LIGHT-REFLECTION AND REFRACTION

Question 1: *Define reflection of light.*

Answer: The phenomenon by which a ray of light changes the direction of propagation when it strikes a boundary between different media through which it cannot pass is described as the reflection of light.

Question 2: *Name the two types of reflection.*

Answer: The two types of reflection are regular reflection and irregular or diffused reflection.

Question 3: *What is meant by diffused reflection?*

Answer: In this type of reflection the different portions of the surface reflect the incident light in different directions and no definite image is formed but the surface becomes visible.

Question 4: *Name the phenomenon due to which we see the non-luminous objects.*

Answer: It is due to diffused or irregular reflection of light that we see the non-luminous objects.

Question 5: *While looking at your image in a large plane mirror, if you touch your left ear it appears as if your image has touched the right ear. Why?*

Answer: It is due to lateral inversion that we feel that the image has touched the right ear.

Question 6: *Name any one device based upon the principle of reflection of light by plane mirrors.*

Answer: Periscope is a device based on the principle of reflection of light.

Question 7: *Define magnification.*

Answer: The ratio of the height of the image to the height of the object is called the linear magnification.

$$m = \frac{h_i}{h_o} = \frac{v}{u}$$

For a real image u and v are negative and the magnification is negative. Negative magnification means the image is inverted. On the other hand for a virtual image u is negative and v is positive and hence the magnification is positive, i.e., the image is erect.

Question 8: *What type of surface causes regular reflection?*

Answer: Smooth polished surfaces cause regular reflection.

Question 9: *Define a) Centre of curvature b) Pole of a spherical mirror*

Answer: Centre of curvature is the centre of the sphere of which the spherical mirror forms a part. Pole of a mirror is the midpoint of the aperture of the spherical mirror.

Question 10: *What kind of mirror is used in a car to view the traffic behind it?*

Answer: Convex mirror is used in a car to view the traffic behind it.

Question 11: *For which position of an object does a concave mirror produce an inverted, magnified and real image?*

Answer: When the object is placed between the focus and the centre of curvature of the concave mirror, the image formed will be inverted, magnified and real.

Question 12: *Name the spherical mirror which can produce a real and diminished image of an object.*

Answer: Concave mirror can produce a real and diminished image of an object.

Question 13: *Give the nature, position and size of the image formed by a concave mirror when an object is placed between focus and pole of the mirror.*

Answer: When an object is placed between the focus and pole of the mirror, the image formed will be virtual, erect and magnified. It will be formed behind the mirror.

Question 14: *List out any two uses of concave mirror.*

Answer: Concave mirrors are used:

1) as reflectors in the head lights of cars, search lights, etc. to obtain a parallel beam of light.
2) by dentists to focus light on the patient's tooth to be examined.

Question 15: *What is the nature of the ray of light incident on a concave mirror, if it passes through the focus of the mirror after reflection?*

Answer: The ray of light is parallel to the principal axis.

Question 16: *What is the mirror formula for a concave mirror?*

Answer: The relationship between the focal length of the mirror (f), the distance of the object from the pole of the mirror (u) and the distance of the image from the pole of the mirror (v) is given by:

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

This is called the mirror formula.

Question 17: *What is the nature of the image formed by a concave mirror, if the magnification produced by it is negative?*

Answer: The image formed will be inverted and real as the magnification is negative.

Question 18: *State the laws of reflection.*

Answer: The laws of reflection are:

1) The incident ray, the reflected ray and the normal drawn at the point of incidence all lie in the same plane.
2) The angle of incidence is equal to the angle of reflection.

Question 19: *List out the characteristics of the image formed by a plane mirror.*

Answer: The image formed by a plane mirror is:
1) erect
2) virtual
3) of the same size as the object
4) the image is at the same distance behind the mirror as the object is in front of it
5) laterally inverted.

