Chapter 10
Light- Reflectiion & Refraction

Intext Questions

On Page 168

Question 1: Define the principal focus of a concave mirror.

Solution: Principal focus of the concave mirror: A point on principal axis on which parallel light rays converges after reflecting from the mirror.

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

Solution:

Radius of curvature, R = 20 cm

Radius of curvature of a spherical mirror = 2 × Focal length (f)

$$R = 2f$$
$$f = 10cm$$

Hence, the focal length of the given spherical mirror is 10 cm.

Question 3: Name the mirror that can give an erect and enlarged image of an object.

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

Question 4: Why do we prefer a convex soirror as a rear-view mirror in vehicles?

Solution: Convex mirrors forms a virtual, erect, and diminished image of the objects that are placed in front of them. These mirrors give a wider field of view, which allows the driver to see most of the traffic behind him. Thus, they are preferred as a rear-view mirror in vehicles.

On Page 171

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

Solution:

Radius of curvature, R = 32 cm

Radius of curvature = 2 × Focal length (f)

$$R = 2f$$
$$f = \frac{R}{2}$$
$$f = 16cm$$

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

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

Solution: Magnification produced by a spherical mirror is:

$$m = \frac{\text{Height of the image}}{\text{Height of the object}} = -\frac{\text{Image distance}}{\text{Object distance}}$$
$$m = \frac{h_1}{h_0} = -\frac{v}{u}$$

Let the height of the object, $h_o = h$

Then, height of the image = −3h

$$\frac{-3h}{h} = -\frac{v}{u}$$
$$\frac{v}{u} = 3$$

Object distance, $u = -10$ cm

$v = 3 \times (-10) = -30$ cm

Here, an inverted image is formed at a distance of 30 cm.

On Page 176

Question 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?

Solution: We know that, light ray bends towards the normal.

Water is optically denser than air; a ray of light travelling from air into the water will bend towards the normal.

Question 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^{-1}.

Solution:

Refractive index of a medium, $n_m = \dfrac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \dfrac{c}{v}$

Speed of light in vacuum, $c = 3 \times 10^8 \, ms^{-1}$

Refractive index of glass, $n_g = 1.50$

$$v = \frac{c}{n_m}$$
$$v = \frac{3 \times 10^8}{1.5}$$
$$v = 2 \times 10^8 \text{ m/s}$$

Thus, Speed of light in the glass $= 2 \times 10^8$ m/s

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

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31	-	-
Water	1.33	Rock salt	1.54
Alcohol	1.36	-	-
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown glass	1.52	Diamond	2.42

Solution: 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.

Highest optical density = Diamond

Lowest optical density = Air

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

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

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

$$v = \frac{c}{n_m}$$

$$v \propto \frac{1}{n_m}$$

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 light travels the fastest in water.

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

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

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

The refractive index of diamond is 2.42.

This means that the speed of light in diamond will reduce by a factor 2.42 compared to its speed in air.

On Page 184

Question 1: Define 1 dioptre of power of a lens.

Solution:

Power of lens: It is defined as the reciprocal of its focal length.

If P is the power of a lens of focal length F in metres, then

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

The S.I. unit of power of a lens is Dioptre. It is denoted by D. 1 dioptre is defined as the power of a lens of focal length 1 metre.

$$\therefore 1\ D = 1\ m^{-1}$$

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

Solution:

Focal length of concave lens, f = 2 m

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

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

$$P = -0.5 D$$

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

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

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Exercise

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

(a) Water

(b) Glass

(c) Plastic

(d) Clay

Solution: (d) Clay

Question 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.

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

Question 3: Where an object should 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.

Solution: (b) At twice the focal length

Question 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

Solution: (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.

