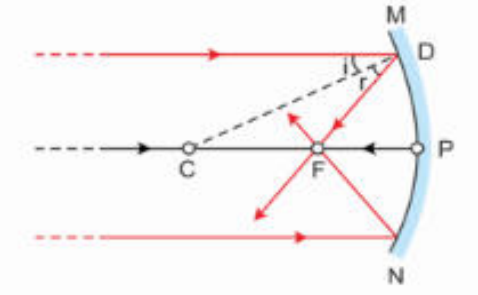
Light Reflection and Refraction

9 Chapter

1. Define the principal focus of a concave mirror.

Ans: The light rays that are parallel to the principal axis of a concave mirror converge at a specific point on its principal axis after reflecting from the mirror. This point is known as the principal focus of the concave mirror.



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

Ans:

Step 1: Given Data.

The radius of curvature of a spherical mirror, $r = 20cm$

The focal length of a spherical mirror, $f = ?$

Step 2: Formula Used.

The focal length of a given mirror is half of the radius of curvature of the same mirror.

$$f = \frac{r}{2}$$

Step 3: Calculation.

$$f = \frac{r}{2}$$

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

$$f = 10 \text{ cm}$$

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

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

Ans: When the object is between the pole and the focus,
a concave mirror can give an erect and enlarged image of an object,
as the image formed is a virtual image.

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

Ans: Convex mirrors always form a virtual, erect,
and diminished image of the objects placed in front of it.
We prefer a convex mirror as rear-view mirrors in vehicles
because it gives a wider field of view,
which allows the driver to see most of the traffic behind him.

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

Ans: Radius of curvature, R = 32 cm
Radius of curvature = 2× focal length (f)

$$F = \frac{R}{2}$$

$$F = \frac{32\ \text{cm}}{2}$$

$$F = 16\ \text{cm}$$

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

**6. 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: Distance of object from concave mirror (u) = - 10 cm
Magnification (m) = 3

$$m = \frac{-v}{u}$$

$$\Rightarrow v = -mu$$

$$= -(3)\times(-10)$$

$$= 30\text{cm}$$

The image will be formed in front of the concave mirror
at a distance of 30 cm from its pole.

7. 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.
When a ray of light travels from an optically rarer medium to an optically denser medium, it gets bent towards the normal.
Since water is optically denser than air,
a ray of light travelling from air into the water will bend towards the normal.

8. 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 $3\times10^{8}\,ms^{-1}$.

Ans: Refractive index of a medium,

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

Speed of light in vacuum, $c = 3\times10^8 ms^{-1}$

Refractive index of glass, $n_g = 1.50$

Speed of light in the glass, $v = \frac{\text{Speed of light in vacuum}}{\text{Refractive index of glass}}$

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

$$v = \frac{3\times10^8}{1.50}$$

$$= 2\times10^8 ms^{-1}$$

Therefore, speed of light in the glass, $v = 2\times10^8 ms^{-1}$.

9. Find out, from the 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: The medium having highest optical density is Diamond (Refractive Index 2.42) and the medium having lowest optical density is Air (Refractive Index 1.0003).
The optical density of a medium is directly related to the refractive index of that medium.
A medium which has the highest refractive index will have the highest optical density and vice-versa.
It can be observed from the table that diamond and air have the highest and lowest refractive index respectively.
Therefore,
diamond has the highest optical density and air has the lowest optical density.

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

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: Using the information given in the table, the refractive index of kerosene is 1.44, that of turpentine is 1.47 and that of water is 1.33.
Thus, water is having a lower refractive index and is optically rarer than kerosene and turpentine. The speed of light is inversely proportional to the refractive index.
Therefore the light travels fastest in water because of its lower optical density.

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

Ans: Refractive index

1. It is defined as the ratio of the speed of light in a vacuum to its speed in a specific medium.

It is denoted by n with $n = \frac{c}{v}$

2.The above statement means that the speed of light in a diamond is $\frac{1}{2.42}$ times the speed of light in a vacuum.

3. As the refractive index of a diamond is quite high, the speed of light in a diamond will reduce by a factor of 2.42 as compared to its speed in air.

12. Define 1 dioptre of power of a lens.

Ans: A dioptre is a unit of measurement of the optical power of a lens or curved mirror, which is equal to the reciprocal of the focal length measured in metres (i.e., 1/metres). It is thus a unit of reciprocal length.
In other words,
1 dioptre is defined as the power of a lens of focal length 1 metre.

