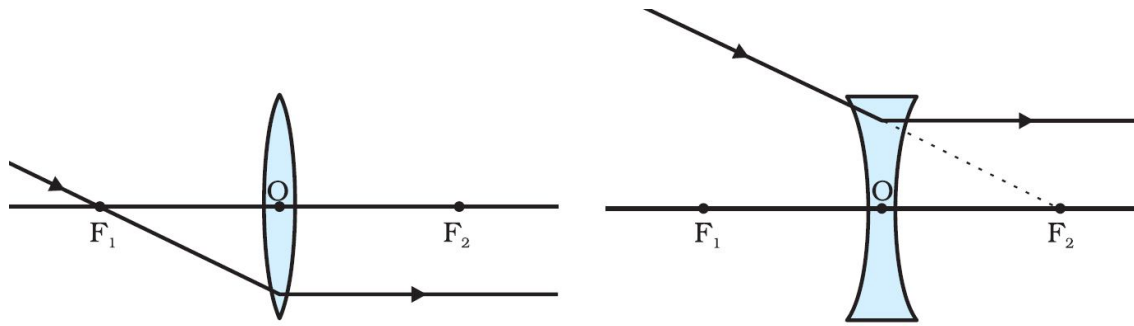
RULES FOR OBTAINING IMAGES FORMED BY SHPERICAL LENSES

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.

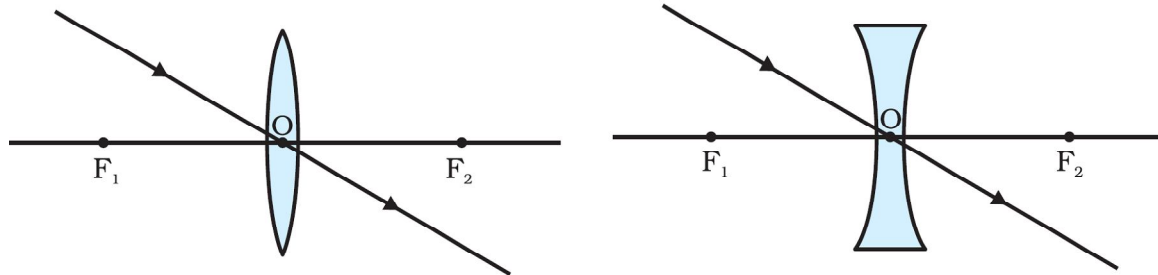
1. A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens, as shown in below figure. In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of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

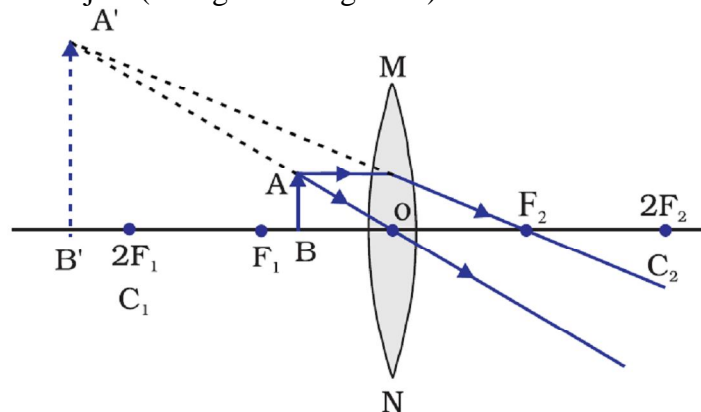


FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONVEX LENS

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:

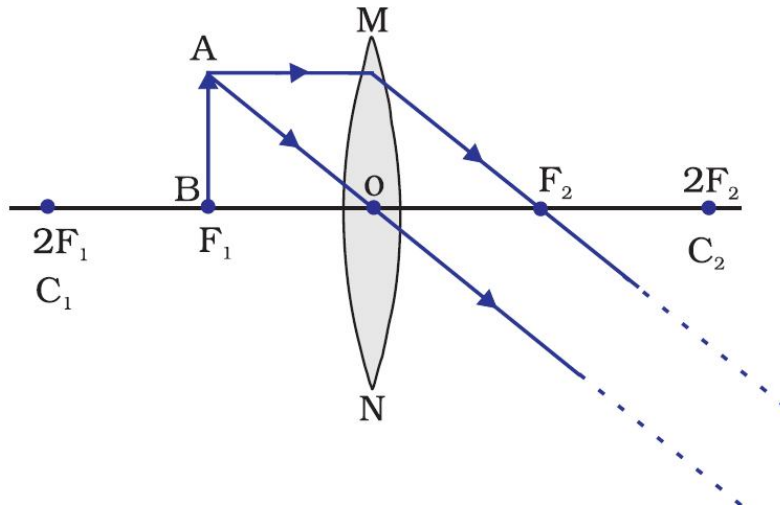
Case-1: Object is in between optical centre(O) and focus (F₁)

When the object is placed between optical centre(O) and focus(F₁), 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 (F₁)

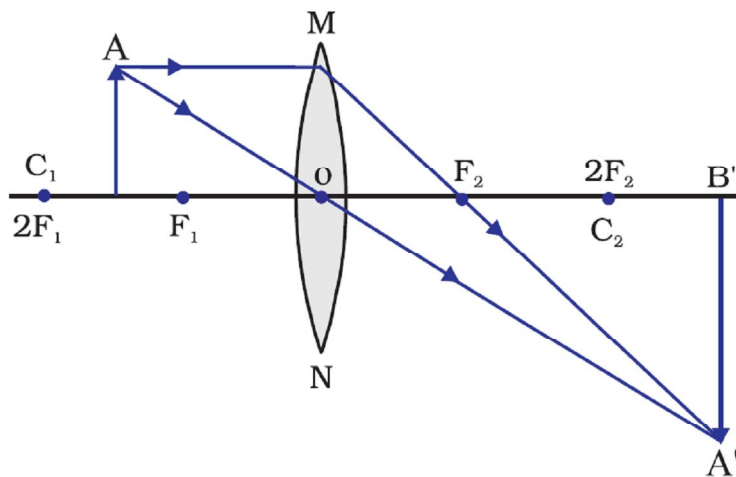
When the object is placed at the focus(F₁), the image formed is
 (i) at infinity
 (ii) real and inverted, and
 (iii) highly enlarged



