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Light–Reflection and Refraction

INTEXT Questions

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

Ans. The point on the principal axis, where all incident rays parallel to principal axis meet after reflection is called principal focus.

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

Ans. $R = 20$ cm

$$f = \frac{R}{2} = \frac{20}{2} = 10$$

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

Ans. Concave mirror.

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

Ans. A convex mirror can show image of a wider area, because of its wide field of view which helps the driver to see more of traffic coming from behind. Therefore, convex mirror is used as rear-view mirror in vehicles.

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

Ans. Given, radius of curvature (R) = 32 cm and focal length (f) =?

We know that, $R = 2f$

$$\Rightarrow f = \frac{32\text{ cm}}{2} = 16\text{ cm}$$

Thus, focal length = 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. Given, $u = -10$ cm

Since image is real inverted so, $m = -3$

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

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

Negative sign indicates the image will be real and image is formed at 30 cm in front of the mirror.

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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?**

Ans. When a ray of light travels from air to water obliquely, it bends towards the normal. This is because water is optically denser than air. So speed of light in water is less than that of air.

2. **Light enters from air to glass having refractive index 1.50. What is the speed of light in glass? The speed of light in vacuum is 3×10^8 m/s.**

Ans. Given, refractive index, $n = 1.5$

$c = 3 \times 10^8$ m/s

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

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

3. **Find out from the given 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

Ans. Diamond has the highest optical density. Air has the lowest optical density.

4. **You are given kerosene, turpentine oil and water. In which of these does the light travel fastest?**

Ans. As we know that the light travels fastest in a medium whose refractive index is smallest. So, the light travels fastest in water as compared to kerosene and turpentine oil.

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

Ans. As we know that refractive index

$$n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$$

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

Here $n = 2.42$ and $c = 3 \times 10^8$m/s

$$\Rightarrow \quad v = \frac{3\times 10^8}{2.42}$$

Thus, the speed of light in diamond will be $\frac{1}{2.42}$ times the speed of light in vacuum.

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1. **Define 1 dioptre of power of a lens.**

Ans. One dioptre is the power of a lens of focal length 1 metre.

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.**

Ans. $v = +50$ cm
Since image is real and of same size. The position of image should be double the focal length.
Hence, the object should be at $2f$.
$v = 2f = 50$, $f = 25$ cm.

$$\text{Power} = \frac{1}{f} = \frac{100}{25} = 4 \text{ D.}$$

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

Ans. As it is a concave lens, thus focal length, $f = -2$ m

So, power of lens, $P = \frac{1}{f}$

$$\Rightarrow \quad P = \frac{1}{-2\,\text{m}} = -0.50 \text{ D}$$

$$\Rightarrow \quad P = -0.5 \text{ D}$$

Therefore power of the given lens is -0.5 D.

TEXTBOOK **Questions**

1. Which one of the following materials cannot be used to make a lens?
(a) Water (b) Glass
(c) Plastic (d) Clay

Ans. (d) Clay

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) Between the pole of the mirror and its principal focus.

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) At twice the focal length

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) Both concave.

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) 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 of focal length 5 cm.

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. We are given the focal length of the concave mirror as $f = -15$ cm.

For getting an erect image using a concave mirror, the object should be placed at a distance less than the focal length, *i.e.* 15 cm from the pole. The image formed will be virtual, enlarged and erect.

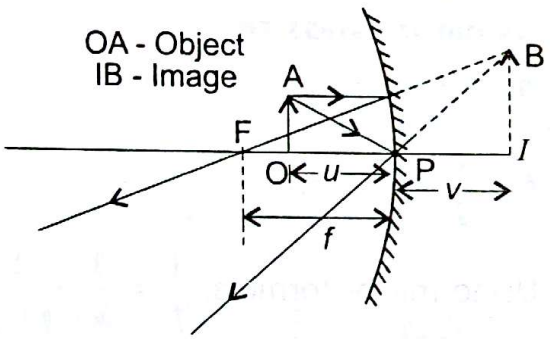


Image formation when the object is placed between focus and pole of a concave mirror

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 mirror, to get powerful and parallel beams of light.

(b) Convex mirror because it always gives an erect image and enables the driver to view much larger area.

(c) Concave or parabolic mirror because it can concentrate sunlight at the focus to produce heat in the solar furnace.

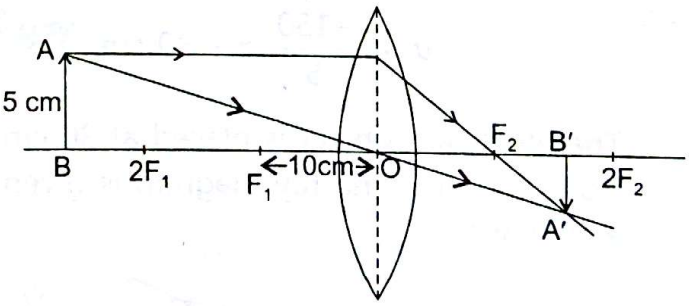
9. One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

Ans. Yes, even when one half of the lens is covered with a black paper, complete image of the object will be formed.

