CLASS X: SCIENCE
Chapter 9: Light - Reflection and Refraction

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Q1. Define the principal focus of a concave mirror.

Ans. The principal focus of a concave mirror is a point on the principal axis, at which the incident rays parallel to the principal axis, after reflection, actually meet.

Q2. The radius of curvature of a spherical mirror is 20 cm. What is its focal length ?

Ans. Given, radius of curvature, R = 20 cm
Focal length, f = (1/2) × radius of curvature
or f = (1/2) × R = (1/2) × 20 = **10 cm**

Q3. Name a mirror that can give an erect and enlarged image of an object.

Ans. Concave mirror

Q4. Why do we prefer a convex mirror as a rear-view mirror in vehicles ?

Ans. Convex mirror is preferred as a rear-view mirror because it always gives an erect, though diminished image. Also, it has a wider field of view as it is curved outwards. Thus, convex mirror enables the driver to view much larger area than would be possible with a plane mirror.

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Q1. Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Ans. Given, radius of curvature, R = +32 cm
Focal length, f = (1/2) × radius of curvature
or f = (1/2) × R = (1/2) × (+32) = **+16 cm**

Q2. 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, magnification, m = – 3

(negative sign is taken as image is real) ;

object distance = – 10 cm

Now, $m = -\frac{v}{u}$ or $v = -m \times u$

or $v = -(-3) \times (-10) = \mathbf{-30\ cm}$

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Q1. 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. The light ray bends towards the normal. This is because it enters from rarer (air) medium to denser (water) medium.

Q2. 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 $3 \times 10^8\ ms^{-1}$.

Ans. We know that, absolute refractive index (n) of a medium is given by,

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

or $v_{glass} = \frac{c}{n_{glass}} = \frac{3 \times 10^8}{1.5} = \mathbf{2 \times 10^8\ m/s}$

Q3. Find out, from Table given below, the medium having highest optical density. Also find the medium with lowest optical density.

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

Ans. Among the media given in the above table, diamond has highest optical density as its refractive index is maximum among the given media. Air has least optical density as its refractive index is minimum among the given media.

Q4. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table 9.3.

Ans. The light travels fastest in water as its refractive index is least $(v \propto 1/n)$ among the three given substances.

Q5. The refractive index of diamond is 2.42. What is the meaning of this statement ?

Ans. We know that, absolute refractive index (n) of a medium is given by,

$n = \frac{c}{v}$ or $v = \frac{c}{n}$ i.e., $v \propto \frac{1}{n}$

Since, the refractive index of diamond is 2.42, this suggests that the speed of light in diamond will reduce by a factor 2.42 compared to its speed in air.

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Q1. Define 1 dioptre of power of a lens.

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

Q2. 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. Given, v = + 50 cm (positive sign is taken because real image in convex lens is formed on the right side).

Since, the image is real and size of the image is equal to the size of object.

$\therefore$ Magnification, m = –1

Now, $m = +\frac{v}{u}$ or $-1 = +\frac{v}{u}$

or $u = -v = -(+50) = \mathbf{-50\ cm}$

By lens equation,

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

$$\frac{1}{(+50)} - \frac{1}{(-50)} = \frac{1}{f}$$

$\frac{1}{f} = \frac{2}{50} = \frac{1}{25}$ or f = + 25 cm = + 0.25 m

Power, $P = \frac{1}{f} = \frac{1}{+0.25} = +4$ **Dioptre**

Q3. Find the power of a concave lens of focal length 2 m.

Ans. Given, focal length = – 2 m

(focal length of concave lens is negative).

Power, $P = \frac{1}{f} = \frac{1}{-2.0}$

or P = – **0.5 Dioptre**

EXERCISES

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 is not transparent, therefore it cannot be used for making lens.

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. Option (d) is correct. 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.

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. When an object is placed at $2F_1$ in front of a convex lens, its image is formed at $2F_2$ on the other side of the lens. The image formed is real, inverted, and of the same size as the object. Thus, option (b) is correct i.e., the object should be placed at twice the focal length from the optical centre of the lens.

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. Option (a) is correct i.e., a concave mirror as well as concave lens both have negative focal length

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. Option (d) is correct. 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.

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

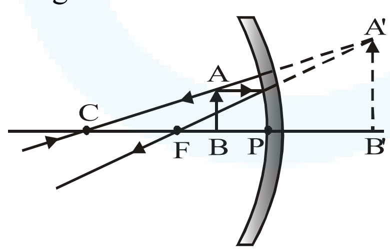
Ans. Option (c) is correct.

