Light - Reflection And Refraction

Multiple Choice Questions

Question 1.
Which of the following can make a parallel beam of light when light from a point source is incident on it?
A. Concave mirror as well as convex lens

B. Convex mirror as well as concave lens

C. Two plane mirrors placed at 90o to each other

D. Concave mirror as well as concave lens

Answer:
Light rays passing through the focus of a concave mirror can makes a parallel beam of light. Similarly light rays passing through a convex lens can make parallel beam of light.

Question 2.
A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is
A. – 30 cm

B. – 20 cm

C. – 40 cm

D. – 60 cm

Answer:
The magnification is given by:

$$-\frac{v}{u} = m = \frac{height\ of object}{height\ of\ image}$$

$$-\frac{-30}{u} = m = \frac{-5}{10}$$

On calculating, we get u= -60 cm

Now, on applying the mirror formula, we get

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

$$\frac{1}{-60} + \frac{1}{-30} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{-1-2}{60}$$

$$\frac{1}{f} = \frac{-3}{60}$$

$$\frac{1}{f} = \frac{-1}{20}$$

Thus, the focal length is, F = -20 cm

Question 3.
Under which of the following conditions a concave mirror can form an image larger than the actual object?
A. When the object is kept at a distance equal to its radius of curvature

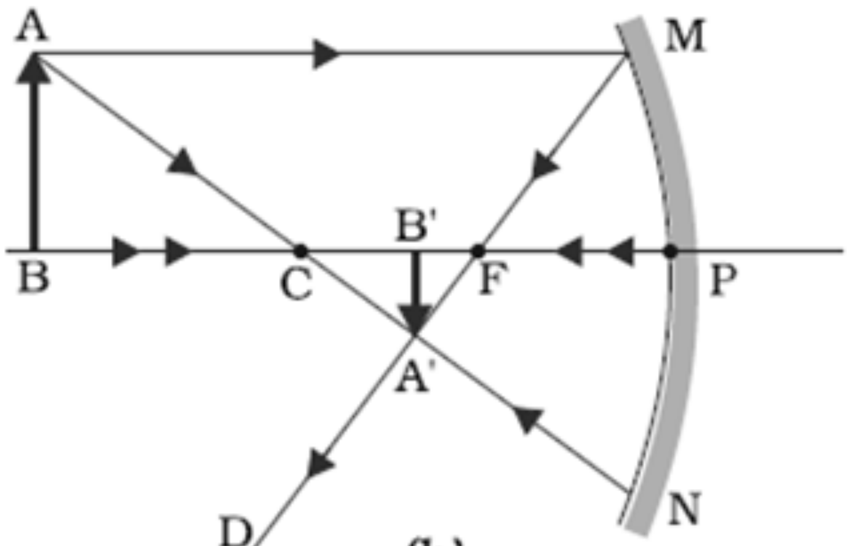
B. When object is kept at a distance less than its focal length

C. When object is placed between the focus and center of curvature

D. When object is kept at a distance greater than its radius of Curvature

Answer:
When the object is placed between the focus and the center of curvature of a concave mirror, the image formed will be beyond C, enlarged in size, Real and inverted.

It can be show with the following ray diagram:



(b)

Question 4.
Figure 10.1 shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is

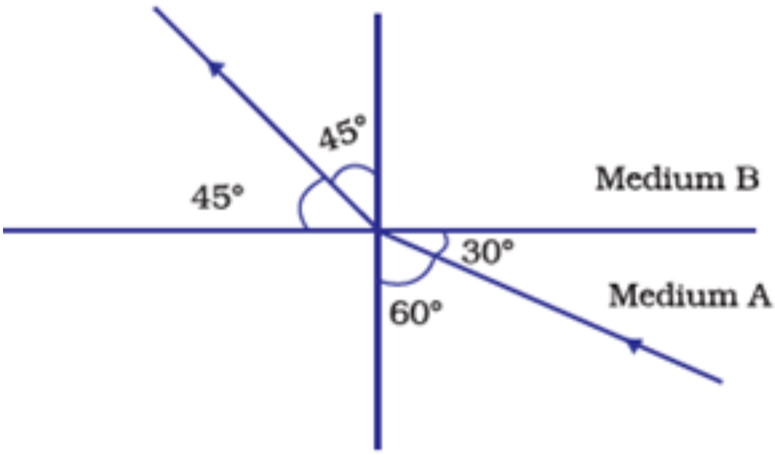


Fig. 10.1

(a) $\sqrt{3}/\sqrt{2}$

B. $\sqrt{2}/\sqrt{3}$

C. 1/ $\sqrt{2}$

D. $\sqrt{2}$

Answer:

According to Snell's law: $n = \frac{Sin\, i}{Sin\, r}$

$$n_{Ba} = \frac{Sin\, 60^{\circ}}{Sin\, 45^{\circ}} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{3}}{\sqrt{2}}$$

Question 5.
A light ray enters from medium A to medium B as shown in Figure 10.2. The refractive index of medium B relative to A will be