Question 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

Solution: (d) Either plane or convex

Question 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

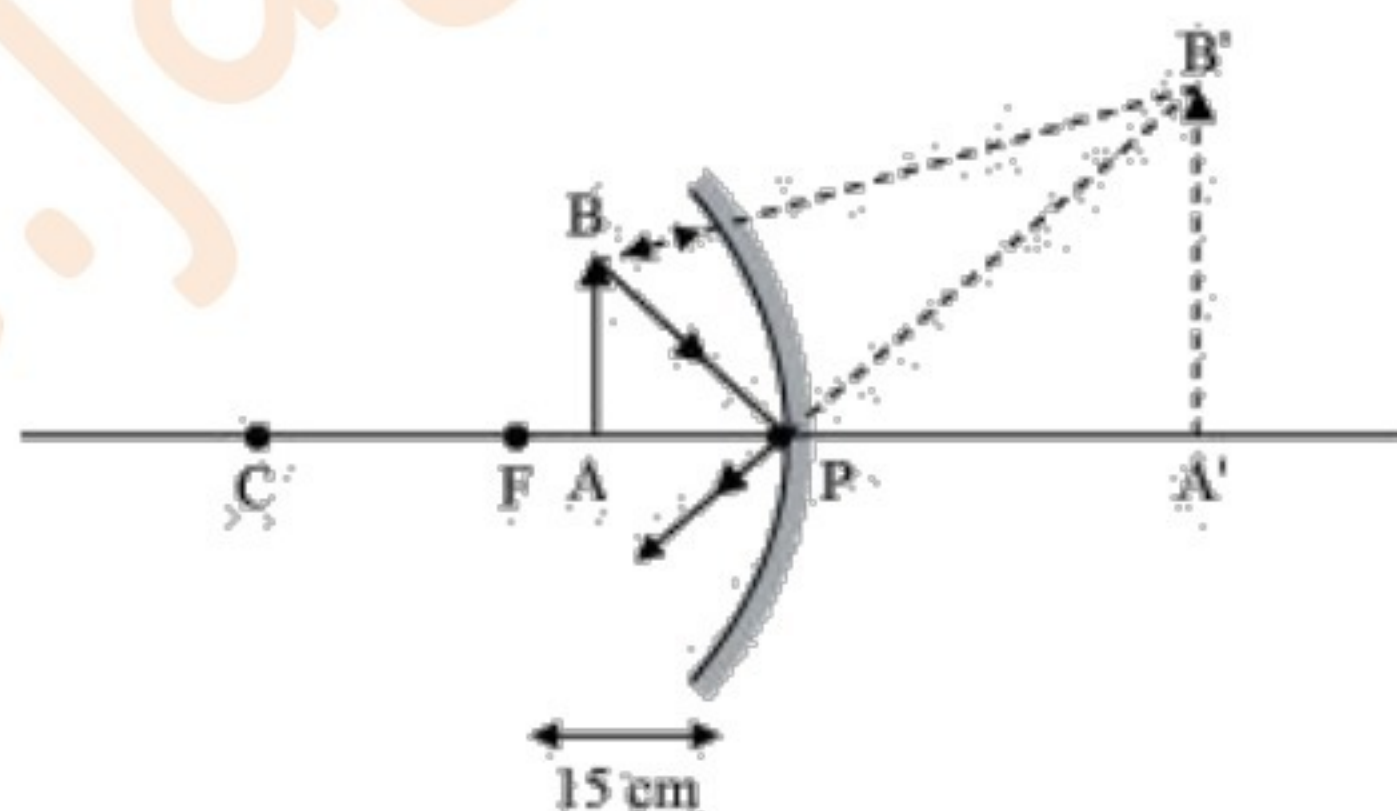**Solution:** (c) A convex lens of focal length 5 cm should be used.

Question 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.

Solution:

Range of object distance = 0 cm to15 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.

Question 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.

Solution:

a) Concave mirror is used in the headlights of a car 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.

