Light Reflection and Refraction

1. Define the principal focus of a concave mirror.

Answer-

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 called the principal focus of the concave mirror.

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

Answer-

Radius of curvature (R) = 20 cm

Radius of curvature of the spherical mirror = 2 × Focal length (f)

R = 2f

f= R/2 = 20 / 2 = 10

Therefore, the focal length of the spherical mirror is 10 cm.

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

Answer-

The mirror that can give an erect and enlarged image of an object is Concave Mirror.

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

Answer-

Convex mirror is preferred as a rear-view mirror in cars and vehicles as it gives a wider field of view, which helps the driver to see most of the traffic behind him. Convex mirrors always form an erect, virtual, and diminished image of the objects placed in front of it.

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

Answer-

Radius of curvature (R) = 32 cm

Radius of curvature = 2 × Focal length (f)

R= 2f

f = R/2 = 32/2 = 16

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

6. A concave mirror produces three times magnified real image of an object placed at 10 cm in front of it. Where is the image located?

Solution :

Distance of object from concave mirror (u)= -10 cm.

Magnification (m) = -3

m = -v/u

v = -mu = -(3) x (-10) = -30 cm.

7. A ray of light traveling in air enters obliquely into water. Does the light ray bend towards or away from the normal? Why?

Solution : The light bends towards the normal on entry into water. It is due to the fact that as compared to air, the water is optically denser medium.

8. 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 3×108 m/s.

Solution :

Speed of light in vacuum (c) = 3 x 10^8 m/s.

Refractive index = c/v.

Speed of light in glass = 3 x 10^8 m/s/ 1.50

= 2 x 10^8 m/s

9. Find out, from Table (10.3), the medium having highest optical density. Also, find the medium with lowest optical density.

Solution : As per table, diamond has highest optical density (2.42). Medium with lowest optical density is air (1.0003)

10. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in table 10.3

Solution : As the refractive index of water is least out of three substances, hence speed of light is maximum in water. So, light travels fastest in water.

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

Answer-

Diamond has a refractive index of 2.42 which means that the speed of light in diamond will reduce by a factor of 2.42 as compared to its speed in the air.

In other words, the speed of light in diamond is 1/2.42 times the speed of light in vacuum.

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1. Define 1 dioptre of power of a lens.

Answer-

Dioptre is the SI unit of power of lens is denoted by the letter D. 1 dioptre can be defined as 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.

Answer-

The position of the image should be at 2F since the image is the real and same size.

It is given that the image of the needle is formed at a distance of 50 cm from the convex lens. Therefore, the needle is placed in front of the lens at a distance of 50 cm.

Object distance (u) = – 50 cm

Image distance, (v) = 50 cm

Focal length = f

According to the lens formula,

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

$$\frac{1}{f} = \frac{1}{50} - \frac{1}{-50}$$

$$= \frac{1}{50} + \frac{1}{50} = \frac{1}{25}$$

$$f = 25cm = 0.25m$$

$$Power\ of\ lens,\ P = \frac{1}{f(in\ metres)} = \frac{1}{0.25} = +4D$$

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

Answer-

Focal length of concave lens (f) = 2 m

Power of lens (P) = 1/f = 1/ (-2) = -0.5D

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Exercise

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

(a) Water

(b) Glass

(c) Plastic

(d) Clay

Answer –

(d) Clay cannot be used to make a lens because if the lens is made up of clay the light rays cannot pass through it

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-

(d) The position of the object should be 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.

Answer –

(b) The object should be placed at twice the focal length

18. A spherical mirror and a thin spherical lens have each a focal length of −15cm−15cm . The mirror and the lens are likely to be

1. Both concave
2. Both convex
3. The mirror is concave and the lens is convex
4. 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

1. Plane
2. Concave
3. Convex
4. Either plane or convex

Ans: d) Erect images are produced by both plane and convex mirrors for objects at any position.

20. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

1. A convex lens of focal length

50 cm50 cm

2. A concave lens of focal length

50 cm50 cm

3. A convex lens of focal length

5 cm5 cm

4. A concave lens of focal length

5 cm5 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 cm15 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.

