Light-Reflection and Refraction

CHAPTER 10

NCERT FOCUS

ANSWERS

Topic 1

1. As $m = \frac{h_2}{h_1} = +1$

$\Rightarrow h_2 = h_1$

i.e., size of image is equal to size of the object. Further, + sign of m indicates that the image is erect and hence virtual.

Topic 2

1. A point on the principal axis where the parallel rays of light after reflecting from a concave mirror meet.

2. Radius of curvature, $R = 20$ cm

$\therefore$ Focal length, $f = \frac{R}{2} = \frac{20}{2} = 10$ cm

3. A concave mirror gives an erect and enlarged image of an object held between pole and principal focus of the mirror.

4. This is because a convex mirror forms erect and diminished (small in size) images of the objects behind the vehicle and hence the field of view behind the vehicle is increased.

5. Given, $R = +32$ cm

$\therefore \quad f = \frac{R}{2} = \frac{32}{2} = +16$ cm

Thus, the focal length of the convex mirror = + 16 cm.

6. Here, linear magnification $(m) = -3$

(Negative sign for real image, which is inverted)

Object distance $(u) = -10$ cm

Image distance $(v) = ?$

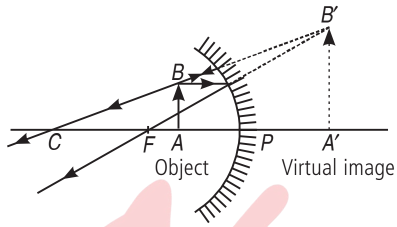
As $\quad m = -\frac{v}{u} \Rightarrow -3 = \frac{-v}{-10} \quad \therefore \quad v = -30$ cm

The image is located at 30 cm in front of the mirror.

7. **(d) :** For virtual, erect and larger image, the object must lie between the pole of the mirror and its focus.

8. **(d) :** The image is erect in a plane mirror and also in a convex mirror, for all positions of the object.

9. A concave mirror produces an erect image if the object is placed between the pole and the focus of the concave mirror. Thus, object may be placed at any position whose distance is less than 15 cm from the concave mirror. The image is virtual and erect. The image is larger than the object.



10. **(a)** For headlights of a car, we use a concave mirror. The light source is held at the focus of the mirror. On reflection, a strong parallel beam of light emerges.

(b) A convex mirror is used as side/rear view mirror, because its field of view is larger and it forms virtual, erect and diminished images of objects behind.

(c) For solar furnace, we use a concave mirror. Light from the sun, on reflection from the mirror, is concentrated at the focus of the mirror, producing heat.

11. Here, object distance $(u) = -10$ cm,

focal length $(f) = 15$ cm,

image distance $(v) = ?$

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

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

$\therefore \quad v = +6$ cm

Here, + sign of v indicates that image is behind the mirror. It must be virtual, erect and smaller in size than the object.

12. Here, object size $(h_1) = 5.0$ cm,

object distance $(u) = -20$ cm

Radius of curvature $(R) = 30$ cm,

image distance $(v) = ?$

As $\quad \frac{1}{v} + \frac{1}{u} = \frac{1}{f} = \frac{2}{R}$

$\Rightarrow \quad \frac{1}{v} = \frac{2}{R} - \frac{1}{u} = \frac{2}{30} + \frac{1}{20} = \frac{4+3}{60} = \frac{7}{60}$

$\therefore \quad v = \frac{60}{7} = +8.57$ cm

Positive sign of v indicates that image is behind the mirror. It must be virtual and erect.

As $\quad m = \frac{h_2}{h_1} = -\frac{v}{u} \Rightarrow \frac{h_2}{5.0} = -\frac{60/7}{-20} = \frac{3}{7}$

$\therefore \quad h_2 = \frac{3}{7} \times 5.0 = \frac{15.0}{7} = 2.1 \text{ cm}$

This is the size of the erect image.

13. Here, object size (h_1) = 7.0 cm,
object distance (u) = – 27 cm,
focal length (f) = –18 cm,
image distance (v) = ?

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

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

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

Therefore, the screen should be held in front of the mirror at a distance of 54 cm from the mirror. The image obtained on the screen will be real.

As $m = \frac{h_2}{h_1} = -\frac{v}{u} \Rightarrow \frac{h_2}{7.0} = -\frac{-54}{-27}$

$\therefore \quad h_2 = -14.0 \text{ cm}$

Negative sign of h_2 shows that the image is inverted.

Topic 3

1. When a ray of light travels from air into water obliquely, it bends towards the normal. This is because water is optically denser than air. On entering water, speed of light decreases and the light bends towards normal.

2. Here, refractive index, $\mu = 1.50$,
speed of light in vacuum, $c = 3 \times 10^8 \text{ m s}^{-1}$
speed of light in glass, v = ?