Case-3: Object is in between F_1 and $2F_2$

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

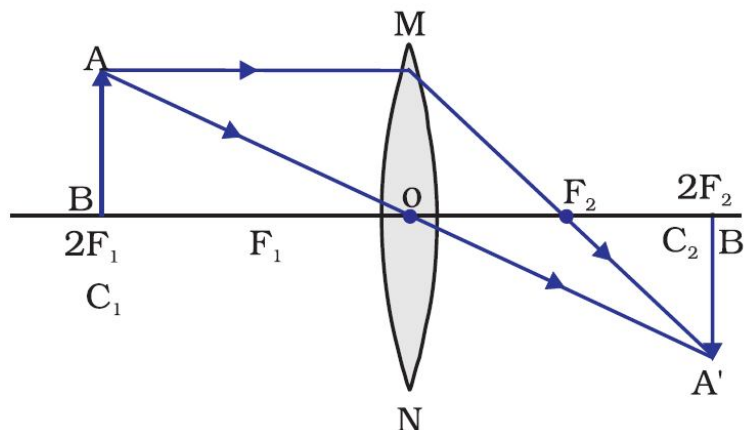
- (i) beyond $2F_2$,
- (ii) real and inverted, and
- (iii) larger than the object (or magnified).



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

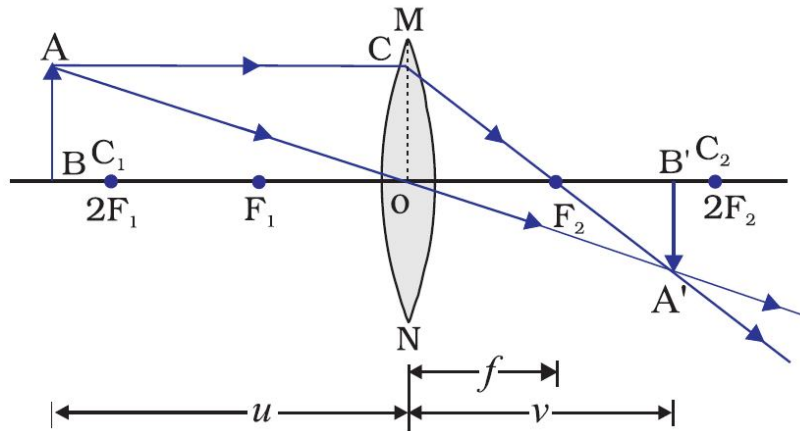
- (i) at $2F_2$ on the other side of the lens,
- (ii) real and inverted, and
- (iii) of the same size as the object.



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

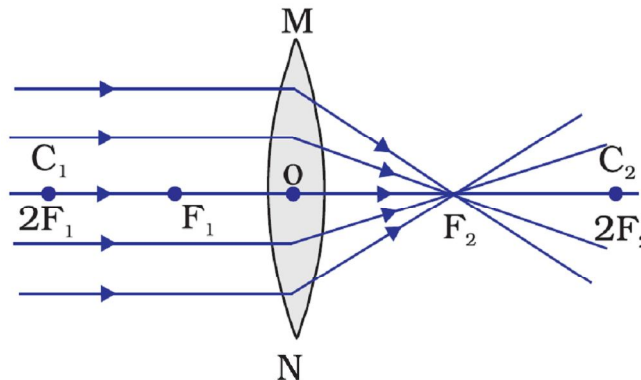
- (i) between F_2 and $2F_2$ on the other side of the lens,
- (ii) real and inverted, and
- (iii) smaller than the object (or diminished)



Case-6: Object is at infinity

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

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



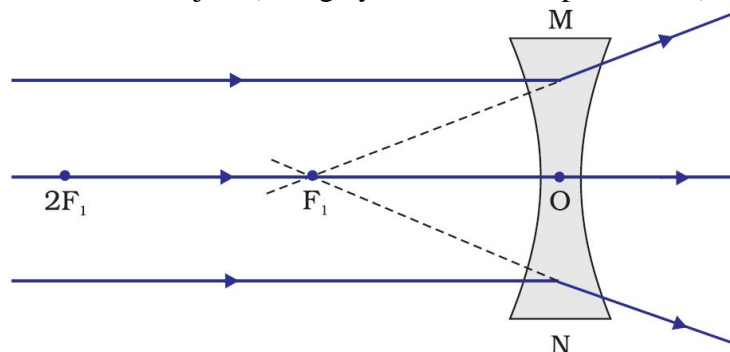
FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONCAVE LENS