Question 20: *Distinguish between concave and convex mirrors.*

Answer:

CONVEX MIRROR	CONCAVE MIRROR
The focus of a convex mirror lies behind the mirror	The focus of a concave mirror is in front of the mirror
The focus of a convex mirror is virtual as the rays of light after reflection appear to come from the focus	The focus of a concave mirror is real as the rays of light after reflection converge at the focus

Question 21: ***Give any four uses of plane mirror.***

Answer: A plane mirror is used:
1. as a looking glass to see our image
2. by interior designers to create an illusion of depth
3. to fold light in a periscope and other optical instruments
4. to build a kaleidoscope, an interesting toy.

Question 22: The radius of curvature of a mirror is + 40 cm.
1) Identify the mirror
2) What is the focal length of the mirror?

Answer: The mirror is a convex mirror.

The focal length $= \frac{R}{2} = \frac{+40}{2} = +20\text{cm}$

Question 23: Two concave mirrors 'A' and 'B' are made from two spheres of radii 30 cm and 32 cm respectively. Which of the two concave mirrors will have larger focal length? What will be the focal length of the concave mirrors 'A' and 'B'?

Answer: The mirror 'B' will have a larger focal length.

The focal length of the mirror 'B' $= \frac{R}{2} = \frac{32}{2} = 16\text{cm}$

The focal length of the mirror 'A' $= \frac{R}{2} = \frac{30}{2} = 15\text{cm}$

Question 24: You are given two mirrors 'A' and 'B' of focal lengths +10 cm and -20 cm respectively. Which one will you use as a converging mirror? Why?

Answer: Mirror B with focal length -20 cm is used as a converging mirror as the parallel rays of light after reflection meet at a point on the principal focus and for a concave mirror according to sign convention the focal length is negative.

Question 25: *Why is a convex mirror used as a rear-view mirror in automobiles?*

Answer: A convex mirror is used as a rear-view mirror because of the following reasons:
1) A convex mirror always forms an erect image of an object
2) It forms a diminished image and as a result images of large number of objects can be seen in the mirror at the same time.

Question 26: *You are given three mirrors of equal size. How will you identify them as convex, concave and plane mirror?*

Answer: Bring each mirror one by one close to an object and observe the image formed in it. If the image is :

1) of the same size as that of the object and erect, the mirror is a plane mirror.
2) large and erect, it is a concave mirror.
3) highly diminished and erect, it is a convex mirror.

Question 27:

An object is placed at a distance of 5 m from a convex mirror of radius of curvature 20 cm where is the image formed and what is its nature?

Answer: For a convex mirror f and R are positive and u is negative.
Distance of the object from the mirror (u) = -5 m = -500 cm
Distance of the image from the mirror (v) = ?
Radius of curvature = 20 cm

$\therefore$ Focal length = $\frac{R}{2}$

$= \frac{20}{2}$

= 10 cm

Mirror formula is

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

$$\frac{1}{10} = \frac{1}{-500} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{500}$$

$$\frac{1}{v} = \frac{50+1}{500}$$

$$= \frac{51}{500}$$

$$v = \frac{500}{51}$$

= 9.8 cm

The image is formed 9.8 cm behind the mirror. The image formed is virtual and erect.

Question 28: What is the position of an image when an object is placed at a distance of 20 cm from a concave mirror of focal length 20 cm?

Answer: For a concave mirror both u and f are negative
Distance between the object and the mirror (u)
= -20 cm Focal length of the mirror (f)
= -20 cm Mirror formula is

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$
$$\frac{-1}{20} = \frac{-1}{20} + \frac{1}{v}$$
$$\frac{1}{v} = -\frac{1}{20} + \frac{1}{20}$$
$$\frac{1}{v} = 0$$
$$v = \frac{1}{0} = \infty$$

Thus, the image will be formed at infinity.

Question 29:

An object is placed at distance of 10cm from the pole of a mirror, and the image of the object is formed at a distance of 30 cm from the mirror on the same side as the object. Is the mirror concave or convex? What is its focal length?

Answer: The image in this case is real as it is in front of the mirror. Only concave mirror gives a real image hence it is a concave mirror.
The distance between the object and the mirror u = -10 cm
The distance between the image and the mirror v = -30cm Focal length f = ?