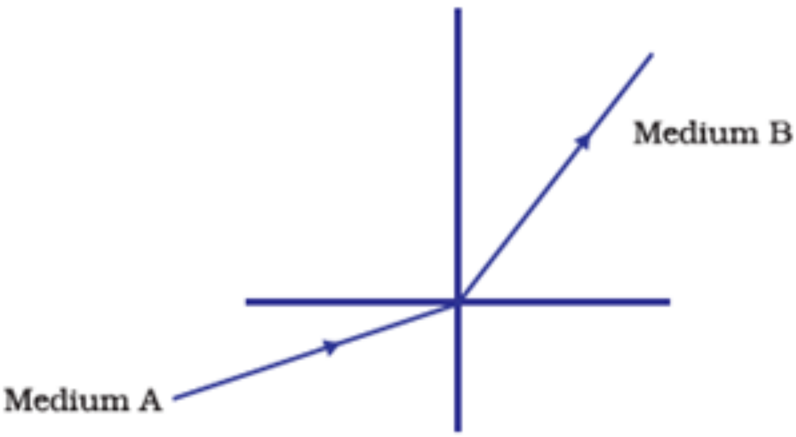


Fig. 10.2

A. greater than unity

B. less than unity

C. equal to unity

D. zero

Answer:
As it is clear from the figure, when the light rays travelled from medium A to medium B, then they bend towards the normal which means that medium B has higher refractive index and less speed of light with respect to medium A. So, refractive index of medium B with respect to medium A will be greater than unity.

Question 6.
Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively as shown in the Figure10.3. Which of the following could be inside the box?

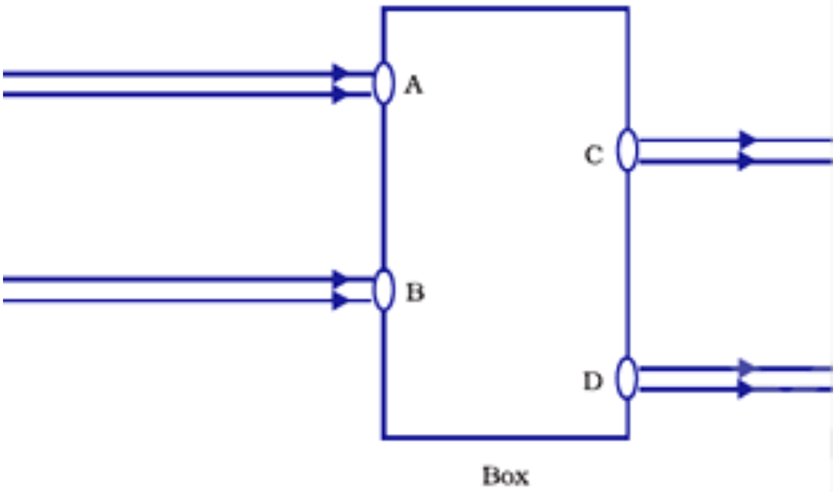


Fig. 10.3

A. A rectangular glass slab

B. A convex lens

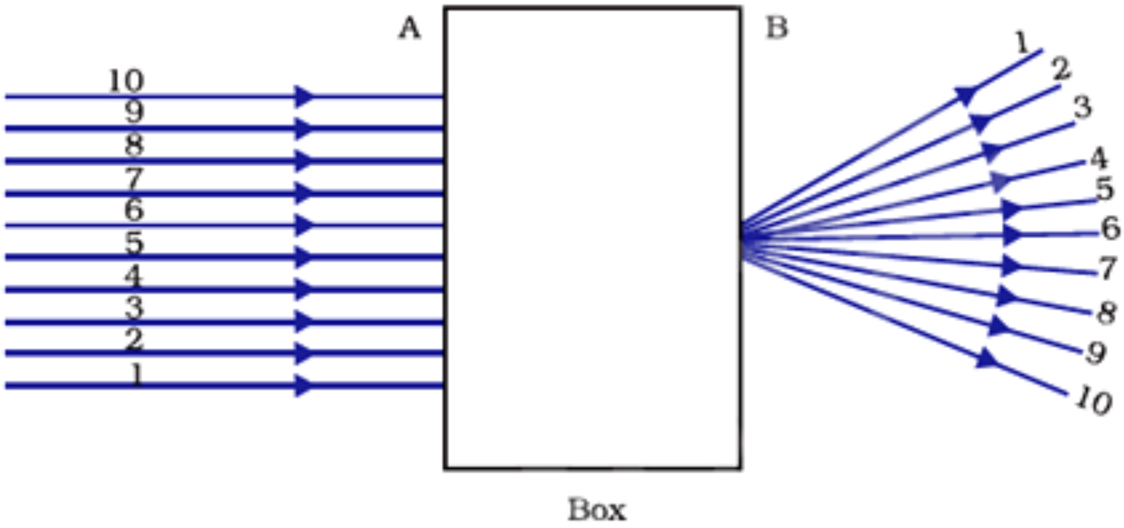
C. A concave lens

D. A prism

Answer:
Since the emergent rays are parallel to the incident rays direction and we know that out of convex lens, concave lens, prism and rectangular glass slab, only glass slab can change the light ray path so that emergent rays are parallel to incident rays. Therefore, correct answer is a rectangular glass slab.

Question 7.

A beam of light is incident through the holes on side A and emerges out of the holes on the other face of the box as shown in the Figure 10.4. Which of the following could be inside the box?



A. Concave lens

B. Rectangular glass slab

C. Prism

D. Convex lens

Answer:
Since a convex lens can converge the light rays at a point and emerged at point B. So, the convex lens is inside the box.