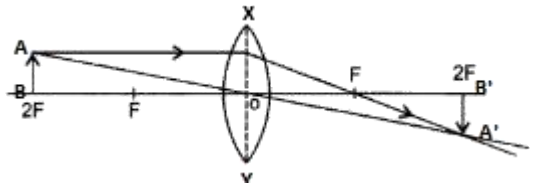
13. Image formed by a convex lens is real and inverted and at a distance of 50cm from the lens. Find the position of the needle in front of the convex lens when the image is equal to the size of the object. Also, calculate the power of the lens.

Ans: It is given that,

Distance of image from convex lens, $v = 50\text{cm}$

Distance of object in front of lens, $u = ?$

The image formed is real and inverted. So, the magnification of the lens is -1.



It is known that,

Magnification of a convex lens, $m = \frac{v}{u}$

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

$\Rightarrow -1 = \frac{50}{u}$

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

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

f is the focal length of the lens

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

$\Rightarrow \frac{1}{f} = \frac{1}{50} + \frac{1}{50}$

$\Rightarrow \frac{1}{f} = \frac{2}{50}$

$\Rightarrow f = \frac{50}{2}$

$\Rightarrow f = 25\text{cm} = 0.25\text{m}$

It is known that,

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

$$\Rightarrow P = \frac{1}{(+0.25)}$$

$$\Rightarrow P = +4D$$

Therefore, the object distance from the lens is $u = -50cm$ and power of the lens is $P = +4D$.

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

Ans: We know that,
focal length is negative for concave lens.
Thus, focal length of the given concave lens,

$$f = -2m$$

$\therefore$ Power of lens,

$$\Rightarrow P = \frac{1}{(-2)}$$

$$\Rightarrow P = -0.5D$$

15. Which one of the following materials cannot be used to make a lens?

a) Water

b) Glass

c) Plastic

d) Clay

Ans: d) Clay can't be used to make a lens because it is opaque.

16. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should the position of the object be?

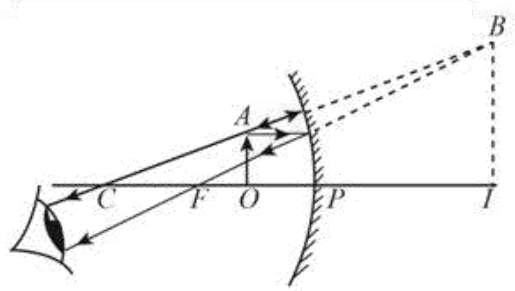
a) Between the principal focus and the centre of curvature

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) The object is placed between the pole of the mirror and its principal focus when the image formed is virtual, erect and larger than the object in the concave mirror.



17. Where should an object be placed in front of a convex lens to get a real image of the size of the object?

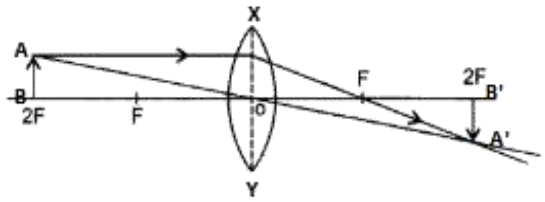
a) At the principal focus of the lens

b) At twice the focal length

c) At infinity

d) Between the optical centre of the lens and its principal focus

Ans: b) An object should be placed at a distance of twice the focal length of a convex lens to get a real image of the size of the object.



18. A spherical mirror and a thin spherical lens have each a focal length of −15cm . 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) For a concave lens the primary focus is on the same side as the object and is negative. In the case of a concave mirror the focus is in front of the mirror and negative. Therefore, the mirror and lens are likely to be concave.

19. 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) Erect images are produced by both plane and convex mirrors for objects at any positions.

20. 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: a) When the object is placed between focus and optic centre, magnified and erect images are formed in a convex lens. So, while reading small letters a convex lens is preferred.

21. 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.

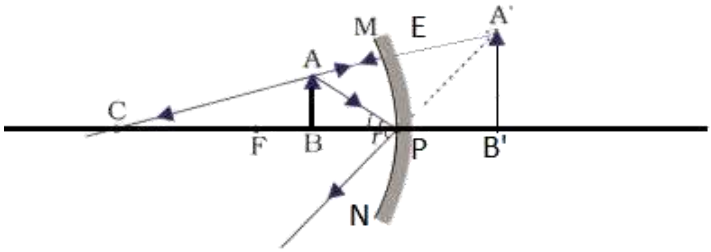
Ans: To obtain an erect image in a concave mirror the object should be placed between Focus and the Optic centre.

Here, the focal length of concave mirror is given as 15cm.

Therefore, the range of distance of the object from the mirror is from 0cm to 15cm.

The nature of the image is virtual.

The image is larger than the object.



A virtual, erect and magnified image is formed.