As, $\mu = \frac{c}{v}$

$\Rightarrow v = \frac{c}{\mu} = \frac{3 \times 10^8}{1.50} = 2 \times 10^8 \text{ m s}^{-1}$

3. The medium with highest optical density is diamond and its refractive index is maximum (= 2.42), also, the medium with lowest optical density is air and its refractive index is minimum (= 1.0003).

4. We know from the definition of refractive index, that the speed of light is higher in a medium with lower refractive index. So, the light travels fastest in water relative to kerosene and turpentine.

5. This statement means that the speed of light in diamond is lower by a factor of 2.42 relative to that in vacuum.

6. The power of a lens whose focal length is one metre (1 m) is one dioptre.

7. Distance of the image from the lens, v = 50 cm
Distance of the object from the lens, u = ?
Size of the image, I = Size of the object, O
From the definition, if h_2 is the height of the image and h_1 is the height of the object,

magnification = $\frac{I}{O} = \frac{-h_2}{h_1} = -1$ [$\because$ The image is inverted]

For a lens, magnification = $\frac{v}{u}$

So, $\frac{v}{u} = -1$

$\Rightarrow \quad u = -v = -50 \text{ cm}$

So, the needle (the object) is placed at a distance of 50 cm in front of the lens.

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

$\Rightarrow \frac{1}{f} = \frac{1}{50 \text{ cm}} - \frac{1}{-50 \text{ cm}} = \frac{1}{50 \text{ cm}} + \frac{1}{50 \text{ cm}} = \frac{2}{50 \text{ cm}} = \frac{1}{25 \text{ cm}}$

$\therefore \quad f = 25 \text{ cm}$

Then, power of the lens = $\frac{100}{f\text{ (cm)}} \text{ D} = \frac{100}{25} \text{ D} = 4 \text{ D}$

8. Focal length of the concave lens = –2 m = – 200 cm

$\because \quad P = 100/f$

$\therefore$ Power of the concave lens = $\frac{100}{-200} \text{ D} = -0.5 \text{ D}$

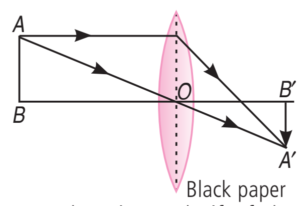
9. **(d) :** The correct answer is (d), because clay is opaque.

10. **(b) :** The object is to be placed at twice the focal length of the lens.

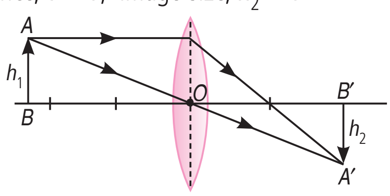
11. **(a) :** As per new cartesian sign conventions, the focal length of a concave mirror and focal length of a concave lens, both are negative. Therefore, both are concave.

12. **(c) :** For reading small letters in a dictionary, we need to use a convex lens of smaller focal length.

13. Yes, it will produce a complete image of the object, as shown in figure. This can be verified experimentally by observing the image of a distant object like tree on a screen, when lower half of the lens is covered with a black paper. However, the intensity or brightness of image will reduce.



14. Here, object size, h_1 = 5 cm
object distance, u = – 25 cm, focal length of lens, f = 10 cm
image distance, v = ?, image size, h_2 = ?



As $\frac{1}{v}=\frac{1}{u}+\frac{1}{f} \Rightarrow v=\frac{50}{3}=16.67$ cm

As v is positive, the image formed is real, on the right side of the lens, as shown in figure.

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

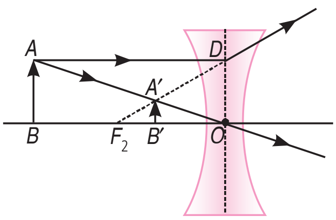
$\therefore \frac{h_2}{5}=\frac{50/3}{-25}=\frac{-2}{3} \Rightarrow h_2=-\frac{10}{3}=-3.3$ cm

Negative sign shows that the image is inverted.

15. Here, focal length of lens, $f=-15$ cm

image distance, $v=-10$ cm

object distance, $u=?$



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

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

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

$\therefore u=-30$ cm

16. Here, focal length, $f=?$, power, $P=-2.0$ D

As $f=\frac{100}{P} \Rightarrow f=\frac{100}{-2.0}=-50$ cm

As power of lens is negative, the lens must be concave.

17. Power of the lens, $P=+1.5$ D $= +1.5$ m^{-1}

$\therefore$ Focal length of the lens, $f=\frac{1}{+1.5\,\text{m}^{-1}}$

$= 0.667$ m $= 66.7$ cm

Thus, the focal length of the lens is 66.7 cm.

Since the focal length of the lens is positive, hence the given lens is a converging lens.

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