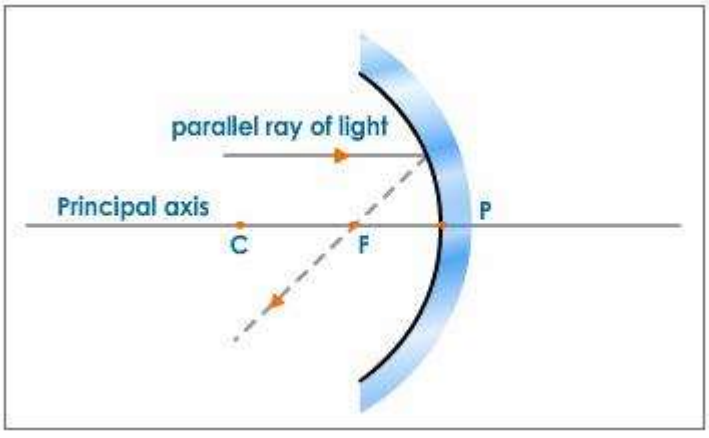
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$
$$= \frac{1}{-10} - \frac{1}{30}$$
$$\frac{1}{f} = \frac{-3-1}{30}$$
$$= \frac{-4}{30}$$
$$f = \frac{-30}{4}$$
= - 7.5 cm

The focal length is negative as the mirror is concave mirror.

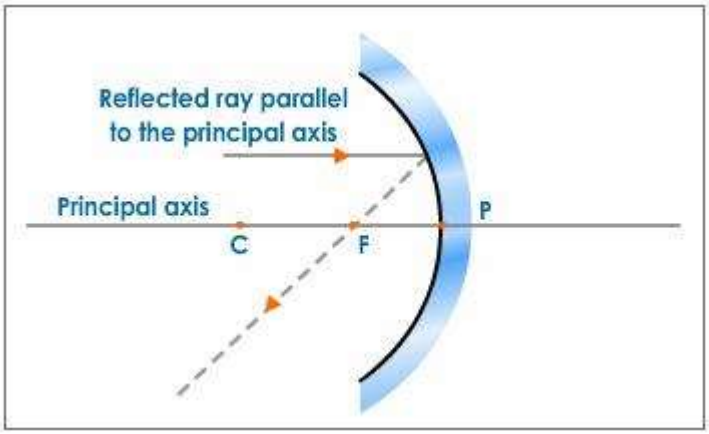
Question 30:

Explain with the help of ray diagrams the rules to be followed when drawing ray diagrams in the case of a concave mirror.

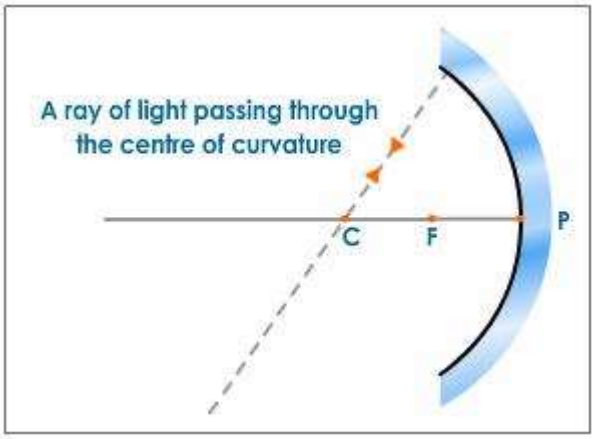
Answer: 1) A ray of light parallel to the principal axis after reflection from a concave mirror passes through its focus.



