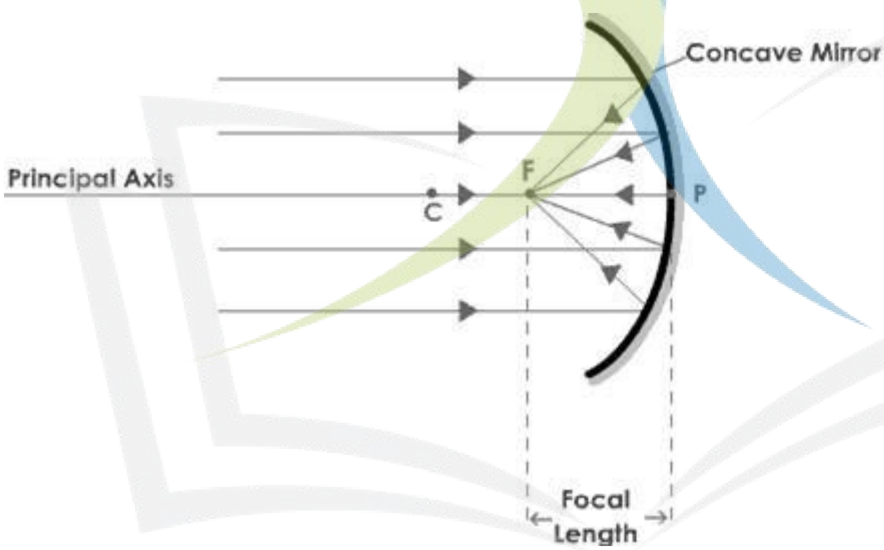
Chapter – 9
Light – Reflection and Refraction

In Text Questions-Pg-142

Q. 1 Define the principal focus of a concave mirror.

Answer: All the light rays which are travelling parallel to the principal axis are bound to meet at a point on the principal axis after reflection from the mirror. This point on the principal axis is called the principal focus of the mirror.



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

Answer: Given, Radius of Curvature, R= 20cmWe Know that

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

$$\therefore f = \frac{20}{2}$$

= 10 cm. Hence the Focal Length of Mirror is 10cm

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

Answer: Concave mirror produces an erect and enlarged image of an object.

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

Answer: We prefer a convex mirror as a rear-view mirror in vehicles because of the following reasons:

(i) A convex mirror always produces an erect image of the objects.

(ii) Also, the image formed is diminished due to which the convex mirror gives a wider view. Therefore, rear-view mirrors are made of convex mirrors.

In Text Questions-Pg-145

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

Ans.: R=+32cm and f=R2=+322=+16cmR=+32cm

and f=R2=+322=+16cm

Thus, the focal length of convex mirror is 16 cm

Q.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.: In this problem we are given,

Magnification, m = -3 (Image is real)

Object distance, u = -10 cm (To the left of mirror)
Image distance, v = ? (To be calculated)
Putting these values in the magnification formula for a mirror:

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

$\Rightarrow$ v = -mu = - (-3) (-10cm) = -30cm

Thus, the image is located at a distance of 30 cm in front of the mirror on its left side.

In Text Questions-Pg-150

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

Ans.: When a ray of light travelling in air enters obliquely into water, it bends towards the normal. This is because water has high refractive index which makes it optically denser than air. Thus, the light ray bends towards the normal when it enters water.

Q.2 Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? 1 speed of light in vacuum is 3 x 108 m s^{-1}

Ans.; We know that:

Refractive index of glass = (Speed of light in air (or vacuum))/(Speed of light in glass)

1.50 = (3×108)/(Speed of light in glass)

Or, Speed of light in glass = $\frac{3\times10^8}{1.5}$ = 2×10^8 ms^{-1}

Thus, the speed of light in glass is 2×108 ms^{-1} (or 2×10^8 m/s).

Q.3 Find out, from Table 9.3, the medium having highest optical density. Also find the medium with lowest optical density

.Ans.: The medium having highest optical density is Diamond (Refractive Index 2.42) and the medium having lowest optical density is Air (Refractive Index 1.0003).

Q.4You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table 9.3.

Ans.:Thus, water is having a lower refractive index and is optically rarer than kerosene and turpentine. The speed of light is inversely proportional to the refractive index. Therefore the light travels fastest in water because of its lower optical density.

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

Ans The above statement means that the speed of light in a diamond is. 42 times the speed of light in a vacuum. As the refractive index of a diamond is quite high, the speed of light in a diamond will reduce by a factor of 2.42 as compared to its speed in air.