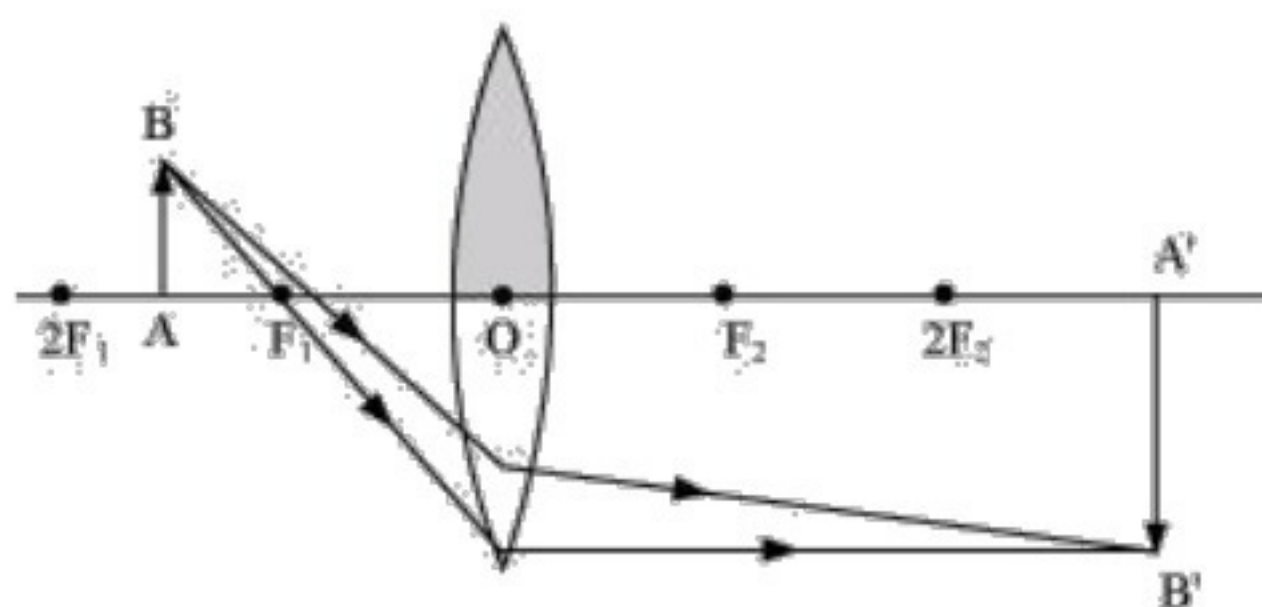c) Concave mirrors are convergent mirrors. That is why they are used to construct solar furnaces.

Question 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.

Solution:

The convex lens will form complete image of an object, even if it's one half is covered with black paper.

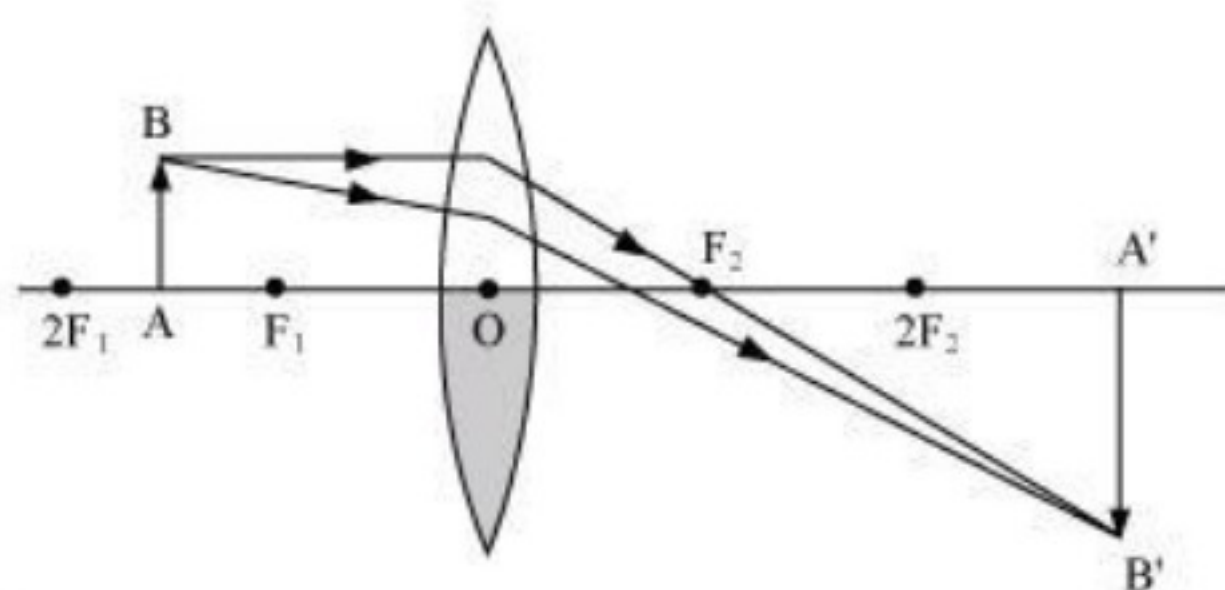Case I: When the upper half of the lens is covered.

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.

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.

Question 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.