22. Name the type of mirror used in the following situations and support your answer with reason.

a) Headlights of a car

Ans: In the headlights of a car, a concave mirror is used. Because in concave mirrors a parallel beam of light is produced if the bulb is placed at the focus.

b) Side/rear-view mirror of a vehicle

Ans: In a side/rear-view mirror of a vehicle , a convex mirror is used. Because when objects are placed in front of the convex mirror, erect and diminished images are formed which gives a wider field of view.

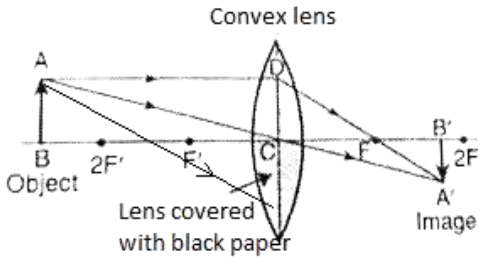
c) Solar furnace

Ans: In solar furnaces, Concave mirrors are used. They converge sunlight to a point and produce high temperatures because of their converging properties.

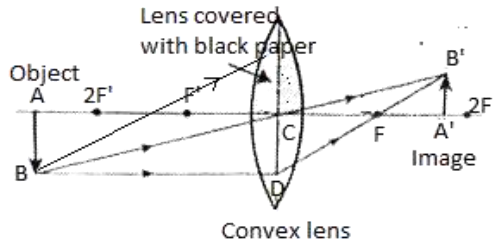
23. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

Ans: Yes, the lens produces a complete image of the object with less intensity.

Consider the following two cases:



In the first case the lower half of the lens is covered with black paper. Light rays coming from the object are refracted only from the upper half and the image is formed, whereas in the lower half the light rays are blocked.



In the second case the upper half of the lens is covered with black paper. Light rays coming from the object are refracted only from the lower half and the image is formed, whereas in the upper half the light rays are blocked.

Therefore, change in intensity of the image is observed i.e., the intensity of the image is less and the complete image is formed.

24. An object of 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: It is given that,

Height of the object, $h_o = 5\text{cm}$

Distance of object in front of lens, $u = -25\text{cm}$

Distance of image from lens, $v = ?$

Focal length of the lens, $f = +10\text{cm}$

From lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

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

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

$\Rightarrow \frac{1}{v} = \frac{25-10}{250}$

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

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

$\Rightarrow v = 16.66\text{cm}$

The positive value of v indicates that the image and the object are on opposite sides.

It is known that,

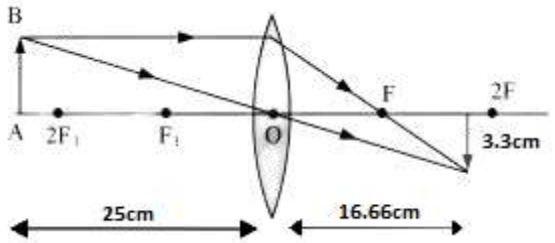
Magnification , $m = \frac{h_i}{h_o} = -\frac{v}{u}$

Height of the image, $h_i = ?$

$\Rightarrow m = \frac{h_i}{5} = -\frac{16.66}{25} = -0.66$

$\Rightarrow h_i = -0.66 \times 5$

$\Rightarrow h_i = -3.3\text{cm}$



As the magnification is -0.66, the negative sign indicates that the object is inverted and less than 1 indicates that the image is smaller than the object.

Therefore, the position of image is 16.66cm from the lens. Height of the object is 3.3cm. Nature of image is real, inverted and diminished.

25. A concave lens of focal length 15 cm forms an image 10 cm from the lens. Find the distance of an object from the lens? Draw the ray diagram.

Ans: It is given that,

Focal length of the lens, $f = -15\text{cm}$

Distance of image from lens, $v = -10\text{cm}$

Distance of object in front of lens, $u = ?$

From lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

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

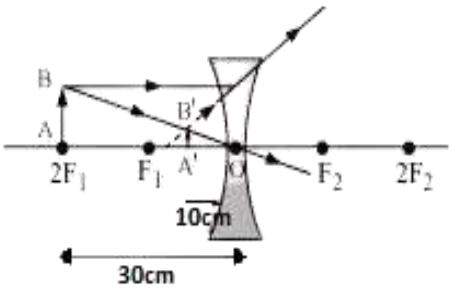
$$\Rightarrow \frac{1}{u} = \frac{1}{(-10)} - \frac{1}{(-15)}$$

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

$$\Rightarrow \frac{1}{u} = \frac{-5}{150}$$

$$\Rightarrow u = -\frac{150}{5}$$

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



Thus, the object is at a distance of 30cm from the lens.