In Text Questions-Pg-158

Q.1 Define 1 Dioptre of power of a lens.

Ans.: 1 Dioptre is the power of a lens whose focal length is 1m.

i. e. Power, P = $\frac{1}{F\ (in\ m)}$

Q.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 in size to the object? Also find the power of the lens.

Ans.: (i) In this case needle is the object. Since the image is real, inverted and of same size as the needle (or object), the needle must be at the same distance (50 cm) in front of lens, as the image is behind the lens. Thus, the needle is placed at a distance of 50 cm from lens in the front.

(ii) When the image formed by a convex lens is of the same size as the needle (or object), then the distance of needle from the lens is 2f (twice the focal length).

In this case: focal length, f = 50/2cm

Thus, the focal length of this convex lens is +25 cm. This is equal to (+25)/100m or +0.25m. Now, Power, P= 1/(f(in meters)) = 1/(+0.25) = +4.0 D

So, the power of this convex lens is +4.0 diopters.

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

Ans.: The focal length of a concave lens is considered negative and hence written with a minus sign. So, focal length of concave lens, f = -2 m

Now, Power, P = $\frac{1}{Focal\ lengths\ of\ lens\ (\ in\ meters)}$

$P = \frac{-1}{2}$

Thus, Power, P = -0.5D, Where D stands for Dioptre

Exercise-Pg-159

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

A. water

B. glass

C. plastic

D. clay

Ans.: Clay cannot be used to make a lens. Because it is opaque material, and light cannot pass through it.

A. 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?

B. between the principal focus and the centre of curvature

C. at the centre of curvature

D. beyond the centre of curvature

E. between the pole of the mirror and its principal focus.

Ans.: When the image formed by a concave mirror is observed to be virtual, erect and larger than the object, the position of image will be between the pole of the mirror and its principal focus

Q.2 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 center of the lens and its principal focus

Ans.: The object should be placed at twice the focal length to get a real image of the size of the object. Thus, option (b) is correct.

Q.3 A spherical mirror and a thin spherical lens each have 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 spherical mirror and a thin spherical lens each having a focal length of -15 cm are both concave.

Q.4 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.: Plane mirror or convex mirror both form erect images. Thus, option (d) is correct.

Q.5 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

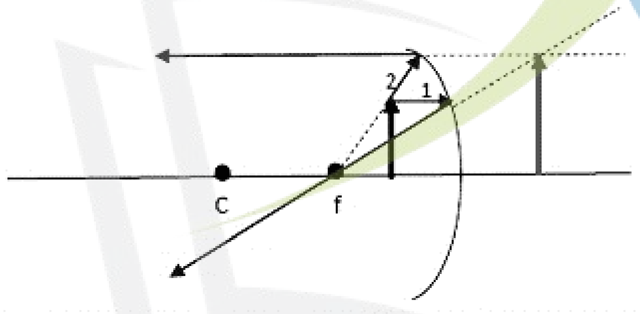
C. A convex lens of focal length 5 cm

D. A concave lens of focal length 5 cm

Ans.: A convex lens of focal length 5 cm is used for reading small letters. Thus, option (c) is correct.

Q.6 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.: In order to obtain an erect image of an object with a concave mirror, the object should be at a distance less than its focal length as seen below:



Here the focal length of concave mirror is 15 cm. So to obtain an erect image the object by using this concave mirror, the object should be placed at any distance which is less than 15 cm from the mirror. The nature of image will be virtual. The image will be larger than the object.

Q.7 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) A concave mirror is used in the headlights of a car. This is because when, a lit bulb is placed at the focus of the concave reflector, then the concave reflector produces a powerful beam of parallel light rays. This beam of light helps us to see things up to a considerable distance in the darkness of night.

(b) A convex mirror is used as side-view mirror or rear-view mirror in a vehicle. This is because:

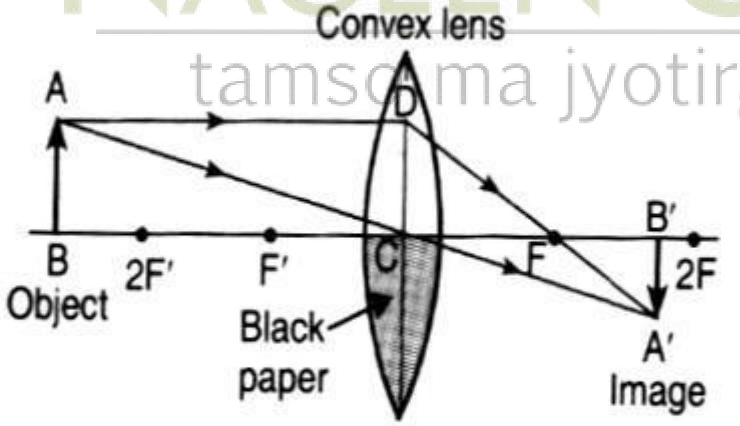
(i) A convex mirror always produces an erect image of the objects

(ii) the image formed in a convex mirror is highly diminished due to which a convex mirror gives a wide field of view of the traffic.