Take a convex lens and focus the light from a distant object onto a screen. As expected an image (sharp) is formed at a distance equal to the focal length. Cover the lower or the upper half of the lens and focus the light from the same object onto the same screen. You will be able to get a sharp image again; however the brightness of the image will be less in the second case. The same effect will be seen even if the lens is half covered with black strips.

10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw a ray diagram and find the position, size and the nature of the image formed.

Ans.



Using lens formula, we have

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

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

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

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

$$\Rightarrow v = \frac{250}{15} = \frac{50}{3}$$

$$= 16.66 \text{ cm}.$$

$$m = \frac{v}{u} = \frac{h'}{h}$$

$$\frac{50/3}{-25} = \frac{h}{5}$$

$$\Rightarrow \quad h = \frac{-10}{3} = -3.33 \text{ cm}$$

Therefore, the image is formed between F_2 and $2F_2$ on the other side of the lens. It is real and inverted, and smaller in size than the object.

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. $f = -15$ cm, $v = -10$ cm

Using lens formula, we have

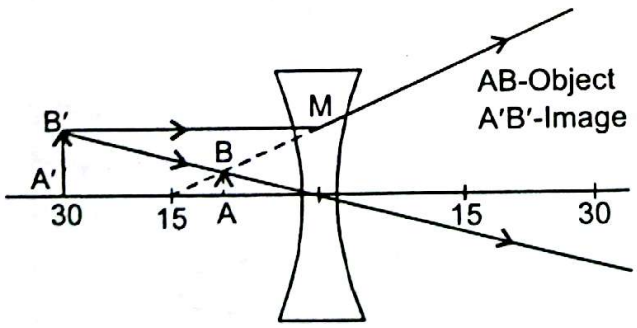
$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

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

$$\frac{1}{u} = \frac{1}{-10} - \frac{1}{-15} = \frac{-5}{150}$$

$$u = \frac{-150}{5} = -30 \text{ cm.}$$

Therefore, the object is placed at 30 cm from the lens. The ray diagram is given as follows:



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. $f = +15$ cm, $u = -10$ cm

For mirror, we have

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

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

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

$$v = \frac{150}{25} = 6 \text{ cm}$$

The image must be virtual and erect.

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

Ans. This means that size of the image is equal to the size of the object.

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. $h_o = +5.0$ cm, $u = -20$ cm,

$$f = \frac{R}{2} = +15 \text{ cm}$$

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, we get

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

$$= \frac{20+15}{300} = \frac{35}{300}$$

$$v = \frac{300}{35} = \frac{60}{7} = 8.57 \text{ cm.}$$

Using $m = \frac{h_1}{h_o} = -\frac{v}{u}$, we get

$$h_1 = -5 \times \frac{8.57}{-20} = 2.16 \text{ cm.}$$

Since v is $+ve$, the image is virtual.

Since $h_1 = 2.16$ cm < 5.0 cm, the image is diminished.

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 nature of the image.

Ans. $h_o = 7.0$ cm, $u = -27$ cm, $f = -18$ cm

Using $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, we get

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-18} - \frac{1}{(-27)}$$

$$= \frac{-1}{18} + \frac{1}{27} = \frac{-3+2}{54} = \frac{-1}{54}$$

$v = -54$ cm

Using $m = \frac{h_1}{h_o} = \frac{-v}{u}$, we get

$$h_1 = -h_o \times \frac{v}{u} = -7 \times \frac{-54}{-27}$$

$$= -14 \text{ cm.}$$

Since $h_1 > h_o$, the image is enlarged.
As the value of h_1 is *–ve*, the image is inverted.
Since v is *–ve*, the image is real.

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

Ans. We know that

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

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

$$= -\frac{100}{2} \text{ cm} = -50 \text{ cm.}$$

As the focal length of lens is *–ve*, it will be 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. $P = +1.5$ D

$$f = \frac{100}{P} \text{ cm} = \frac{100}{1.5}$$

$$= \frac{1000}{15} = +66.67 \text{ cm} = +0.67 \text{ m}$$

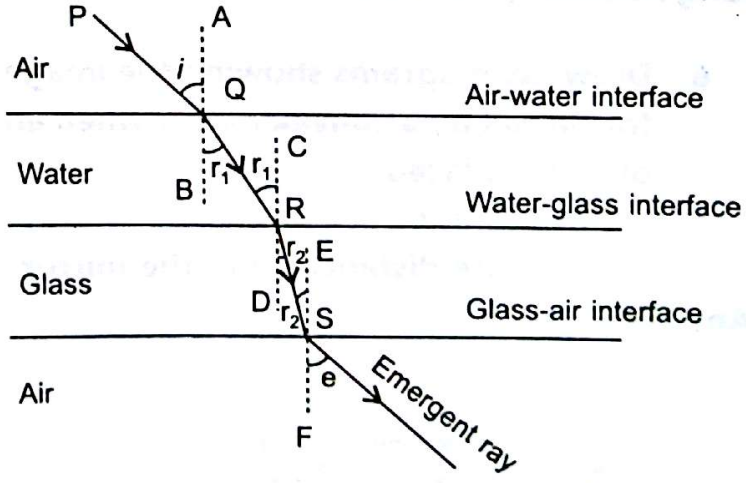
As the focal length is *+ve*, it is convex lens. Hence, it is a converging lens.