Question 8.
Which of the following statements is true?
A. A convex lens has 4 diopter power having a focal length 0.25 m

B. A convex lens has –4 diopter power having a focal length 0.25 m

C. A concave lens has 4 diopter power having a focal length 0.25 m

D. A concave lens has –4 diopter power having a focal length 0.25 m

Answer:
Since power of a lens is given by the relation:

P = 1/f

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

$$f = \frac{1}{4} = 0.25\ m$$

So, a convex lens has 4 diopter power having a focal length of 0.25 m.

Question 9.
Magnification produced by a rear view mirror fitted in vehicles
A. is less than one

B. is more than one

C. is equal to one

D. can be more than or less than one depending upon the position of the object in front of it

Answer:
Since, Magnification is defined as the ratio of height of the image to the height of object and we know that a rear view- mirror i.e. convex mirror forms a virtual erect and diminished image. So, Magnification produced by convex mirror will be less than one.

Question 10.
Rays from Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?
A. 15 cm in front of the mirror

B. 30 cm in front of the mirror

C. between 15 cm and 30 cm in front of the mirror

D. more than 30 cm in front of the mirror

Answer:
We know that in case of a concave mirror, when the object is placed at infinity, then the light rays after reflection gets converged at focus of the concave mirror. Sun is at the infinity point, So focal length of the mirror will be 15 cm. The object should be placed between at 2f to obtain the same size of image as that of the object.

So, object distance = 2f = 2 x 15 = 30 cm

Question 11.
A full length image of a distant tall building can definitely be seen by using
A. a concave mirror

B. a convex mirror

C. a plane mirror

D. both concave as well as plane mirror

Answer:
As we know that, a convex mirror forms virtual, erect and diminished sized images. So, a full length image of a distant tall building can be achieved by taking its diminished image by convex mirror.

Question 12.
In torches, search lights and headlights of vehicles the bulb is placed
A. between the pole and the focus of the reflector

B. very near to the focus of the reflector

C. between the focus and center of curvature of the reflector

D. at the center of curvature of the reflector

Answer:
Since light rays when falls on a mirror, they become parallel to the principal axis and we get a concentrated light ray. This is the reason why the bulb is placed very near to the focus of the reflector or mirror.

Question 13.

The laws of reflection hold good for
A. plane mirror only

B. concave mirror only

C. convex mirror only

D. all mirrors irrespective of their shape

Answer:
The laws of reflection hold good for all the mirrors having smooth surface for light reflection irrespective of their shape.

Question 14.
The path of a ray of light coming from air passing through a rectangular glass slab traced by four students are shown as A, B, C and D in Figure 10.5. Which one of them is correct?