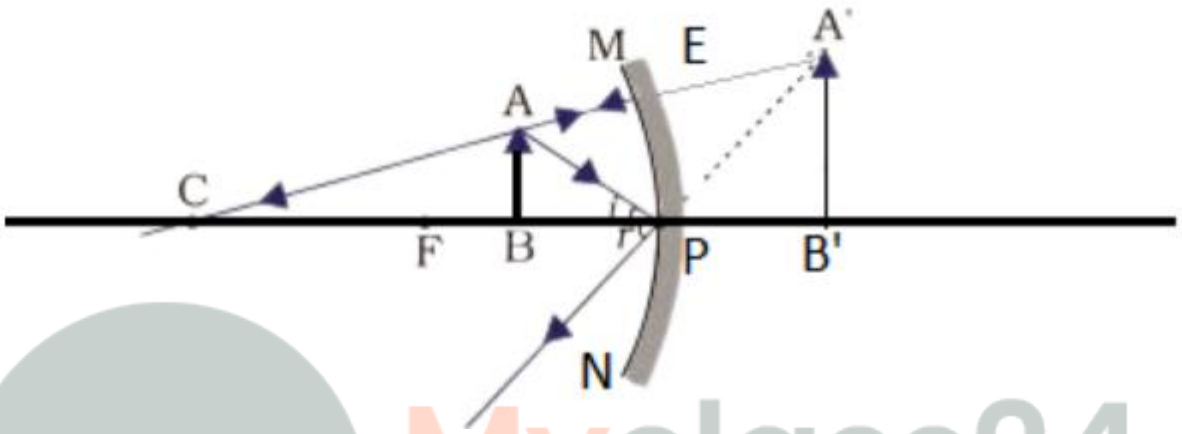
Ans: To obtain an erect image in a concave mirror the object should be placed between Focus and the Optic centre.

Here, the focal length of the concave mirror is given as 15cm15cm.

Therefore, the range of distance of the object from the mirror is from 0cm0cm to15cm15cm.

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.

1. 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.

2. 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.

3. 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.

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-

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

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-

Height of the Object, h_0 = 5 cm

Distance of the object from converging lens, u = -25 cm

Focal length of a converging lens, f = 10 cm

Using lens formula,

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

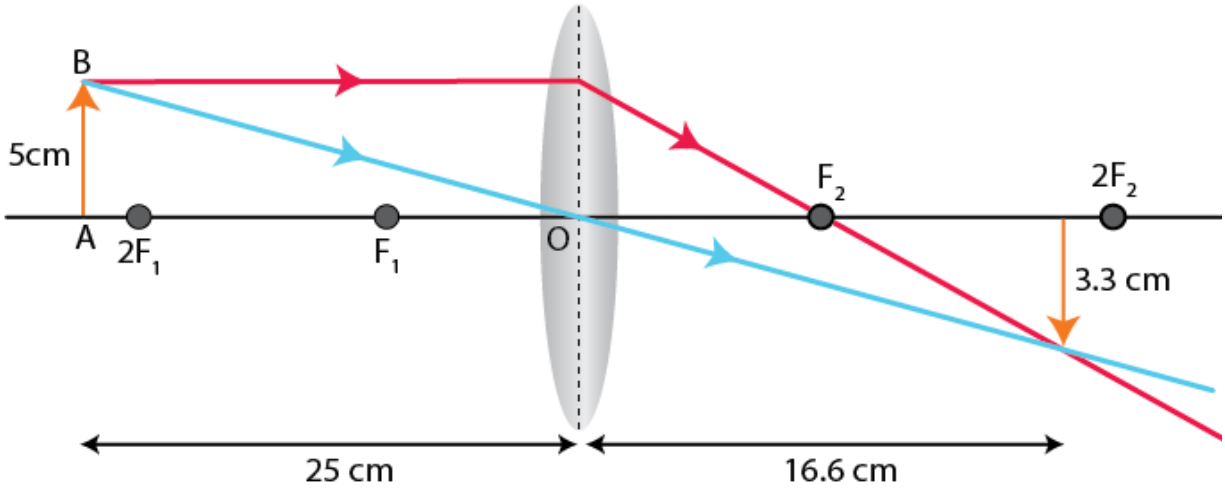
$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{15}{250}$$

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

$$Also,\ for\ a\ converging\ lens,\ \frac{h_i}{h_0} = \frac{v}{u}$$

$$h_i = \frac{v}{u} \times h_0 = \frac{50 \times 5}{3 \times (-25)} = \frac{10}{-3} = -3.3cm$$

Thus, the image is inverted and formed at a distance of 16.7 cm behind the lens and measures 3.3 cm. The ray diagram is shown below.