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

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

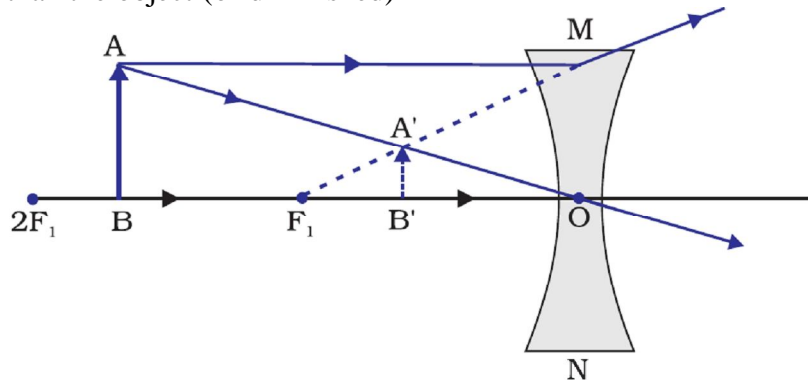


Case-2: Object is in between optical centre(O) and infinity

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

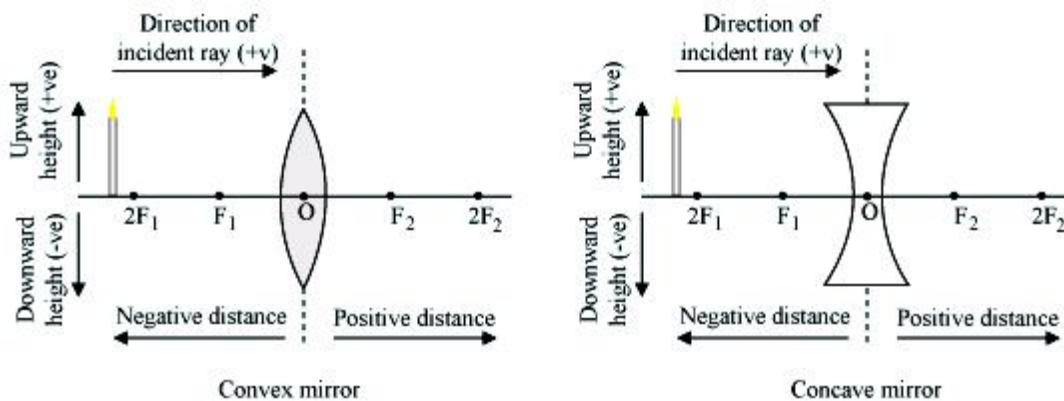
(iii) smaller than the object (or diminished)



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.



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 be 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 images 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 CONVEX 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 'diopetre'. It is denoted by the letter D. If f is expressed in metres, then, power is expressed in dioptres. Thus, 1 diopetre 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, \dots 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 $+3.5\text{ D}$ 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.
 - a). What is the power of the combination?
 - b). What is the focal length of the combination?
 - c). 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
 - a). calculate the focal length of lens Y.
 - b). State the nature of the lens Y.
20. Two lenses A and B have focal lengths of +20cm and – 10 cm, respectively.
 - a). What is the nature of lens A and lens B?
 - 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 diopetre 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 Diopetre. It is denoted by D.

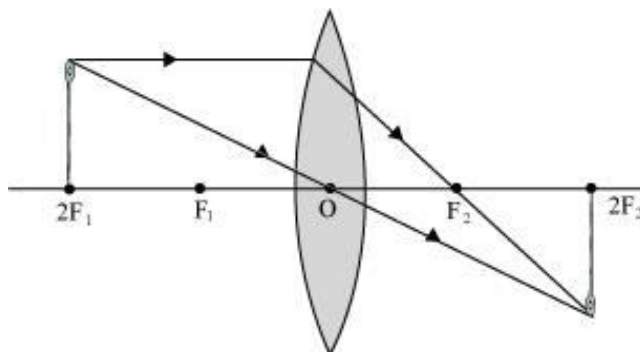
$$P = \frac{1}{f(\text{in metres})}$$

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

Hence, 1 D = 1 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.

Object distance, $u = -50$ cm

Image distance, $v = 50$ cm

Focal length = f

According to the lens formula,

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

$$\frac{1}{f} = \frac{1}{50} - \frac{1}{-50} = \frac{1}{50} + \frac{1}{50} = \frac{1}{25}$$

$$f = 25\text{cm} = 0.25\text{m}$$

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

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

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

Focal length of concave lens, $f = 2$ 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 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 cm
(b) A concave lens of focal length 50 cm
(c) A convex lens of focal length 5 cm
(d) A concave lens of focal length 5 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.

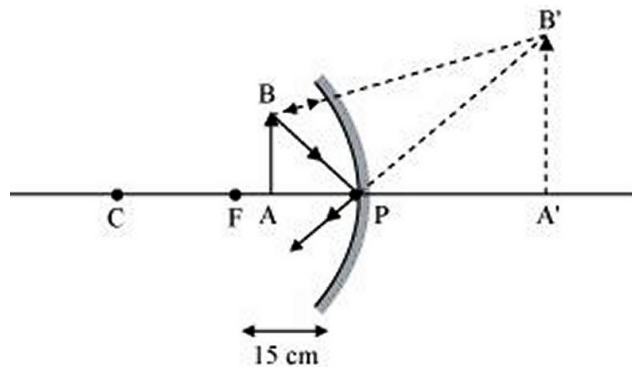
7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

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.

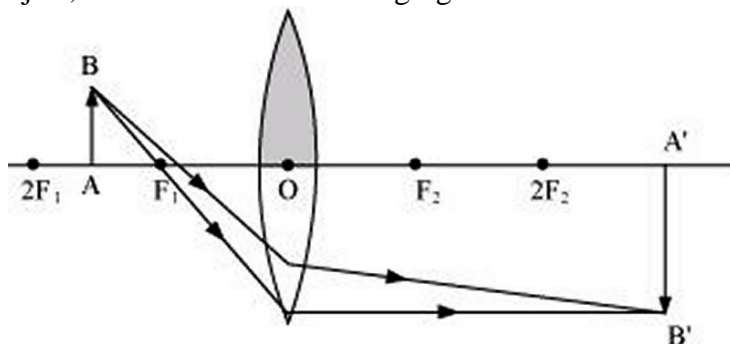
9. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

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.

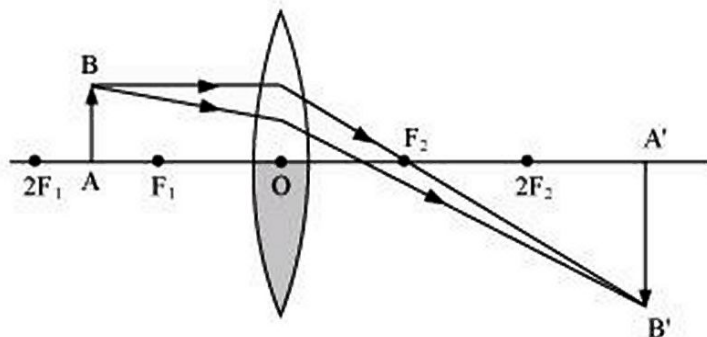
Case I: When the upper half of the lens is covered

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, $u = -25$ cm

Object height, $h_o = 5$ cm

Focal length, $f = +10$ 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.