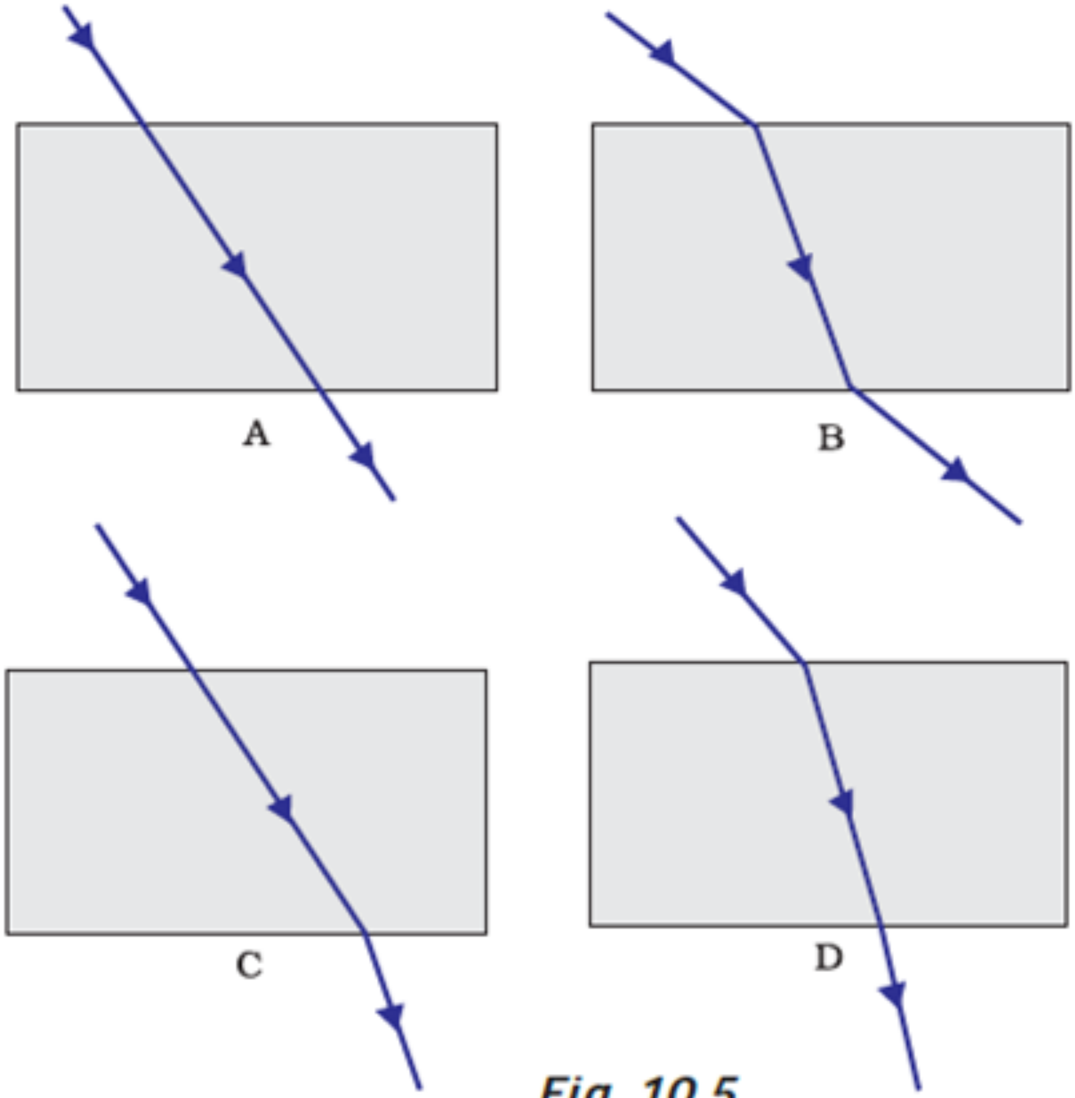


Fig. 10.5

A. A

B. B

C. C

D. D

Answer:
Since when path of a ray of light coming from air when passes through a rectangular glass slab, then the emergent ray is parallel to the incident ray direction which is correctly shown in figure B.

Question 15.
You are given water, mustard oil, glycerin and kerosene. In which of these media a ray of light incident obliquely at same angle would bend the most?

A. Kerosene

B. Water

C. Mustard oil

D. Glycerin

Answer:
Since Glycerin has highest refractive index among kerosene, Water and mustard oil, so the ray of the light incident obliquely at the some angle would bend the most in Glycerin medium.

Question 16.
Which of the following ray diagrams is correct for the ray of light incident on a concave mirror as shown in Figure 10.6?

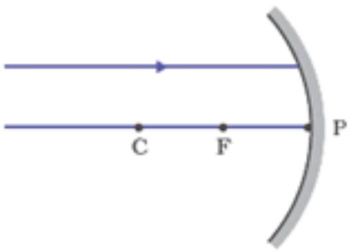


Fig. 10.6

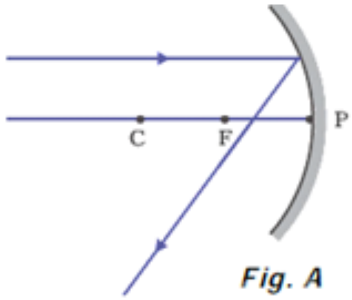


Fig. A

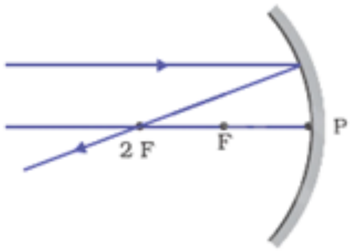


Fig. B

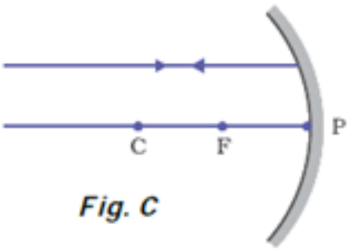


Fig. C

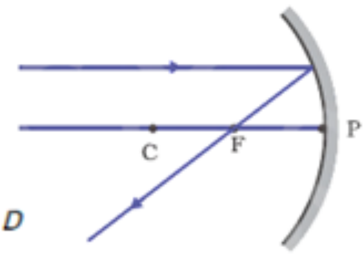


Fig. D

A. Fig. A

B. Fig. B

C. Fig. C

D. Fig. D

Answer:
The light rays parallel to the principal axis will pass through the focus of the mirror after reflection of light. So, figure D is correct.

Question 17.
Which of the following ray diagrams is correct for the ray of light incident on a lens shown in Fig. 10.7?

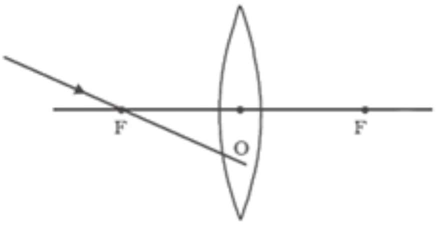


Fig. 10.7

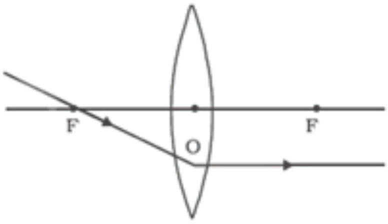


Fig. A

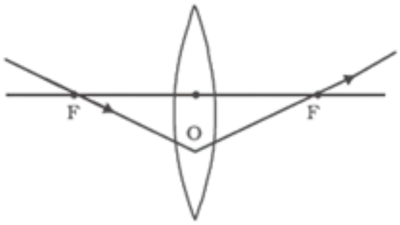


Fig. B

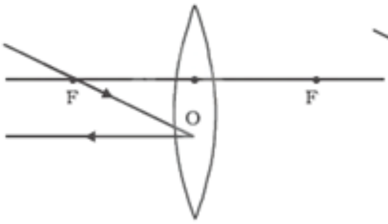


Fig. C

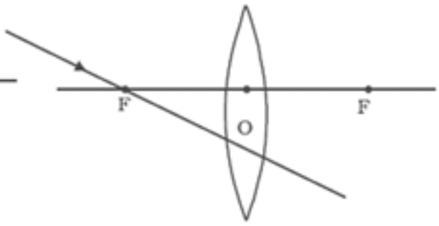


Fig. D

A. Fig. A.

B. Fig. B.

C. Fig. C.

D. Fig. D

Answer:
When a ray of light passes through the focus of a convex lens, then after the reflection of light, the ray becomes parallel to the principal axis of the convex lens. So figure A is correct.