For reading small letters in a dictionary, a convex lens of small focal length is used as it is kept quite close to the page of the dictionary.

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. The object should be placed between pole and focus to get an erect image. Thus, the range of distance from the mirror will be in between 0 to 15 cm (or less than 15 cm) i.e., the range is **0 cm – 15 cm.**

The ray diagram for this is as given below :



8. Name the type of mirror used in the following situations

(a) Headlights of a car.

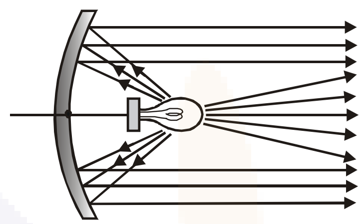
(b) Side/rear-view mirror of a vehicle.

(c) Solar furnace.

Support your answer with reason.

Ans. (a) Concave mirror.

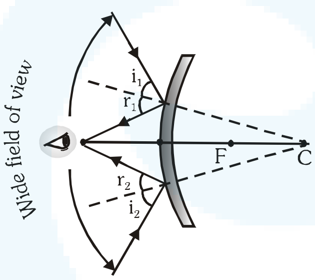
Concave mirror is used in the headlights of a vehicle because it produces powerful and almost parallel beam of light when the light source is placed at its principal focus.



A bulb placed at the focus of a concave mirror produces a strong, almost parallel beam

(b) Convex mirror.

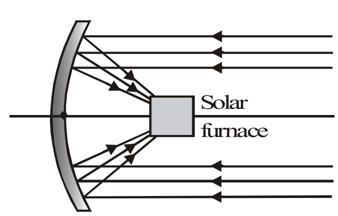
Convex mirror is used in rear-view mirror of a vehicle. Convex mirror gives a virtual, erect, and diminished image of the object placed in front of it. Because of this, it has a wide field of view. It enables the driver to see most of the traffic behind him.



A convex mirror has a wide field of view

(c) Concave mirror.

Concave mirrors are converging mirrors. That is why they are used to construct solar furnaces. Concave mirrors converge the parallel light incident on them at a single point which is called principal focus. Hence, they can be used to produce a large amount of heat at that point.



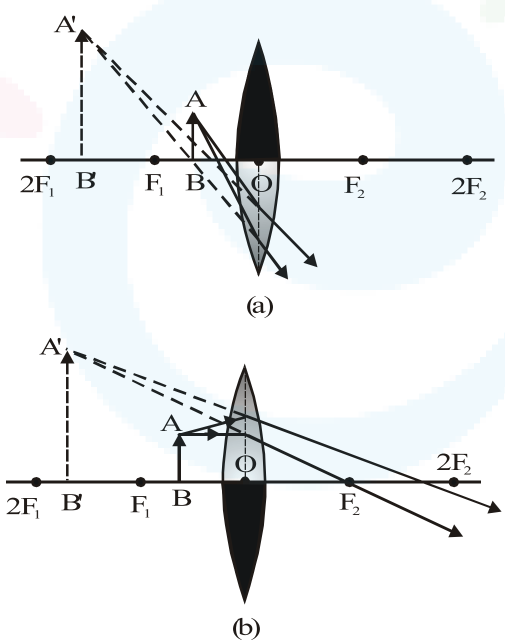
A solar furnace placed at the focus of a concave mirror.

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. The convex lens will form complete image of an object, even if its one half is covered with black paper. Only the brightness of the image will reduce, in this case it will be half of the brightness of original image. It can be understood by the following two cases:

(a) Let the upper half of the lens be covered and an object be placed between optical centre and the focus F_1. The light rays from the object falling on the lower half of the lens form a virtual, erect and magnified image [see fig.(a)]

(b) Let the lower half of the lens be covered and an object be placed between optical centre and the focus F_1. The light rays from the object falling on the upper half of the lens form a virtual, erect and magnified image [see fig.(b)]



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.

Ans. Given, $h_1 = +5$ cm ; $u = -25$ cm ;

$f = +10$ cm

By lens equation,

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

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

or $$\frac{1}{v} + \frac{1}{25} = \frac{1}{+10}$$

or $$\frac{1}{v} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$$

or $v = +50/3 = $ **+ 16.67 cm**

Magnification, $m = +\frac{v}{u} = \frac{+(50/3)}{(-25)} = -\frac{2}{3}$

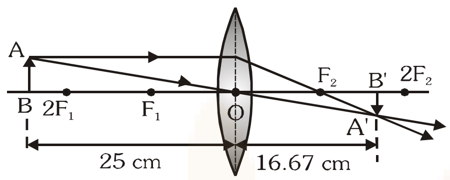
Now, $m = \frac{h_2}{h_1}$

or $$-\frac{2}{3} = \frac{h_2}{h_1}$$

or $$h_2 = -\frac{2}{3}h_1 = -\frac{2}{3} \times 5 = -\frac{10}{3}$$

or $h_2 = $ **–3.33 cm**

The image is real, inverted and diminished.