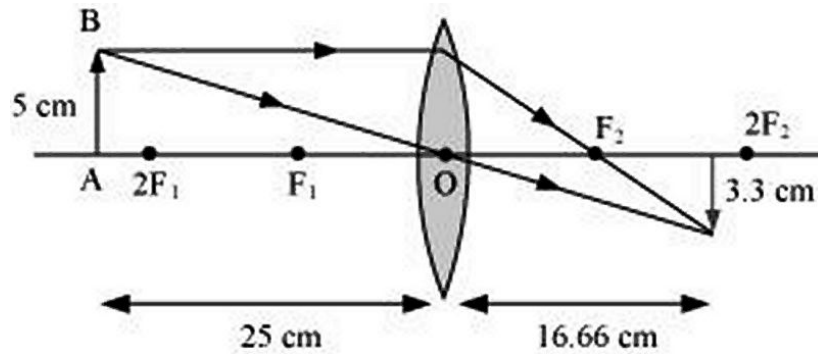
$$\text{Magnification, } m = \frac{\text{Height of the Image}}{\text{Height of the object}} = \frac{v}{u} = \frac{16.67}{-25} = -0.67$$

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 (OF1), $f = -15$ cm

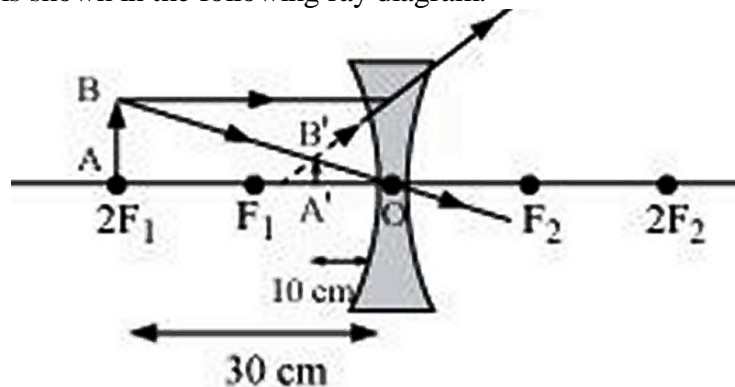
Image distance, $v = -10$ cm

According to the lens formula,

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

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

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, $f = +15$ cm

Object distance, $u = -10$ 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, $u = -20$ cm

Object height, $h = 5$ cm

Radius of curvature, $R = 30$ cm

Radius of curvature = $2 \times$ Focal length

$R = 2f$

$f = 15$ 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, $u = -27$ cm

Object height, $h = 7$ cm

Focal length, $f = -18$ 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.

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

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

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

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 - 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

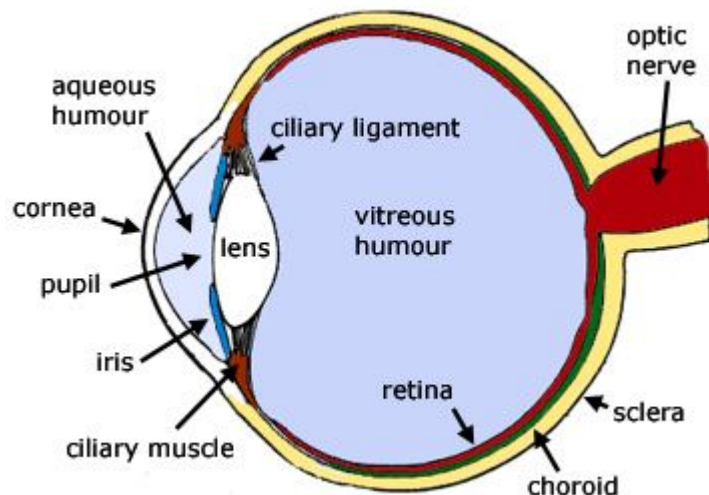
Optic Nerve: a bundle of nerve fibers that carries messages from the eyes to the brain
Macula: a small and highly sensitive part of the retina responsible for central vision, which allows a person to see shapes, colors, and details clearly and sharply.

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.

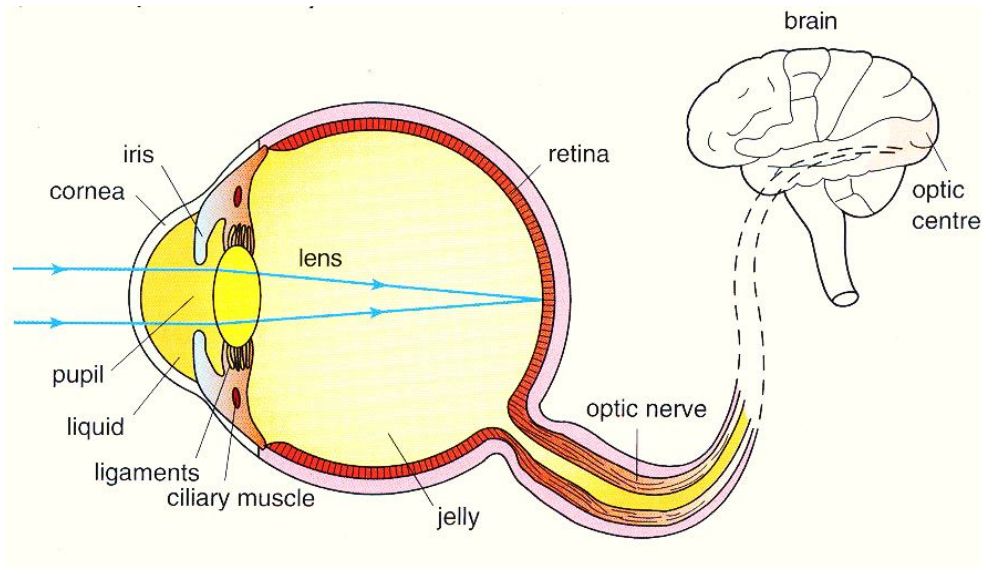
Vitreous humour: The space between the lens and retina filled with the gel like Vitreous Humor.



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.