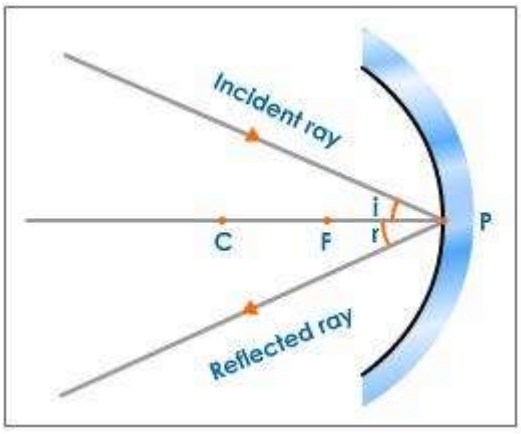
2) A ray of light passing through the focus of a concave mirror after reflection emerges parallel to the principal axis.



3) A ray of light passing through the centre of curvature of a concave mirror retraces its path after reflection as the ray passing through the centre of curvature acts as a normal to the spherical mirror.

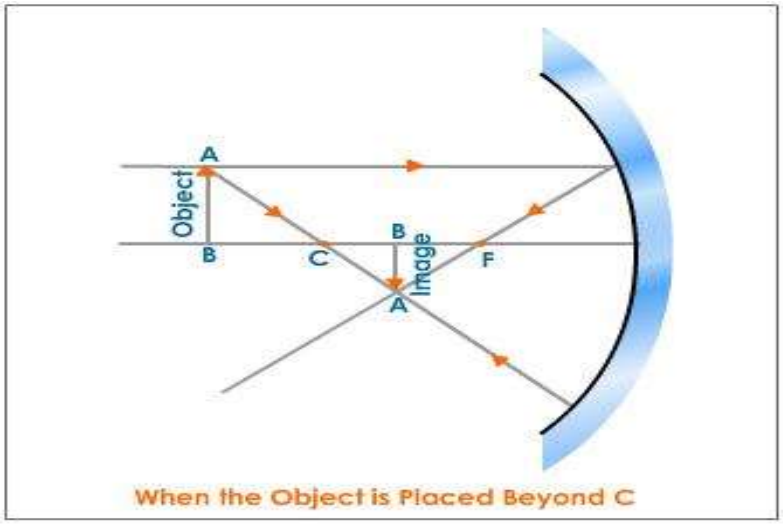


4) A ray of light which strikes the mirror at its pole gets reflected according to the law of reflection.



Question 31: *Draw a ray diagram to show the position, nature and size of the image formed by a concave mirror when the object is placed beyond the centre of curvature of the mirror.*

Answer: Object is placed beyond C



The image formed is between F and C.

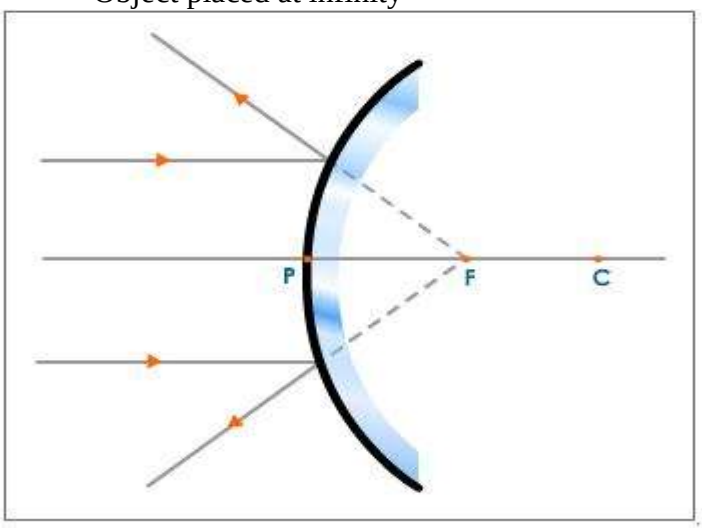
It is a) inverted

b) diminished and

c) real.

Question 32: *Draw a ray diagram to show the position, nature and size of the image formed by a convex mirror when the object is placed at infinity.*

Answer: Object placed at infinity



The image is formed at the focus of the mirror. It is virtual, diminished and erect.

Question 33: The focal length of a concave mirror is 15 cm. If the object is placed at a distance of 20 cm from the pole of the mirror, where will the image be formed? Draw the ray diagram to show the formation of the image.