Question 18.
A child is standing in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller. The following is the order of combinations for the magic mirror from the top.
A. Plane, convex and concave

B. Convex, concave and plane

C. Concave, plane and convex

D. Convex, plane and concave

Answer:
Since the image of her head is big, it means that the concave mirror has been used of higher focal length. The middle portion of the body of the child remains of same size which confirms the usage of plane mirror in the middle and in the bottom, the legs appears smaller which means that convex lens has been used in the bottom. So, the correct combination is: concave, plane mirror and convex mirror.

Question 19.
In which of the following, the image of an object placed at infinity will be highly diminished and point sized?
A. Concave mirror only

B. Convex mirror only

C. Convex lens only

D. Concave mirror, convex mirror, concave lens and convex lens.

Answer:
When the object is placed at infinity, then the incident rays fall parallel on the principal axis, which on after reflection by a concave mirror, convex mirror and convex lens passes through the focus of the reflector. The image thus obtained is diminished and point sized.

Short Answer Questions

Question 1.
Identify the device used as a spherical mirror or lens in following cases, when the image formed is virtual and erect in each case.

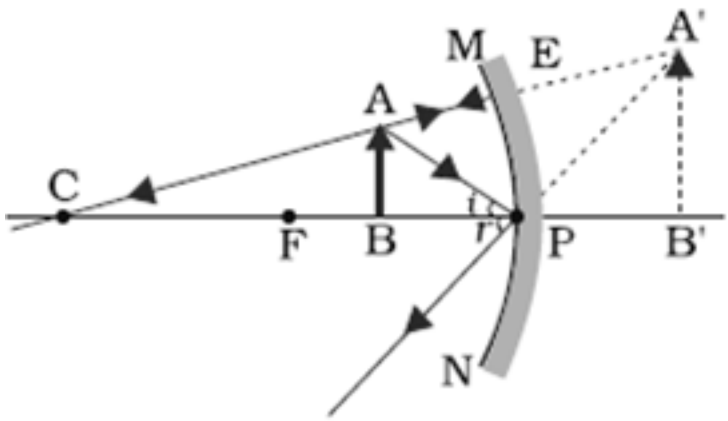
(a) Object is placed between device and its focus, image formed is enlarged and behind it.

(b) Object is placed between the focus and device, image formed is enlarged and on the same side as that of the object.

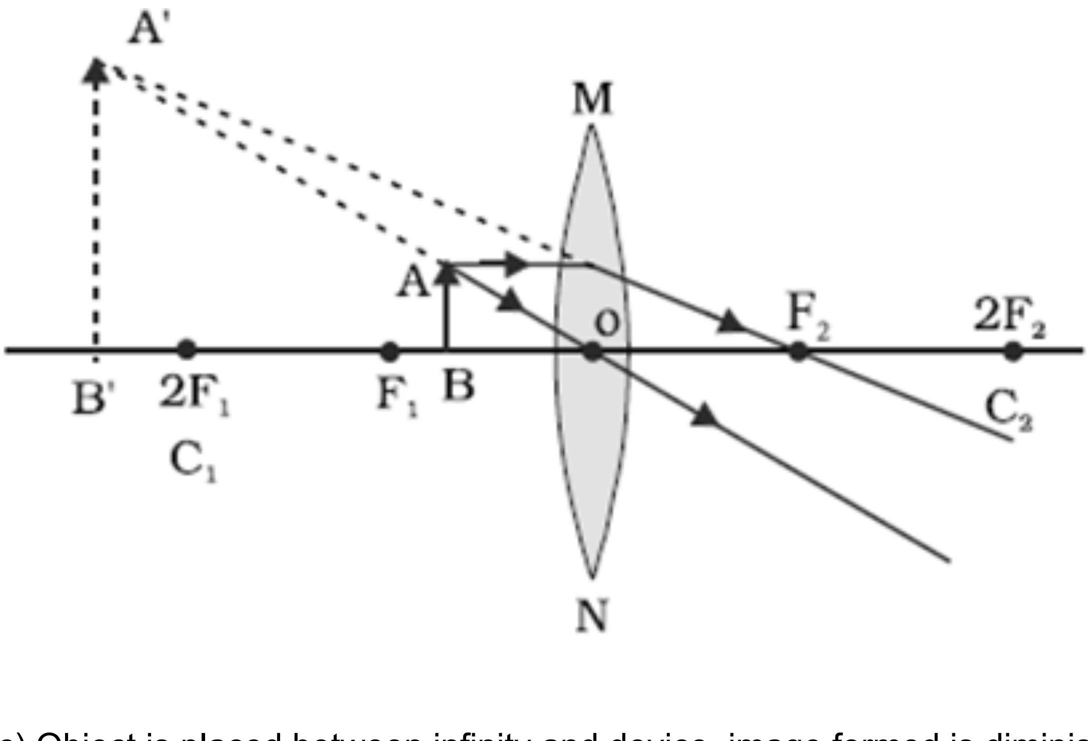
(c) Object is placed between infinity and device, image formed is diminished and between focus and optical center on the same side as that of the object.