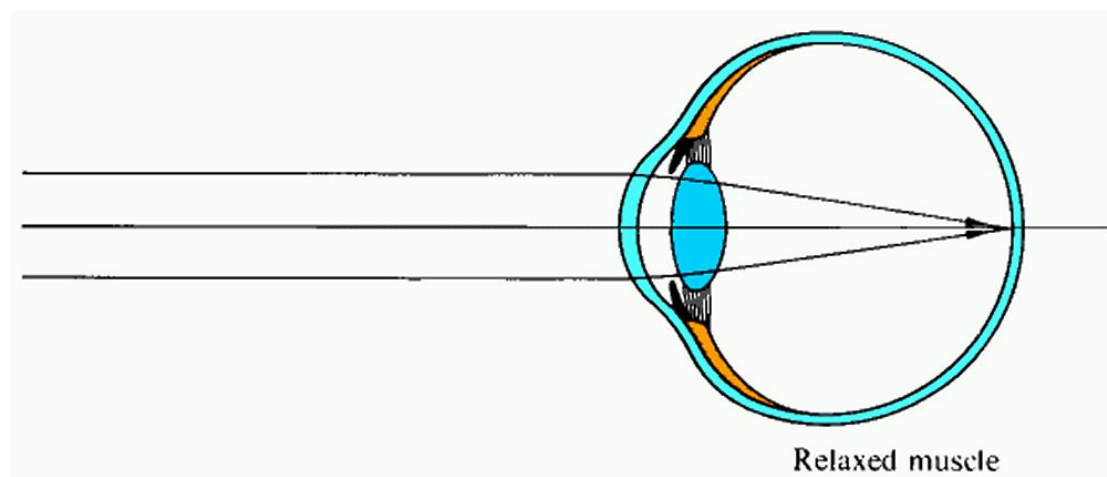


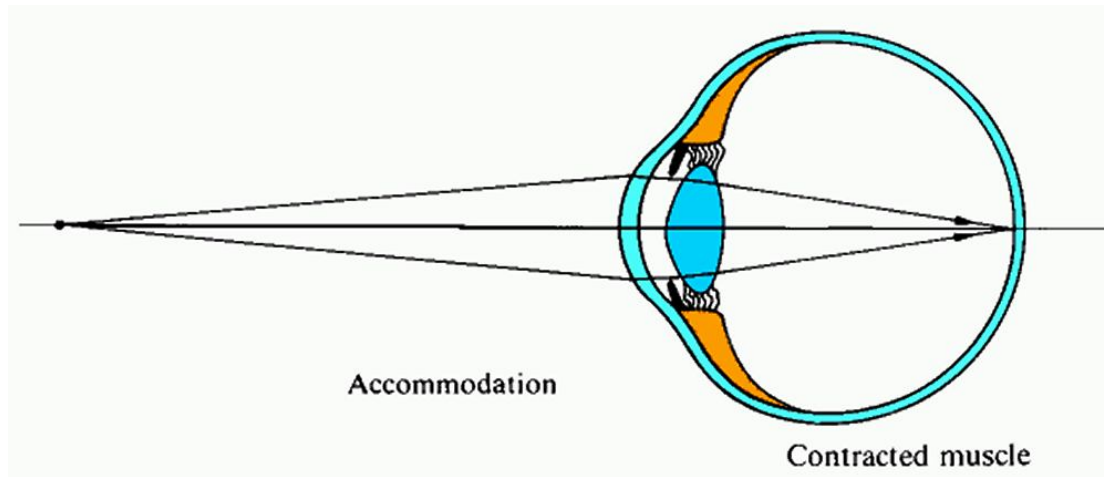
POWER OF ACCOMMODATION

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

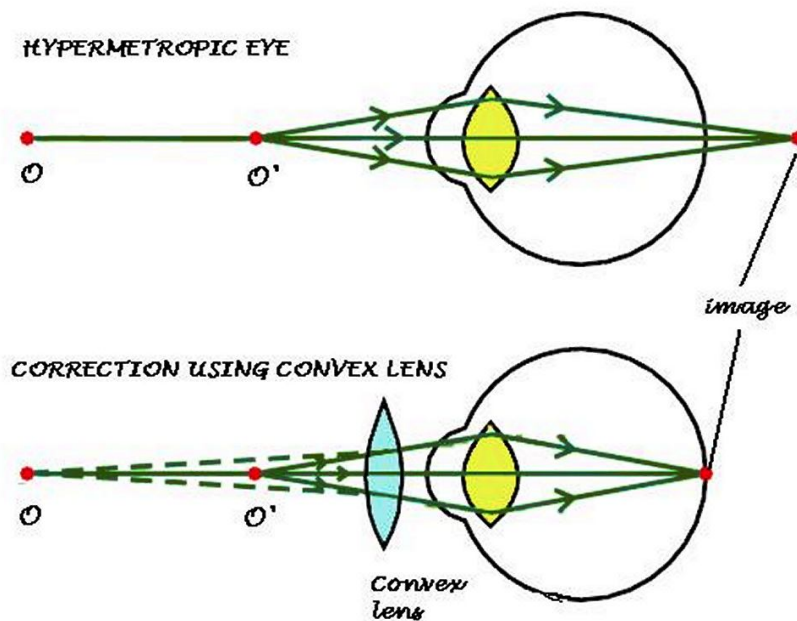
A normal eye can see all objects over a wide range of distances i.e., from 25 cm to infinity. But due to certain abnormalities the eye is not able to see objects over such a wide range of distances and such an eye is said to be defective. Some of the defects of vision are

- 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.



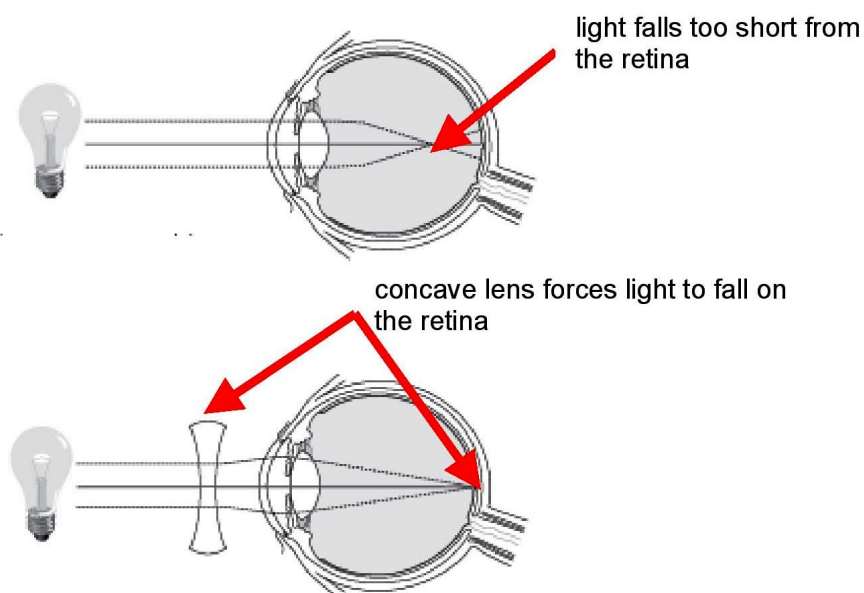
MYOPIA

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.