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-

Focal length of concave lens (OF_1), f = – 15 cm

Image distance, v= – 10 cm

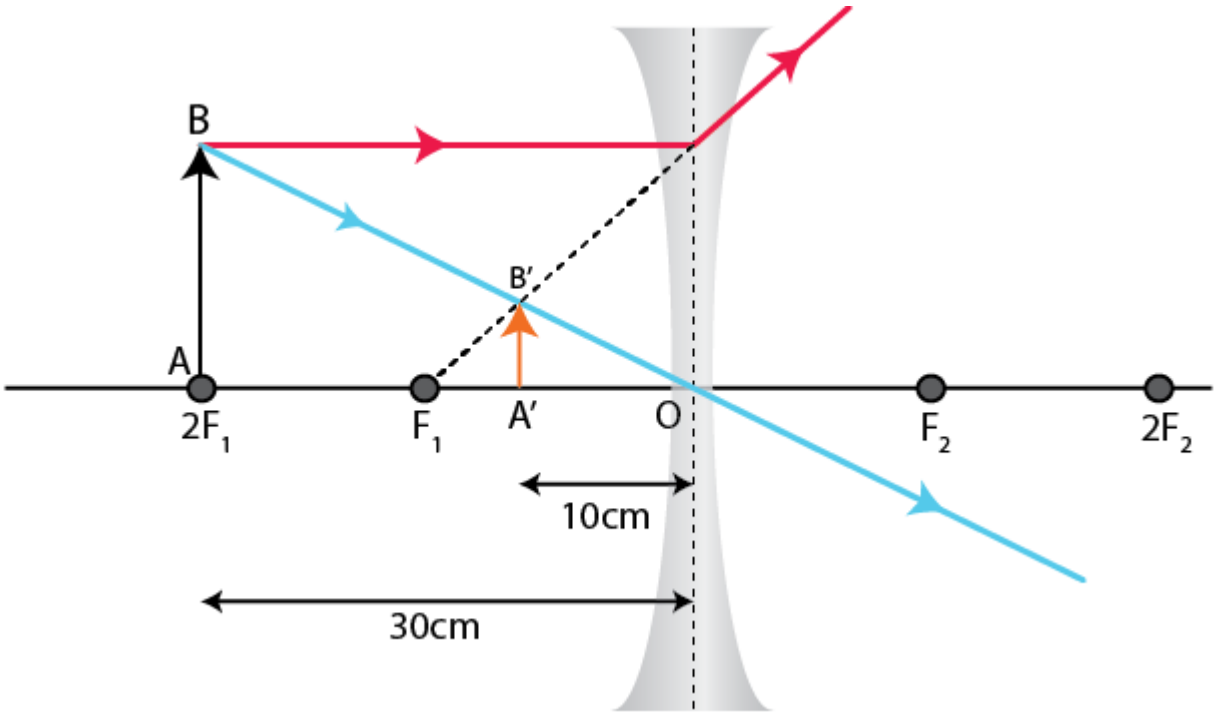
According to the lens formula,

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

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

$$v = -\frac{5}{150} = -30cm$$

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.



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-

Focal length of convex mirror (f) = +15 cm

Object distance (u) = – 10 cm

According to the mirror formula,

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

$$\frac{1}{v} = \frac{1}{15} - \frac{1}{-10} = \frac{2+3}{30}$$

$$v = \frac{5}{30} = 6cm$$

$$Magnification = \frac{-v}{u} = \frac{-6}{-10} = 0.6$$

The image is located at a distance of 6 cm from the mirror on the other side of the mirror.

The positive and a value of less than 1 of magnification indicates that the image formed is virtual and erect and diminished.

27. The magnification produced by a plane mirror is +1. What does this means?

Solution :

$m = h_i/h_0 = v/u$

Magnification produced by a plane mirror is +1 which means that size of image formed is exactly equal to size of object behind the mirror.

28. 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.

Solution :

Radius of curvature (R) = 30 cm

f = R/2 = 30/2 = 15 cm

u = –20 cm, h= 5 cm.

1/v +1/u = 1/f

1/v = 1/15+ 1/20 = 7/60

v = 60/7 = 8.6 cm.

image is virtual and erect and formed behind the mirror.

$h_i/h_0 = v/u$

$h_i/5 = 8.6/20$

h_i = 2.2 cm.

Size of image is 2.2 cm.

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.

Solution :

u = – 27 cm, f = – 18 cm. h_o= 7.0 cm

1/v = 1/f- 1/u

1/v = -1/18 + 1/27 = -1/54

V = – 54 cm.

Screen must be placed at a distance of 54 cm from the mirror in front of it.

h_i/h_0= v/u

h_i/h_0= v/u

h_i/7 = +54/-27

h_i = -2 x 7 = -14 cm.

Thus, the image is of 14 cm length and is inverted image.

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

Solution :

Power of lens (P) = -2.0 D

P = 1/f or f = 1/m

f = 1/-2.0 = -0.5 m.

(-ve) sign of focal length means that the lens is concave lens.

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?

Solution :

P = +1.5 D

f = 1/P = 1/+1.5 = 0.67 m.

As the power of lens is (+ve), the lens is converging lens.