Solution:

Object distance, u = −25 cm

Object height, h_o = 5 cm

Focal length, f = +10 cm

According to the lens formula,

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

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

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{25}$$

$$\frac{1}{v} = \frac{15}{250}$$

$$v = 16.66 cm$$

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

$$\text{Magnification, } m = -\frac{\text{Image distance}}{\text{Object distance}} = -\frac{v}{u} = \frac{-16.66}{25} = -0.66$$
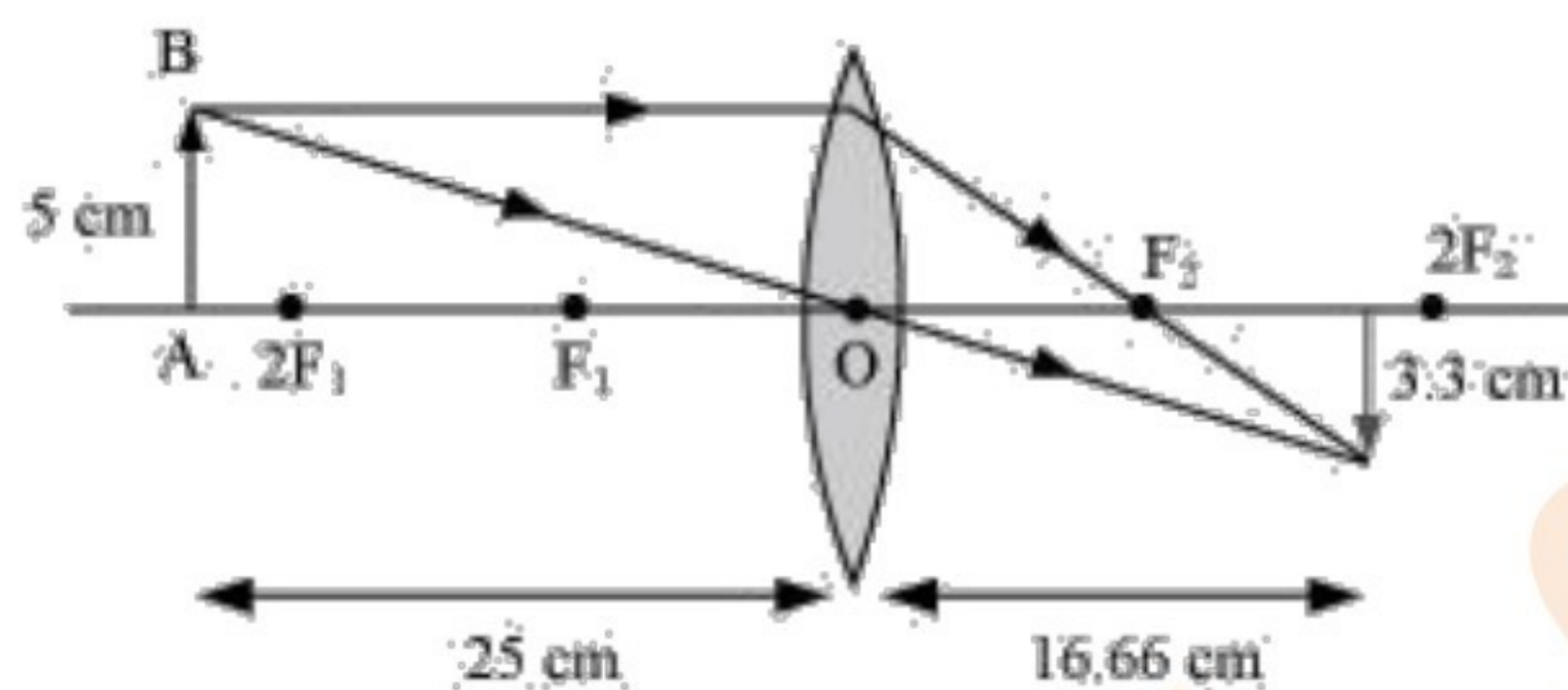
The negative sign shows that the image is real and formed behind the lens.

Magnification, $m = -\dfrac{\text{Height of the image}}{\text{height of the object}} = \dfrac{h'}{5}$

$h' = -0.66 \times 5$

$h' = -3.3 cm$

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

Question 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.