(c) A concave mirror is used in a solar furnace. This is because when the solar furnace is placed at the focus of a large concave reflector, then the concave reflector converges and focuses the sun's heat rays on the furnace due to which the solar furnace gets very hot.

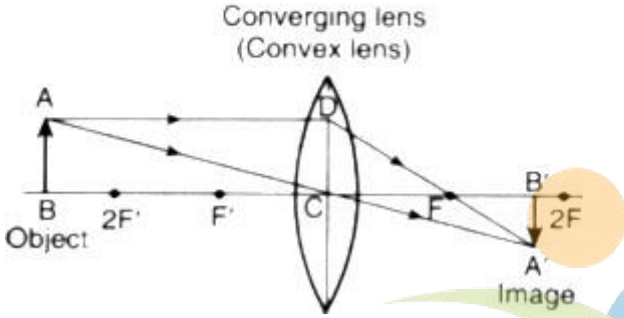
Q.8 One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object ? Verify your answer experimentally. Explain your observations.

Ans.: When a convex lens is half covered with a black paper. It will produce a complete image of an object because light rays can still pass through its optical centre (as shown in figure given here).



Q.9 : 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 nature of the image formed.

Ans,.: A converging lens means a convex lens. The diagram is shown below:



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

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

$$= \frac{-1}{25cm} + \frac{1}{10cm}$$

$$= \frac{-2+5}{50} = \frac{3}{50}$$

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

Here, Object distance, u = - 25 cm

Image distance, v = ? (To be calculated)

And, Focal length, f = + 10 cm (because it is convex lens)

Now, putting these values in the lens formula:

Thus, the position of image is at a distance of 16.67 cm from the lens. The plus sign for image distance shows that the image is formed on the right side of lens (or behind the lens) and that the nature of image is real and inverted.

Let us calculate the magnification now. For a lens:

Magnification,

Thus, the position of image is at a distance of 16.67 cm from the lens. The plus sign for image distance shows that the image is formed on the right side of lens (or behind the lens) and that the nature of image is real and inverted.

Let us calculate the magnification now. For a lens:

Magnification,

$m = \frac{v}{u} = \frac{16.67}{-25} = -0.67$

We will now calculate the size of image h2 by knowing the size of object h1 and value of m:

Now,

$m = \frac{h_2}{h_1}$

$h_2 = h_1 \times m = 5 \times 0.67 = 3.35cm$

Thus, the size of image is 3.35 cm. The negative sign of the magnification shows that the image is inverted.

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

Answer: Here, Object distance, u = ? (To be calculated)

Image distance, v =- 10 cm (To the left of concave lens)

Focal length, f =- 15 cm (It is a concave lens)

Now, putting these values in the lens formula:

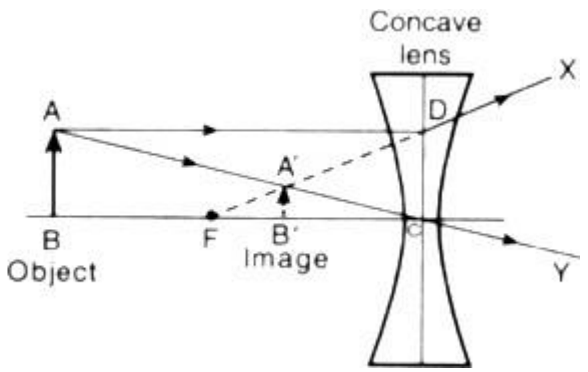
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Putting the values of v and f in the above equation, we get

$$-\frac{1}{u} = -\frac{1}{15} + \frac{1}{10}$$

$$-\frac{1}{u} = \frac{-2+3}{30}$$

$$-\frac{1}{u} = \frac{1}{30}$$



Object distance, u = -30 cm

Thus, the object is placed at a distance of 30 cm from the concave lens. The minus sign with object distance shows that the object is on its left side. The diagram is shown as:

Q.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.