26. 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: It is given that,

Focal length of the convex mirror, $f = +15\text{cm}$

Distance of object in front of convex mirror, $u = -10\text{cm}$

Distance of image from convex mirror, $v = ?$

From mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

$$\Rightarrow \frac{1}{v} = \frac{1}{15} - \frac{1}{(-10)}$$

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

$$\Rightarrow \frac{1}{v} = \frac{25}{150}$$

$$\Rightarrow v = \frac{150}{25}$$

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

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

It is known that,

$$\text{Magnification }, m = \frac{h_i}{h_o} = -\frac{v}{u}$$

$$\Rightarrow m = \frac{-6}{-10} = +0.6$$

The positive magnification indicates that the image is erect. As magnification is less than 1 it indicates that the image is smaller than the object.

Therefore, the position of image is $6cm$ behind the mirror. Nature of image is virtual, erect and diminished.

27. What does "The magnification produced by a plane mirror is +1 " mean?

Ans: It is known that,

$$\text{Magnification produced by a plane mirror is, } m = \frac{h_i}{h_o} = -\frac{v}{u}$$

where,

h_i is the height of the image

h_o is the height of the object

u is the distance of the object in front of lens

v is the distance of image from lens

Magnification produced by a plane mirror is $+1$ means that $h_i = h_o$ that is the size of the image is the same as the size of the object.

The positive size indicates that the image is erect.

Therefore, magnification equal to $+1$ means that the size of the image is the same as object and erect.

28. An object 5 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: It is given that,

Distance of object in front of mirror, $u = -20cm$

Distance of image from the mirror, $v = ?$

Radius of curvature of the mirror, $R = 30cm$

Focal length of the mirror, $f = ?$

It is known that,

Radius of curvature is equal to twice the focal length.

$\Rightarrow R = 2f$

$\Rightarrow 30 = 2f$

$f = \frac{30}{2} = 15cm$

From mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

$\Rightarrow \frac{1}{v} = \frac{1}{15} - \frac{1}{(-20)}$

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

$\Rightarrow \frac{1}{v} = \frac{20+15}{300}$

$\Rightarrow \frac{1}{v} = \frac{35}{300}$

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

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

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

It is known that,

$$\text{Magnification}, m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Height of the object, $h_o = 5\text{cm}$

Height of the image, $h_i = ?$

$$\Rightarrow h_i = -\frac{v}{u} \times h_o$$

$$\Rightarrow h_i = -\frac{8.57}{(-20)} \times 5$$

$$\Rightarrow h_i = 2.14\text{cm}$$

Therefore, the image is formed at a distance of 8.57cm behind the mirror. Nature of image is virtual, erect and diminished.

29. 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.

Ans: It is given that,

Distance of object in front of mirror, $u = -27\text{cm}$

Distance of image from the mirror, $v = ?$

Focal length of the mirror, $f = -18\text{cm}$

From mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

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

$$\Rightarrow \frac{1}{v} = -\frac{1}{18} + \frac{1}{27}$$

$$\Rightarrow \frac{1}{v} = \frac{-3+2}{54}$$

$$\Rightarrow \frac{1}{v} = -\frac{1}{54}$$

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

The negative value of v indicates that the screen should be placed at a distance of 54cm in front of the mirror and the image is real.

It is known that,

Magnification , $m = \frac{h_i}{h_o} = -\frac{v}{u}$

Height of the object, $h_o = 7\text{cm}$

Height of the image, $h_i = ?$

$$\Rightarrow h_i = -\frac{v}{u} \times h_o$$

$$\Rightarrow h_i = -\frac{-54}{(-27)} \times 7$$

$$\Rightarrow h_i = -14\text{cm}$$

The height of image is 14cm.

Therefore, the image is formed at a distance of 54cm in front of the mirror. Nature of image is real, inverted and enlarged.

30. Find the focal length of a lens of power $-2.0\ D$. What type of lens is this?

Ans: It is given that,

Power of a lens, $P = -2.0D$

Focal length of a lens, $f = ?$

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

$$\Rightarrow -2 = \frac{1}{f}$$

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

Negative f indicates concave lens.

Therefore, the focal length of lens is $f = -0.5\text{m}$ and the lens is concave.

31. 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: It is given that,

Power of a lens, $P = +1.5D$

Focal length of a lens, $f = ?$

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

$$\Rightarrow 1.5 = \frac{1}{f}$$

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

Positive f indicates a convex lens.

Therefore, the focal length of lens is $f = 0.66\text{m}$ and the lens prescribed is a diverging lens.