Answer: Focal length (f) = - 15 cm

The distance between the object and the mirror (u) = - 20 cm

The distance between the image and the mirror (v) = ?

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

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

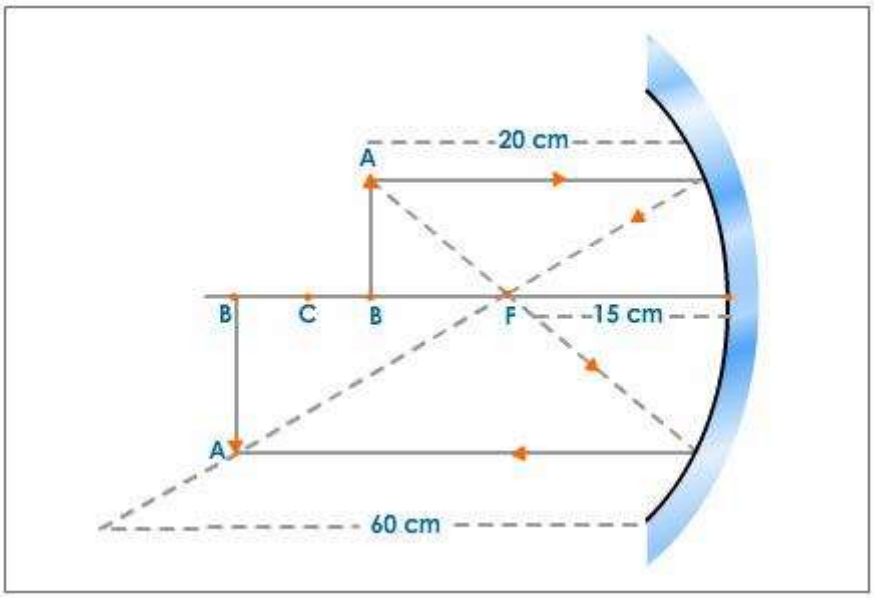
$$\frac{1}{v} = \frac{-1}{15} + \frac{1}{20}$$

$$= \frac{-4+3}{60}$$

$$\frac{1}{v} = -\frac{1}{60}$$

V = -60 cm

The image is formed 60 cm away from the pole of the mirror that is, on the same side of the mirror where the object is placed.



Question 34

The image formed by a convex mirror of focal length 30 cm is 1/4th size of the object. What is the distance of the object from the mirror?

Answer: Focal length = +30 cm

The distance between the object and the mirror (u) = ?

The distance between the image and the mirror (v) = ?

Let the size of the object be equal to 1.

Given size of the image = 1/4 size of the object.

$h_o = 1$

$$h_I = \frac{1}{4}$$

But we know that

$$\frac{h_I}{h_o} = \frac{-v}{u}$$

$$\frac{h_I}{h_o} = \frac{1}{4} = \frac{-v}{u}$$

$$v = -\frac{u}{4}$$

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

$$\frac{1}{u} - \frac{1}{\frac{u}{4}} = \frac{1}{f}$$

$$\frac{1}{u} - \frac{4}{u} = \frac{1}{30}$$

$$\frac{-3}{4} = \frac{1}{30}$$

u = -90 cm

The distance of the object from the mirror = 90 cm

Question 35: *An object 6 cm long is placed 1 metre in front of a concave mirror of 10 cm focal length. Find the nature and the size of the image.*

Answer: u = -1m = -100cm f = -10cm

v = ?

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

$$\frac{1}{-10} = \frac{1}{v} - \frac{1}{100}$$

$$\frac{1}{v} = \frac{1}{-10} + \frac{1}{100}$$

$$= \frac{-10+1}{100}$$

$$= \frac{-9}{100}$$

$$v = \frac{-100}{9}$$

= -11.11cm

The image is real and inverted and 11.11 cm from the mirror.

$$v = \frac{-100}{9}$$

$$\frac{h_I}{6} = \frac{-100}{9 \times 100}$$

$$\frac{h_I}{6} = \frac{-1}{9}$$

$$h_I = \frac{-6}{9}$$

$$= \frac{-2}{3}$$

h_I = -0.666cm

Size of the image = 0.666 cm

Negative sign indicates that the image is real and inverted.