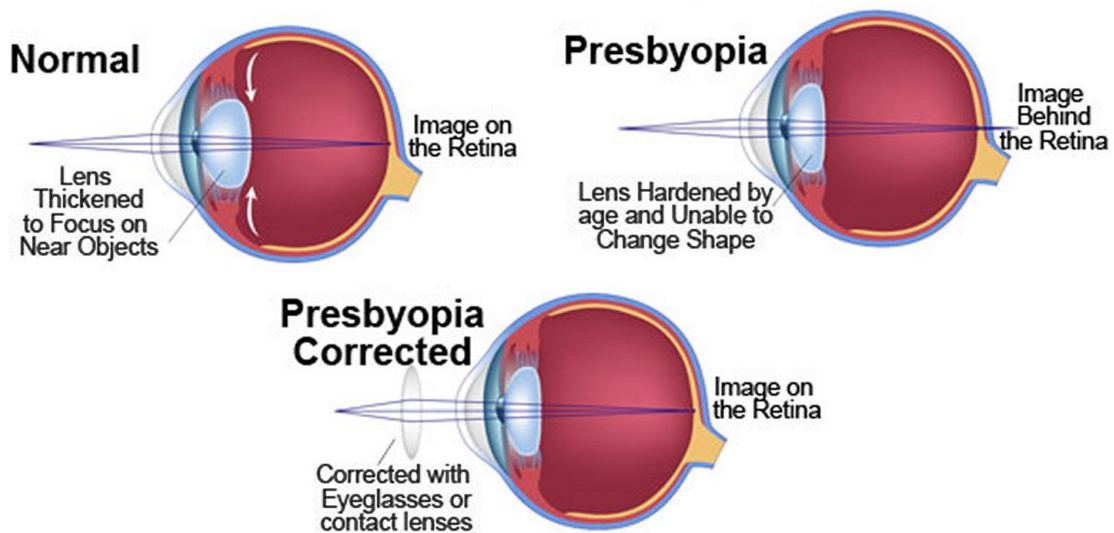


PRESBYOPIA

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.

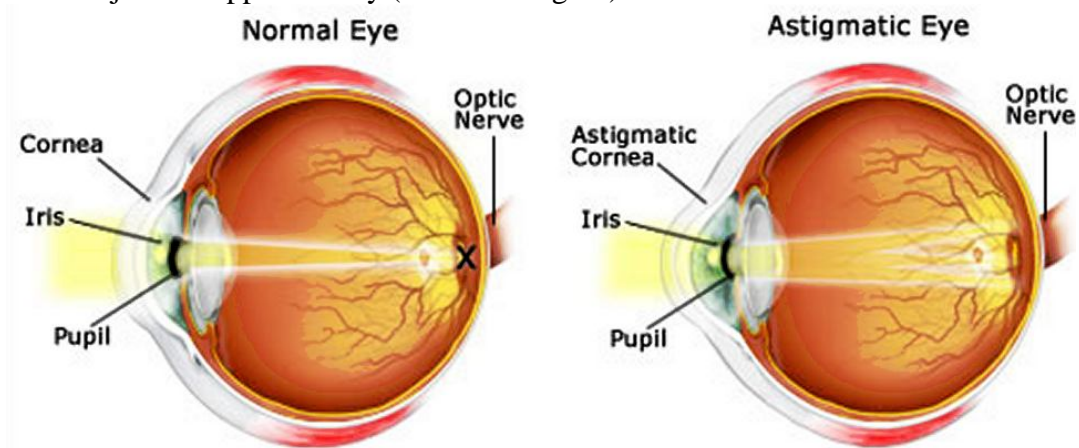
Astigmatism is a type of refractive error. A refractive error means that the shape of the eye does not bend light properly, resulting in a blurred image. Light has to be bent (refracted) by the lens and the cornea correctly before it reaches the retina in order to see things clearly.

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?

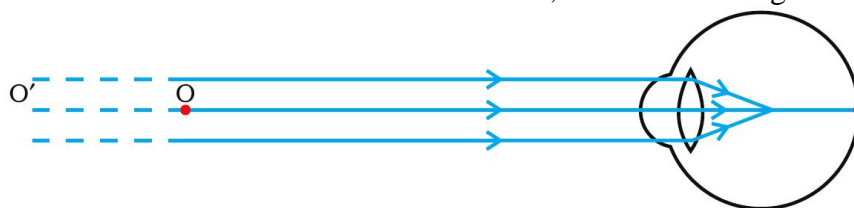
Ans:

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.

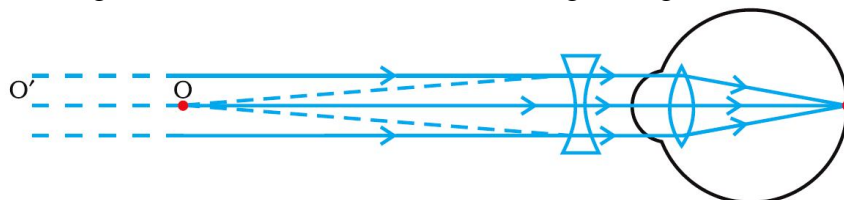
2. A person with a myopic eye cannot see objects beyond 1.2 m distinctly. What should be the type of the corrective lens used to restore proper vision?

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.