Answer: We can find the position of image by calculating the image distance, v.

Here, Object distance, u =- 10 cm (To the left of mirror)

Image distance, v = ? (To be calculated)

And, Focal length, f = +15 cm (It is a convex mirror)

Putting these values in the mirror formula:

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

we get:

$$\frac{1}{v} + \frac{1}{-10} = \frac{1}{15}$$

$$\frac{1}{v} - \frac{1}{10} = \frac{1}{15}$$

$$\frac{1}{v} = \frac{1}{15} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{2+3}{30}$$

$$\frac{1}{v} = \frac{5}{30}$$

$$\frac{1}{v} = \frac{1}{6}$$

So, Image distance, v = + 6cm

Thus, the position of image is at a distance of 6 cm from the convex mirror on its right side (behind the mirror). Since the image is formed behind the convex mirror, therefore, the nature of image is virtual and erect.

Q.13 The magnification produced by a plane minor is +L What does this mean ?

Ans.: The plus sign (+) of the magnification shows that the image is virtual and erect. And the value 1 for magnification shows that the image is exactly of the same size as the object. So, the magnification of +1 produced by a plane mirror means that the image formed in a plane mirror is virtual and erect, and of the same size as the object.

Q.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.: Here, Object distance, u = -20 cm (to the left of mirror)

Image distance, v = ? (To be calculated)

Radius of curvature, R = +30cm (It is a convex mirror)

So, Focal length, $f = \frac{R}{2} = \frac{30}{2} = +15$cm.

Now, putting these values of u and applying formula:

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

we get:

$$\frac{1}{v}-\frac{1}{20}=\frac{1}{15}$$

$$\frac{1}{v} = \frac{1}{15}+\frac{1}{20}$$

$$\frac{1}{v} = \frac{4+3}{60}=\frac{7}{60}$$

$V = \frac{60}{7}$ or $V = +8.57$ cm

Thus, the position of image is 8.57 cm behind the mirror (on its right side). Since the image is formed behind the convex mirror, therefore, the nature of image is virtual and erect.

Now,

For a mirror, Magnification, $m = (-\frac{v}{u})$

So, $m = -(\frac{+8.57}{-20}) = +0.42$

Also, magnification, $m = \frac{h_2}{h_1}$

Where h_2 = Heigh t of image, h_1= Height of Object

So, $+0.42 = \frac{h_2}{5.0}$

$h_2 = 0.42\times5.0 = 2.1$ cm

Thus, the size of image is 2.1 cm.

Q.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 focused image can be obtained? Find the size and nature of the image.

Ans.: Here, Object distance, u = -27 cm (To the left side of mirror)

Image distance, v = ? (To be calculated)

Focal length, f = -18 cm (It is a concave mirror)

Height of object, h_1 = 7.0 cm

And, Height of image, h_2 = ? (To be calculated)

Now, For a mirror:

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

$$\frac{1}{v} + \frac{1}{-27} = \frac{1}{-18}$$

$$\frac{1}{v} - \frac{1}{27} = -\frac{1}{18}$$

$$\frac{1}{v} = -\frac{1}{18} + \frac{1}{27}$$

$$\frac{1}{v} = \frac{-3+2}{54} = -\frac{1}{54}$$

Image distance, v = -54 cm

Since the image distance is minus 54 cm, therefore, the screen should be placed at a distance of 54 cm in front of the concave mirror (on its left side). The nature of image obtained on the screen is real and inverted.

Also, For a mirror $\frac{h_2}{h_2} = \frac{-54}{-27}$

$$\frac{h_2}{7.0} = -2$$

h_2 = -2 × 7.0

= -14.0 cm

Thus, the size of image is 14.0 cm.

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

Ans.: The power of this lens has a negative sign (or minus sign), indicating its a concave lens. Now,

Power, P = $\frac{1}{f\ (in\ meters)}$ = f (Focal length)

So, -2.0 = $\frac{1}{f}$

and f = $-\frac{1}{2.0}$m

Or, f = $-\frac{1}{2.0} \times 100\ cm$

So, Focal length of lens, f = -50 cm

Q.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?

Answer:

The power of this lens is positive (with a plus sign), therefore, this is a convex lens or converging lens. Now,

Power, P = $\frac{1}{f\ (in\ meters)}$

So, + 1.5 = $\frac{1}{f}$

$\therefore f = \frac{1}{+1.5m}$

$\Rightarrow f = \frac{1}{1.5m} \times 100\ cm$

So, Focal length of lens, f = +66.7 cm.