Question 36:

A candle is held 3 cm away from a concave mirror whose radius of curvature is 24 cm. Where is the image formed? What is the nature of the image?

Answer:

Radius of the curvature = -24 cm

Focal length

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

$$= \frac{-24}{2}$$

= -12 cm

Distance between the object and the mirror u = -3 cm

Distance between the image and the mirror v = ?

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

$$\frac{1}{-12} = \frac{1}{-3} + \frac{1}{v}$$

$$\frac{1}{v} = -\frac{1}{12} + \frac{1}{3}$$

$$= \frac{-1+4}{12}$$

$$= \frac{3}{12}$$

$$v = \frac{12}{3}$$

= 4 cm

Magnification

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

$$= -\frac{+4}{-3}$$

= + 1.33

The image is 4 cm behind the mirror and it is virtual, magnified and erect.

Question 37

How far should one hold an object from a concave mirror of focal length 40 cm so as to get virtual image twice the size of the object?

Answer: Focal length = -40 cm

Let the height of the object be equal to 1

Then, the height of the image = 2

$$m = \frac{h_I}{h_o} = +\frac{v}{u}$$

(Since the mirror is a concave mirror the image formed will be erect and virtual.)

$$m = 2 = +\frac{v}{u}$$

$v = +2u$

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

$$-\frac{1}{40} = \frac{1}{2u} + \frac{1}{u}$$

$$= \frac{1+2}{2u}$$

$$= \frac{3}{2u}$$

$$-\frac{1}{40} = \frac{3}{2u} \text{ or } 2u = -120$$

$$u = \frac{-120}{2}$$

$$\therefore = -60cm$$

The object should be held at 60 cm from the pole of the mirror.

Question 38

An object is kept at a distance of 5 cm in front of a convex mirror of focal length 10 cm. Calculate the position and magnification of the image.

Answer: Distance between the object and the mirror u = -5 cm

Focal length f = +10 cm

Distance between the image and the mirror v = ?

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

$$\frac{1}{+10} = \frac{1}{v} - \frac{1}{5}$$

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{5}$$

$$= \frac{1+2}{10}$$

$$= \frac{3}{10}$$

$$v = \frac{10}{3}$$

= 3.33cm

The image is formed 3.33 cm behind the mirror.

Magnification

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

$$= -\frac{3.33}{-5}$$

= +0.67

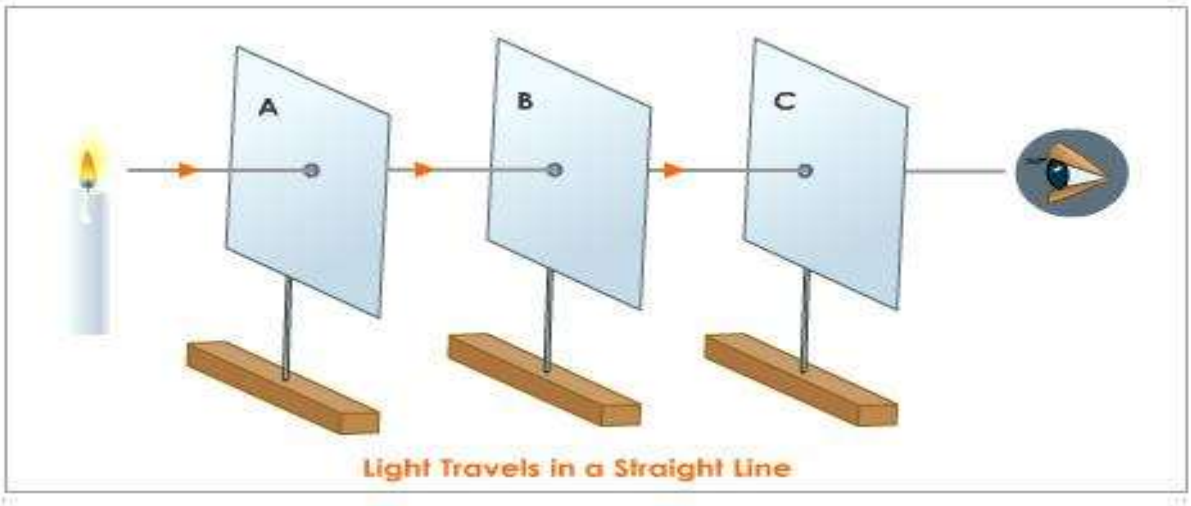
As the magnification is +ve, the image formed is virtual and erect.