(d) Object is placed between infinity and device, image formed is diminished and between pole and focus, behind it.

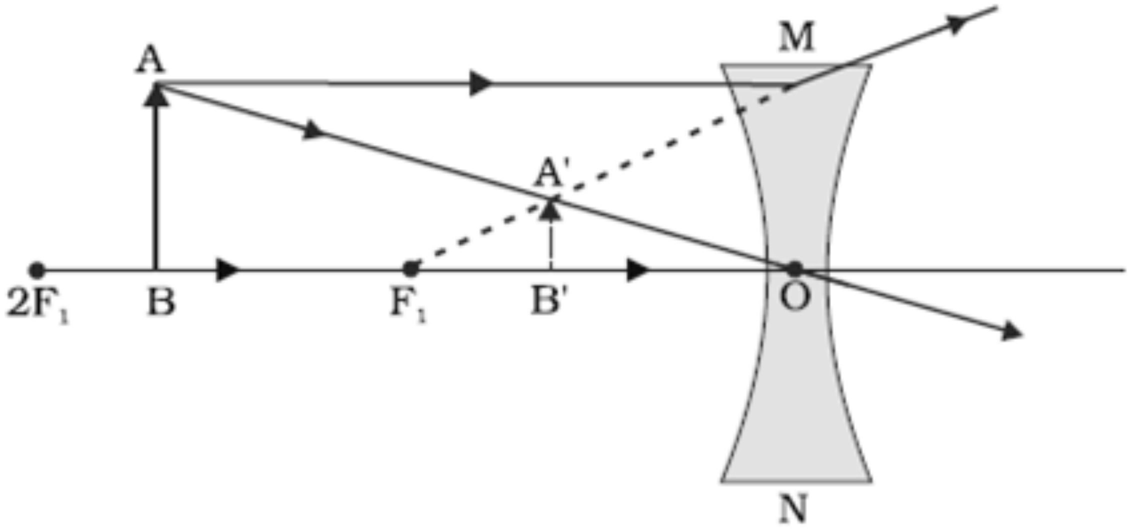
Answer:
(a) The device when Object is placed between device and its focus, image formed is enlarged and behind it. Will be a concave mirror.



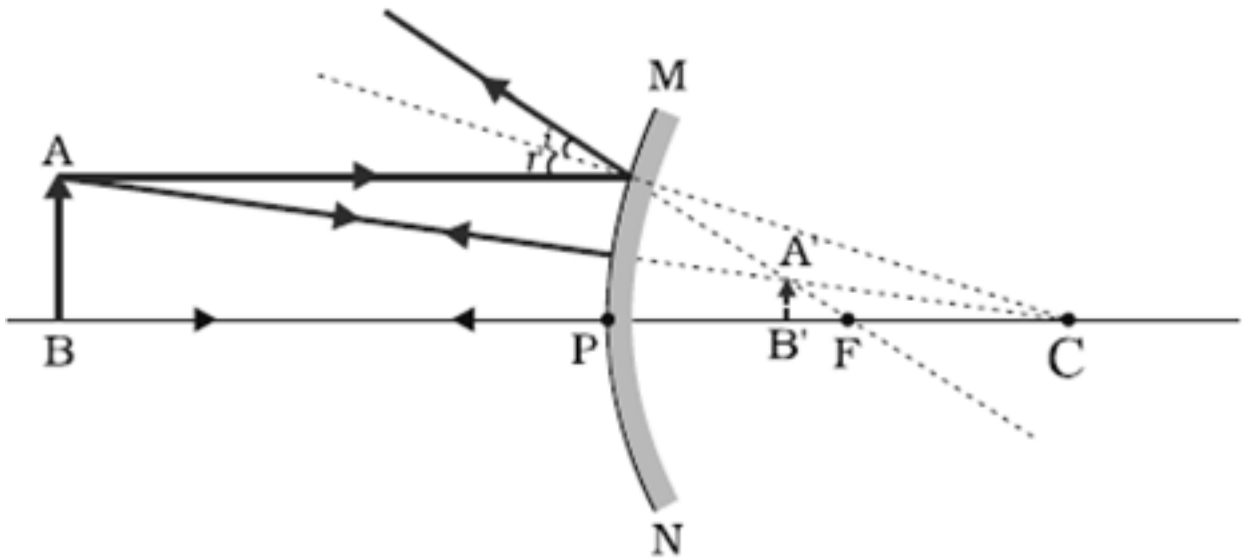
(b) Object is placed between the focus and device, image formed is enlarged and on the same side as that of the object, then the device is a convex lens. It can be shown with the following ray diagram:



(c) Object is placed between infinity and device, image formed is diminished and between focus and optical centre on the same side as that of the object, then the device will be a concave lens. The ray diagram is:



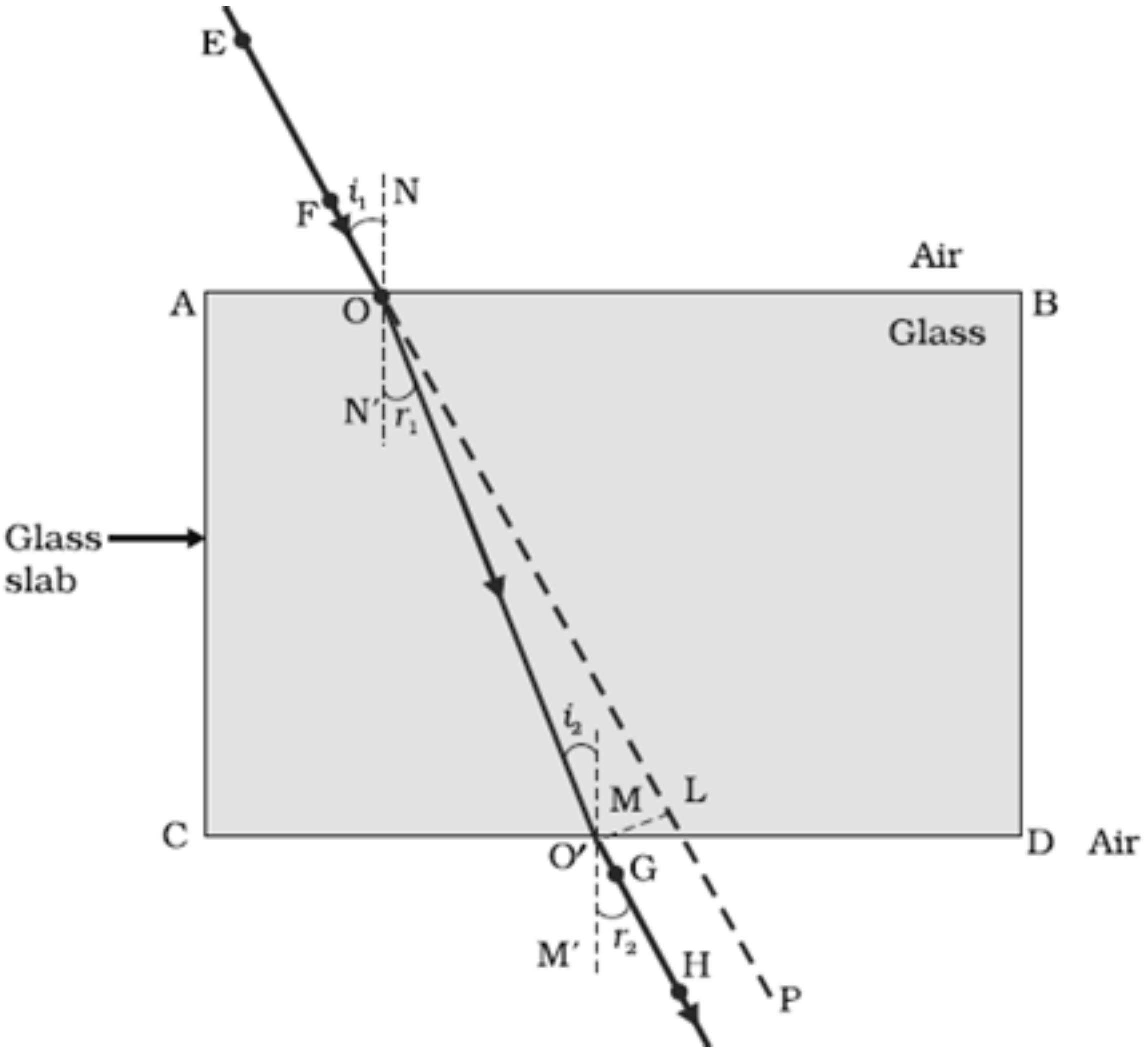
(d) Object is placed between infinity and device, image formed is diminished and between pole and focus, behind it, then the device used will be a convex mirror. The ray diagram will be as follows:



Question 2.
Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself? Explain using a diagram.

Answer:
When light rays is incident on the rectangular glass slab immersed in any medium , then it is refracted by the glass slab and after refracting it comes out of the glass and gets another interface of glass and air, so on going from denser to rarer, it bends away from the normal ray. As the glass slab is rectangular in shape and both

sides have the same medium. So, the light ray which is incident and the emergent rays are parallel. It can be shown with the help of following diagram:



Question 3.
A pencil when dipped in water in a glass tumbler appears to be bent at the interface of air and water. Will the pencil appear to be bent to the same extent, if instead of water we use liquids like, kerosene or turpentine. Support your answer with reason.

Answer:
The pencil when dipped in water in a glass tumbler appears to be bent at the interface of air and water due to the refraction of light but if we use liquid like kerosene in place of water, then the pencil will bend more than it bend in case of water because the refractive index of kerosene is higher than that of water and is therefore optical denser than water.

So, the pencil will not bend to the same extent due to different refractive indices of different media.

Question 4.
How is the refractive index of a medium related to the speed of light? Obtain an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?

Answer:
The refractive index of a medium is related to the speed of light by the following relation:

n = c/ v where n is the refractive index

c is the speed of light

v is the velocity of the light in the medium

The expression of refractive index of a medium w.r.t another medium in terms of speed of light in these two media is as follows:

Let light travels from a medium say air to a medium 1, then the refractive index of medium 1 can be written as:

$$n_1 = \frac{c}{v_1} \quad \text{........(1)}$$

When light rays are travelling from air to a medium 2, then the refractive index of medium 2 can be written as:

$$n_2 = \frac{c}{v_2} \quad \text{..........(2)}$$

Dividing equation (2) by equation (1), we get

$$\frac{n_2}{n_1} = \frac{\left(\frac{c}{v_2}\right)}{\left(\frac{c}{v_1}\right)} = \frac{v_1}{v_2}$$

Question 5.
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.

