Exercises

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

(a) Water

(b) Glass

(c) Plastic

(d) Clay

Answer 1:
(d) A lens allows light to pass through it. Since clay does not show such property, it cannot be used to make a lens.

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.

Answer 2:
(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.

Question 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.

Answer 3:
(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.

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

Answer 4:
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

Answer 5:
(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.

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

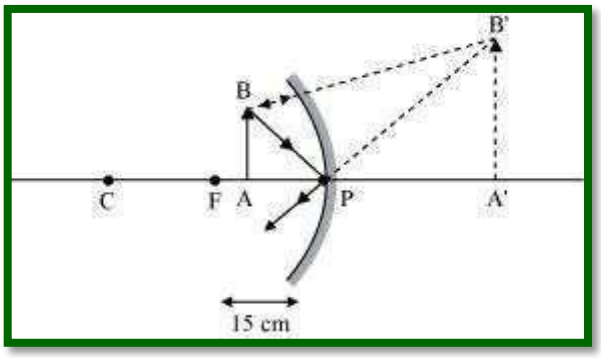
(c) A convex lens of focal length 5 cm

(d) A concave lens of focal length 5 cm

Answer 6:
(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.

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.

Answer 7:
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, as shown in the given figure.



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.

Answer 8:
(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.

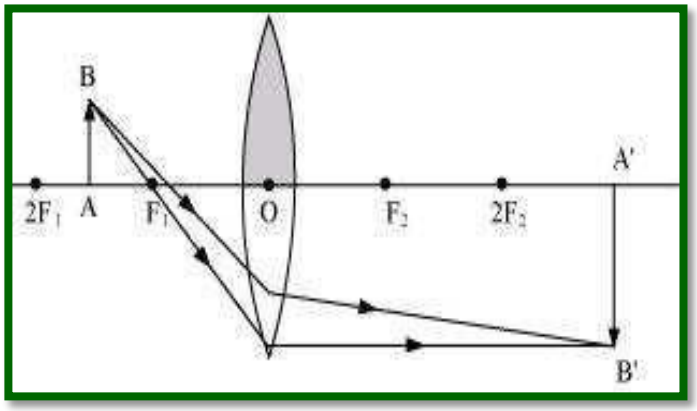
(c) Concave mirrors are convergent mirrors. That is why they are used to construct solar furnaces. Concave mirrors converge the light incident on them at a single point known as principal focus. Hence, they can be used to produce a large amount of heat at that point.

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.

Answer 9:
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

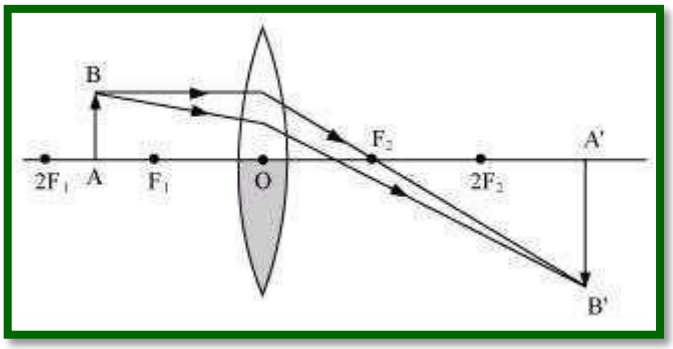
When the upper half of the lens is covered
In this case, a ray of light coming from the object will be refracted by the lower half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in the following figure.



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.



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.

Answer 10:

Object distance, u = −25 cm

Object height, h_o = 5 cm

Focal length, f = +10 cm

According to the lens formula,

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

$$\frac{1}{v}=\frac{1}{f}+\frac{1}{u}=\frac{1}{10}-\frac{1}{25}=\frac{15}{250}$$

$$v=\frac{250}{15}=16.66\text{ cm}$$

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

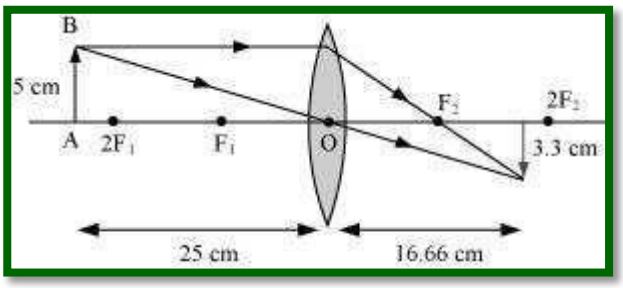
$$\text{Magnification}, m=-\frac{\text{Image distance}}{\text{Object distance}}=-\frac{v}{u}=\frac{-16.66}{25}=-0.66$$

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

$$\text{Magnification}, m=\frac{\text{Image height}}{\text{Object height}}=\frac{H_1}{H_o}=\frac{H_1}{5}$$

$$H_1=m\times H_o=-0.66\times 5=-3.3\text{ cm}$$

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.



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.

Answer 11:
Focal length of concave lens (OF_1), $f = -15$ cm

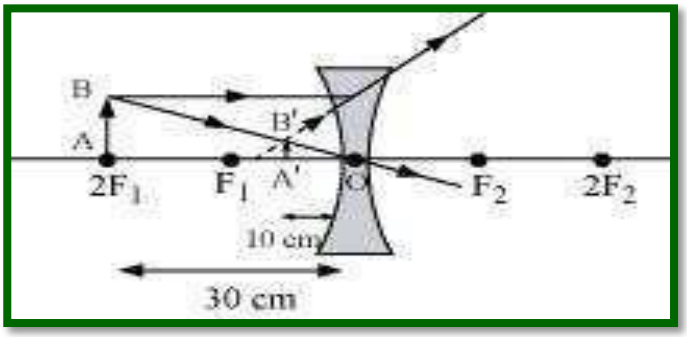
Image distance, $v = -10$ cm
According to the lens formula,

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

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{-1}{10} - \frac{1}{(-15)} = \frac{-1}{10} + \frac{1}{15} = \frac{-5}{150}$$

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

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.



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.

Answer 12:
Focal length of convex mirror, f = +15 cm
Object distance, u = −10 cm
According to the mirror formula,

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

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{15}+\frac{1}{10}=\frac{25}{150}$$

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

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.

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

Answer 13:
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.

Answer 14:
Object distance, u = −20 cm
Object height, h = 5 cm
Radius of curvature, R = 30 cm
Radius of curvature = 2 × Focal length
R = 2f f = 15 cm

According to the mirror formula,

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

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

$$v=8.57\text{ cm}$$

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

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

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

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

$$h'=m\times h=0.428\times 5=2.14\text{ cm}$$

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

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

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.

Answer 15:
Object distance, u = −27 cm
Object height, h = 7 cm
Focal length, f = −18 cm

According to the mirror formula,

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

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

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

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

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

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

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

$$h' = 7 \times (-2) = -14 \text{ cm}$$

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?

Answer 16:

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

$$P = -2 \text{ D}$$

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

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

Question 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 17:

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

$$\text{Power}, P = 1.5 \text{ D}$$

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

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