Question 39

Describe an experiment to show that in a homogeneous transparent medium light travels in a straight line.

Answer:

In a homogeneous transparent medium light travels in a straight line and this is known as rectilinear propagation of light. This can be demonstrated by the following experiment:



Take three cardboards A, B and C and make a pinhole at their centre. Place a candle on one side and arrange the cardboards in such a way that the three pinholes and the candle flame are in a straight line. Light the candle, then the candle flame will be visible through the pinhole of the cardboard C. Now slightly displace any one of the cardboards and try to see the flame through the pinhole of the cardboard C. The flame will not be visible. From this it is clear that light travels in a straight line.

Question 40:

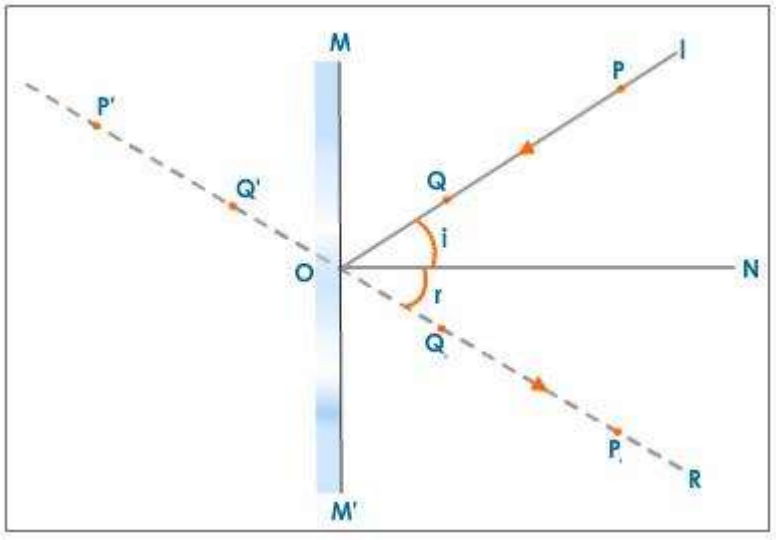
State the laws of reflection and verify them.

Answer: Laws of reflection:

1) The incident ray, the reflected ray and the normal at the point of incidence lie in the same plane.

2) The angle of incidence is equal to the angle of reflection.

Verification of the Laws of Reflection:



1) Fix a sheet of white paper on a drawing board.

2) Draw a line MM' on it and mark a point O at the centre of the line and a normal ON is drawn on MM'.

3) Draw IO, the incident ray in such a way that $\angle IOM$ is less than 90^0.

4) Place a strip of plane mirror vertically with its silvered surface on MM'.

5) Fix two pins P and Q on the incident ray IO.

6) Fix P' and Q' on other side of the normal, to represent the reflected image of P and Q, as observed in the mirror as P' and Q'

7) Remove the pins and draw a line OR passing through P' and Q' to represent the reflected ray.

8) Measure the angle of incidence $\angle ION$ and the angle of reflection $\angle NOR$.

9) $\angle i = \angle r$ and P, Q, P', Q', N and O lie in the same plane, thus verifying the laws of reflection.

10) Repeat the experiment for different measures of angles of incidence. The laws of reflection are found to be always true for different values of angle of incidence.