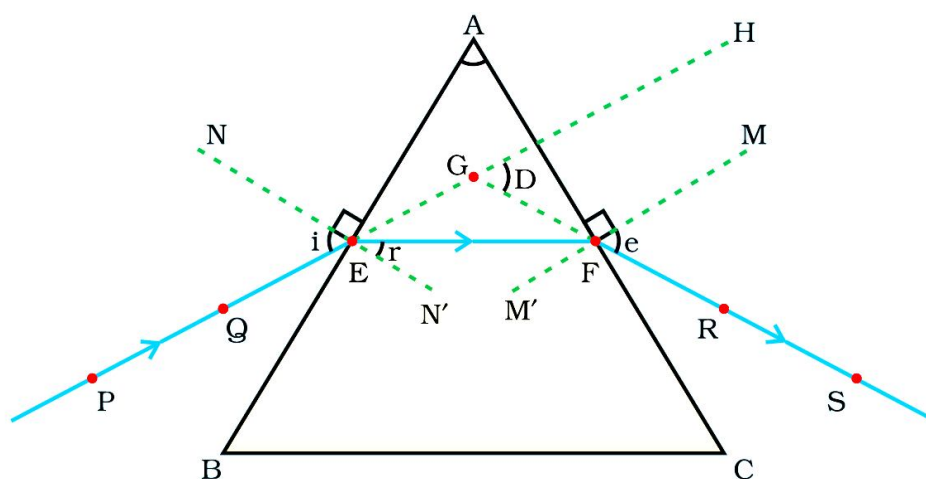
4. A student has difficulty reading the blackboard while sitting in the last row. What could be the defect the child is suffering from? How can it be corrected?

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

EF – Refracted ray

FS – Emergent ray

$\angle A$ – Angle of the prism

$\angle i$ – Angle of incidence

$\angle r$ – Angle of refraction

$\angle e$ – Angle of emergence

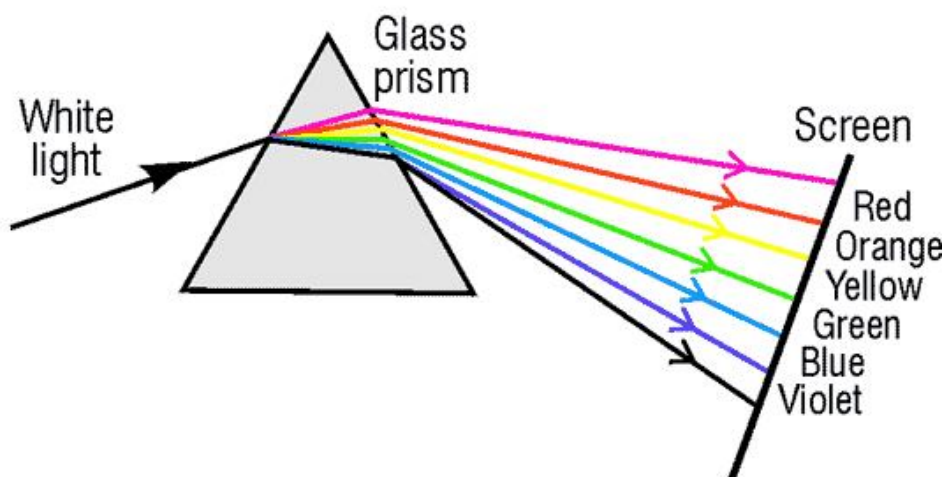
$\angle D$ – Angle of deviation

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

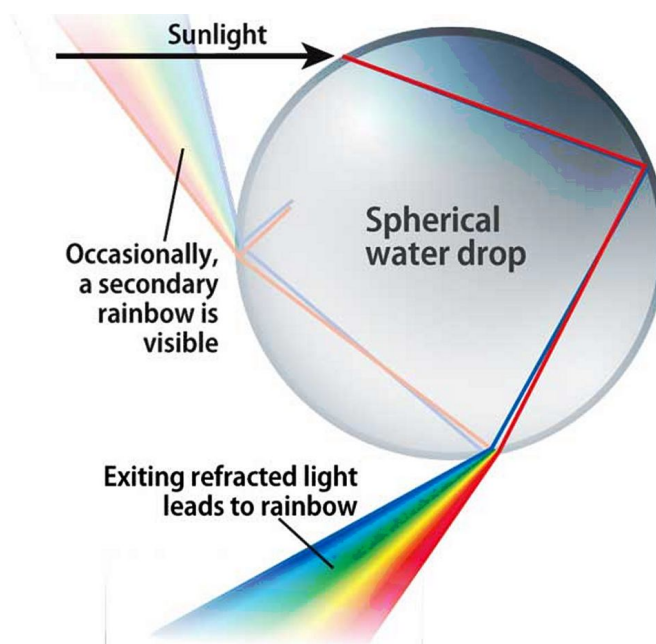
When a ray of light enters the prism, it bends towards the normal; because light is entering from a rarer medium to a denser medium. Similarly, when the light emerges from the prism, it follows the laws of refraction of light. Due to the angle of the prism and due to different wavelengths of different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