Selected NCERT Exemplar Problems

Short Answer Questions

1. Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself? Explain using a diagram.

Ans. Due to variation in speed of light in different medium, light bends as it moves from one medium to another. Since, there are two surfaces for refraction which are parallel, the light ray should bend in opposite sense in them equally, the emerging light ray is always parallel to the incident ray.



2. A pencil when dipped in water in a glass tumbler appears to be bent at the interface of air and water. Will the pencil appears to be bent to the same extent, if instead of water we use liquids like, kerosene or turpentine. Support your answer with reason.

Ans. No, it will depend on the refractive index of the liquid in which the pencil is dipped. The tip at the bottom will get elevated as per the relation.

$$\text{Refractive index } (n) = \frac{\text{real depth}}{\text{apparent depth}}$$

3. Refractive index of diamond with respect to glass is 1.6 and absolute refractive index of glass is 1.5. Find out the absolute refractive index of diamond.

Ans. $n_{dg} = 1.6,\ n_g = 1.5$

Since, $n_{dg} = \frac{n_d}{n_g}$, we have

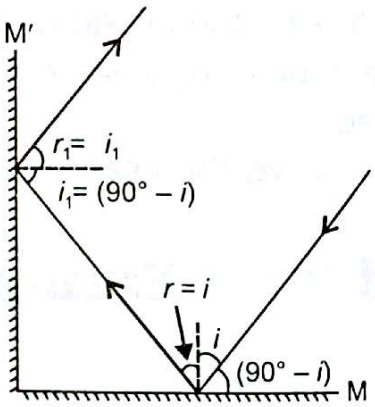
$n_d = n_g \times n_{dg} = 1.5 \times 1.6 = 2.4$

4. A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Ans. Yes, for getting virtual image the object has to be placed between the optical centre and the focus. For real and enlarged image, the object should be placed between F and 2F.

5. Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.

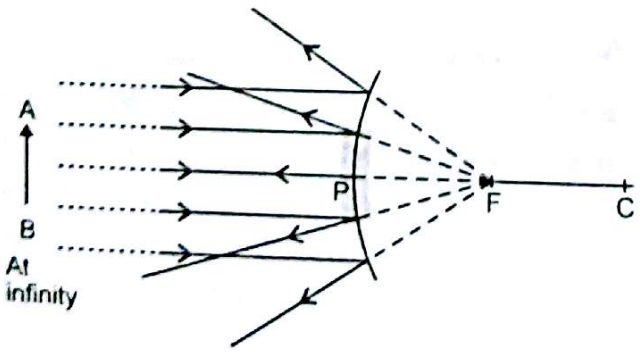
Ans. When the two mirrors are placed at 90° to each other, the incident and the reflected rays will remain parallel to each other.



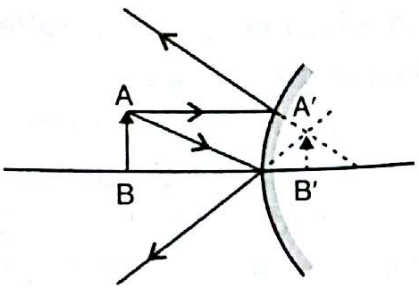
Long Answer Questions

6. Draw ray diagrams showing the image formation by a convex mirror when an object is placed
(a) at infinity
(b) at finite distance from the mirror

Ans. (a)



(b)



7. The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. If the image is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the

lens? What is the nature of the image at a distance of 80 cm and the lens?

Ans. $m = \frac{h_I}{h_o} = \frac{v}{u}$ for a lens.

Image is real, $m = -3 = \frac{v}{u}$

With $v = 80$ cm, $u = \frac{v}{-3} = \frac{80}{-3}$ cm and the lens will be convex.

8. Define power of a lens. What is its unit? One student uses a lens of focal length 50 cm and another of –50 cm. What is the nature of the lens and its power used by each of them?

Ans. Power of a lens: The ability of a lens to converge or diverge the light rays is called power (P) of the lens. It is defined as the reciprocal of the focal length, *i.e.* $P = \frac{1}{f}$.

The SI unit of power of a lens is dioptre (D). A lens of focal length 100 cm has a power of 1 dioptre, *i.e.* 1 dioptre = 1 m^{-1}. The lens of focal length +50 cm has a power of +2 D and is convex while the other is having a power of –2 D and is concave.