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. Given, f = – 15 cm,

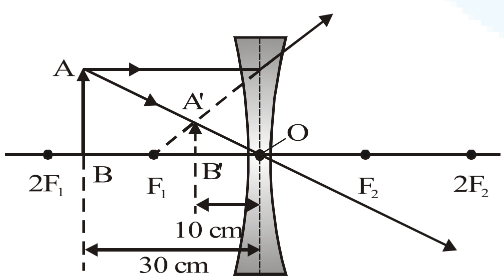
v = – 10 cm (negative sign is taken because the image formed in concave lens is always towards left)

By lens equation,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \quad \text{or} \quad \frac{1}{(-10)}-\frac{1}{u}=\frac{1}{-15}$$

$$\text{or} \quad \frac{-1}{10}+\frac{1}{15}=\frac{1}{u} \quad \text{or} \quad \frac{1}{u}=\frac{-3+2}{30}=-\frac{1}{30}$$

or u = – **30 cm**



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. Given, object distance, u = – 10 cm ;

focal length, f = + 15 cm ;

image distance, v = ? ; magnification, m = ?

Mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \quad \text{or} \quad \frac{1}{v}+\frac{1}{(-10)}=\frac{1}{(+15)}$$

or $\frac{1}{v}=\frac{1}{10}+\frac{1}{15}=\frac{3+2}{30}=\frac{5}{30}=\frac{1}{6}$ or v = **+ 6 cm**

Now, magnification, $m=-\frac{v}{u}=-\frac{(+6)}{(-10)}$ = **+ 0.6**

The image is located 6 cm behind the mirror ; it is a virtual, erect and diminished image.

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

Ans. Magnification for a plane mirror is + 1. The positive sign means the image is virtual and erect. The numerical value (magnitude) '1' means that the size of the image is exactly 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. Given, object distance, u = – 20 cm ;

radius of curvature, R = + 30 cm ;

height of object, h_1 = + 5 cm ;

image distance, v = ? ; magnification, m = ? ;

height of image, h_2 = ?

Focal length, f = R/2 = (+30)/2 = + 15 cm

Mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \quad \text{or} \quad \frac{1}{v}+\frac{1}{(-20)}=\frac{1}{(+15)}$$

or $\frac{1}{v}=\frac{1}{20}+\frac{1}{15}=\frac{3+4}{60}=\frac{7}{60}$

or v = + 60/7 cm = **+ 8.57 cm**

Now, magnification, $m=-\frac{v}{u}=-\frac{(+60/7)}{(-20)}=+\frac{3}{7}$

or $m = +$ **0.428**

Also, $m = \frac{h_2}{h_1}$ or $+\frac{3}{7} = \frac{h_2}{(+5)}$

or $h_2 = +\frac{15}{7} = $ **+ 2.14 cm**

The image is located at a distance of 8.57 cm behind the mirror ; it is virtual, erect and diminished of size 2.14 cm.

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 the nature of the image.

Ans. Given, object height, $h_1 = +7$ cm ;

object distance, $u = -27$ cm ;

focal length, $f = -18$ cm ;

image distance, $v = ?$; image height, $h_2 = ?$

Mirror formula,

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

or $\frac{1}{v} = \frac{1}{27} - \frac{1}{18} = \frac{3-4}{54} = \frac{-1}{54}$ or $v = $ **– 54 cm**

Now, magnification, $m = -\frac{v}{u} = -\frac{(-54)}{(-27)} = $ **– 2**

Also, $m = \frac{h_2}{h_1}$ or $-2 = \frac{h_2}{(+7)}$ or $h_2 = $ **– 14 cm**

The image is located at a distance of 54 cm in front of the mirror ; it is real, inverted and magnified of size 14 cm.

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

Ans. Given, power, $P = -2.0$ D

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

or $f = \frac{1}{P} = \frac{1}{-2} = -\mathbf{0.5\ m} = -\mathbf{50\ cm}$

The lens is a concave (or diverging) 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. Given, power, P = +1.5 D

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

or $f = \frac{1}{P} = \frac{1}{+1.5} = \frac{10}{15} = +\frac{2}{3}$

or f = +0.66 m = **+ 66 cm**

The lens is a convex (or converging) lens.