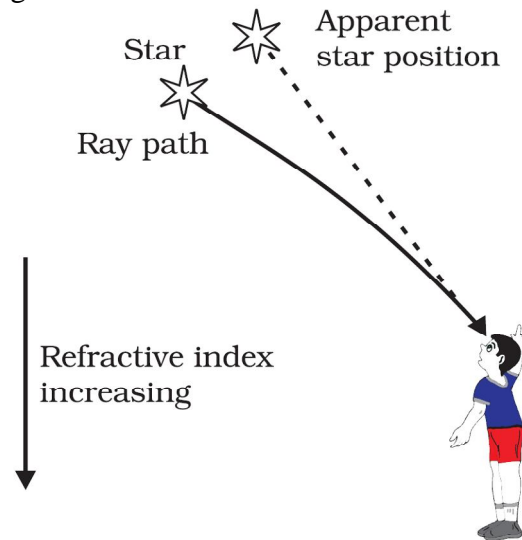
ATMOSPHERIC REFRACTION

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

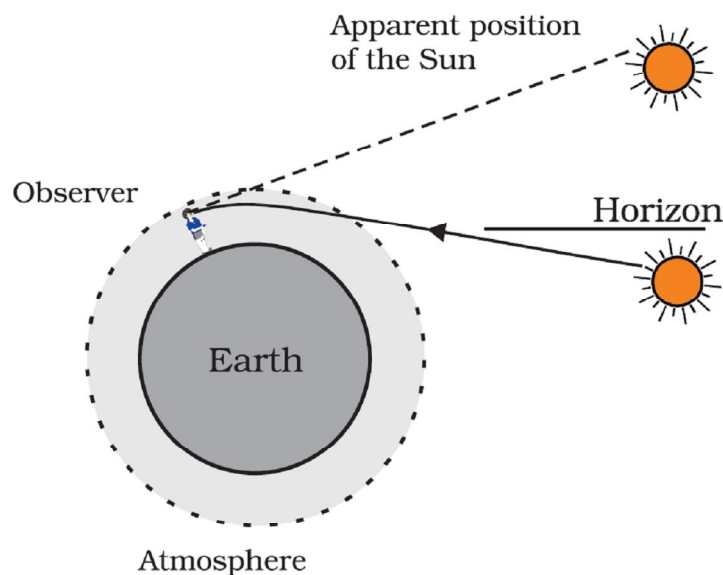
Stars emit their own light and they twinkle due to the atmospheric refraction of light. Stars are very far away from the earth. Hence, they are considered as point sources of light. When the light coming from stars enters the earth's atmosphere, it gets refracted

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.



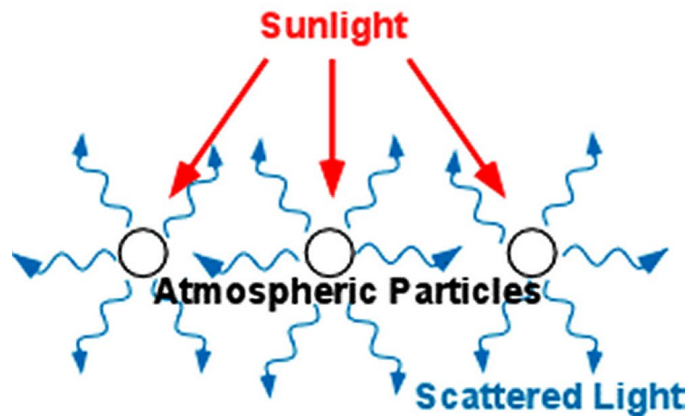
ADVANCE SUNRISE AND DELAYED SUNSET

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.

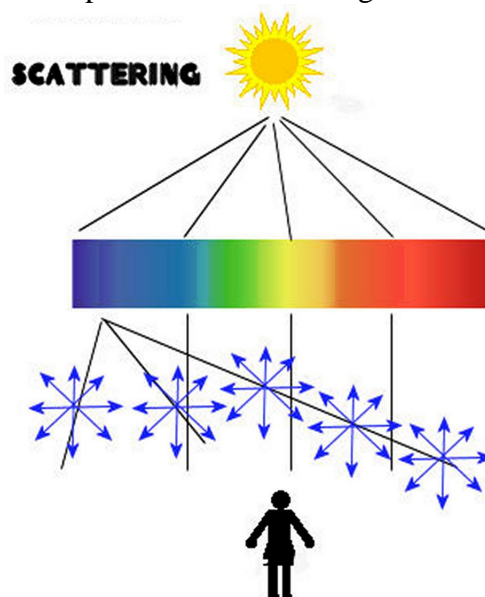


TYNDALL EFFECT

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.

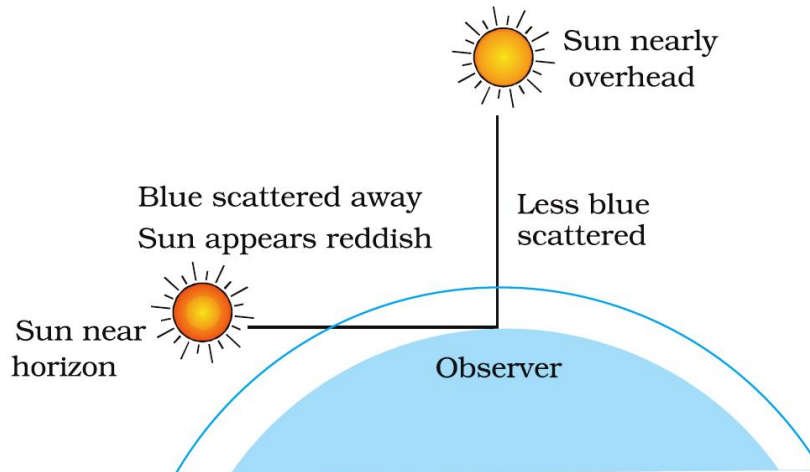
WHY IS THE COLOUR OF THE CLEAR SKY BLUE?

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, $u = \text{infinity}$

Image distance, $v = -80$ cm

Focal length = f

According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-80} - \frac{1}{\infty} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{-80} \Rightarrow f = -80\text{cm} = -0.8\text{m}$$

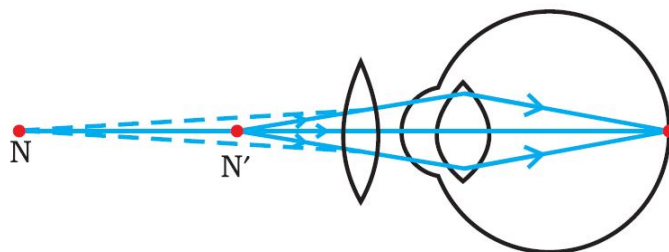
$$P = \frac{1}{f(\text{in metres})} = \frac{1}{-0.8} = -1.25\text{D}$$

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, $u = -25$ cm

Image distance, $v = -1$ m = -100 m

Focal length, f

Using the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-100} - \frac{1}{-25} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{25} - \frac{1}{100} = \frac{4-1}{100} = \frac{3}{100}$$

$$\Rightarrow f = \frac{100}{3} \text{ cm} = \frac{1}{3} \text{ m}$$

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

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 reach the eyes of the astronauts and the sky appears black to them.