Solution:

Focal length of concave lens (OF_1), $f = -15$ cm

Image distance, $v = -10$ cm

According to the lens formula,
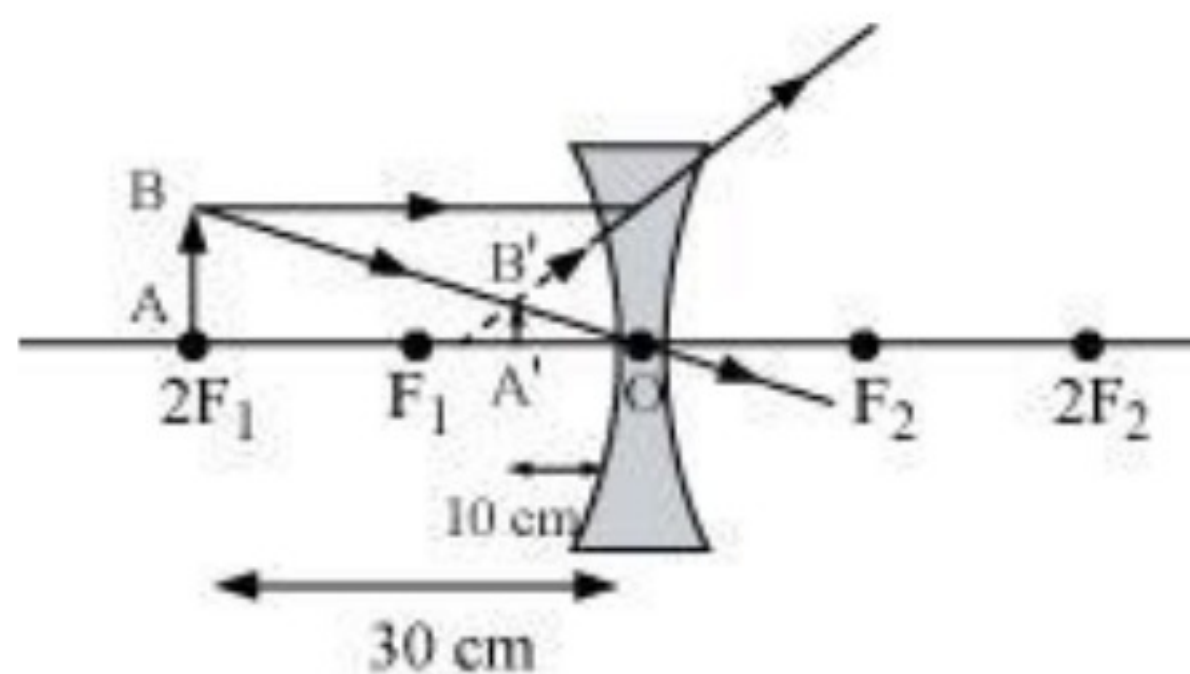
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

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

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

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

$$u = -30 cm$$

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.

Question 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.

Solution:

Focal length of convex mirror, f = +15 cm

Object distance, u = −10 cm

According to the mirror formula,

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

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

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

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

$$v=6cm$$

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.

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

Solution: Magnification produced by a mirror is given by the relation

$$\text{Magnification, } m = \frac{\text{Image height (H}_1)}{\text{Object height (H}_0)}$$

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.

Question 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.

Solution:

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,

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

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

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

$$\frac{1}{v} = \frac{7}{60}$$

$$v = 8.57 \, cm$$

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

Magnification, $m = -\dfrac{\text{Image distance}}{\text{Object distance}} = \dfrac{-8.57}{-20} = 0.428$

Magnification, $m = \dfrac{\text{Image height}}{\text{Object height}} = \dfrac{h'}{h}$

$h' = mh$

$h' = 0.428 \times 5$

$h' = 2.14 cm$

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

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

Question 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 the nature of the image.

Solution:

$u = -27 cm$

$h = 7 cm$

$f = -18 cm$

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

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

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

$\dfrac{1}{v} = -\dfrac{1}{54}$

$v = -54 cm$

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

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

Magnification, $m = -\dfrac{\text{Height of the image}}{\text{height of the object}} = \dfrac{h'}{h}$

$h' = 7 \times -2$

$h' = -14 cm$

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

Question 16: Find the focal length of a lens of power −2.0 D. What type of lens is this?

Solution:

Power of a lens, $\text{P} = \dfrac{1}{f}$

$P = -2D$

$f = -\dfrac{1}{2}$

$f = -0.5m$

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