Answer:
Refractive index of diamond with respect to glass ndg = 1.6

Absolute refractive index of glass = 1.5

Now $n_{dg} = \frac{n_d}{n_g}$

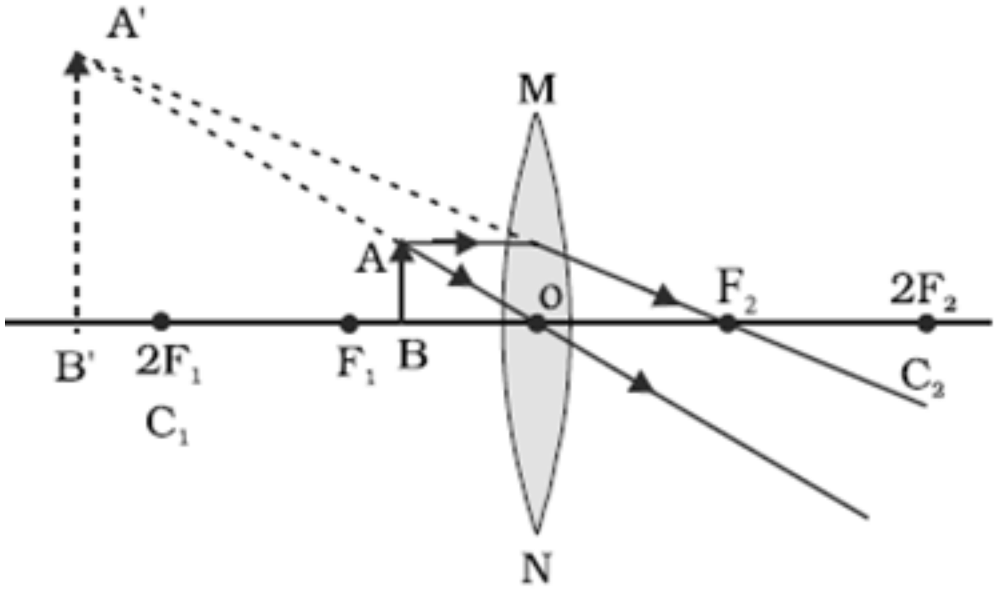
Putting the values 1.6 = $\frac{n_d}{1.5}$

nd = $1.6 \times 1.5 = 2.4$

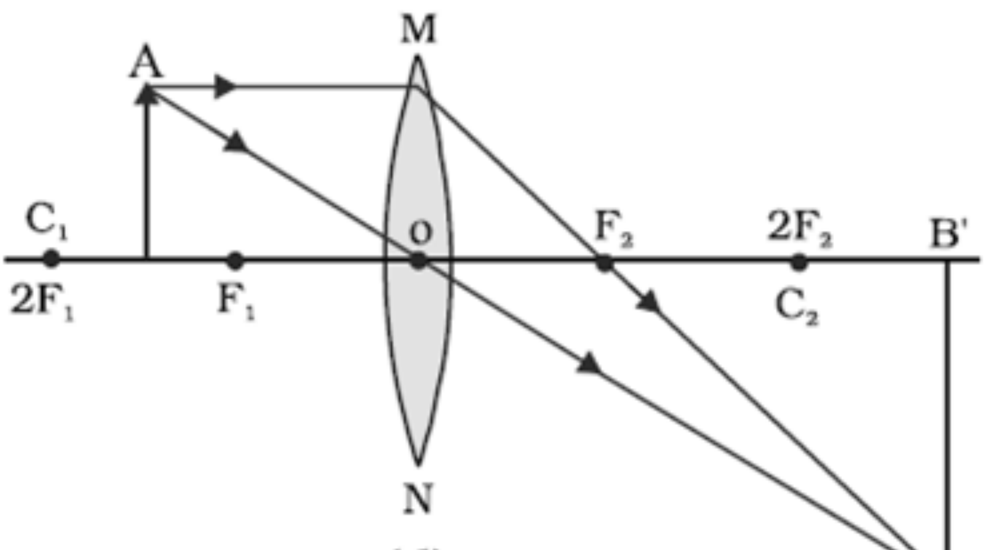
Question 6.
A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Answer:
Yes, the statement is correct.

To get the magnified virtual image, the object is to be placed between the optical centre of the convex lens and the focus F1 of the convex lens. The image formed will be virtual and magnified.



However, for obtaining a magnified real image, the object should be placed in between F1 and 2F1 of the convex lens.



(d)

Question 7.
Sudha finds out that the sharp image of the window pane of her science laboratory is formed at a distance of 15 cm from the lens. She now tries to focus the building visible to her outside the window instead of the window pane without disturbing the lens. In which direction will she move the screen to obtain a sharp image of the

building? What is the approximate focal length of this lens?

Answer:
To get a sharp image of the object, Sudha should move the screen towards the lens and keeping the lens fixed because the object is now placed at beyond 2f and the lens will form the image towards on opposite side between F and 2F.

Since the actual distance between the window pane and the mirror is 15 cm. So, the approximate focal length of the lens will be approximately 15 cm.

Question 8.
How are power and focal length of a lens related? You are provided with two lenses of focal length 20 cm and 40 cm respectively. Which lens will you use to obtain more convergent light?

Answer:
Power and focal length of a lens are related to each other by the following relation:

$P = 1/ f$

Where P is the power of lens

f is the focal length of the lens and should be in m.

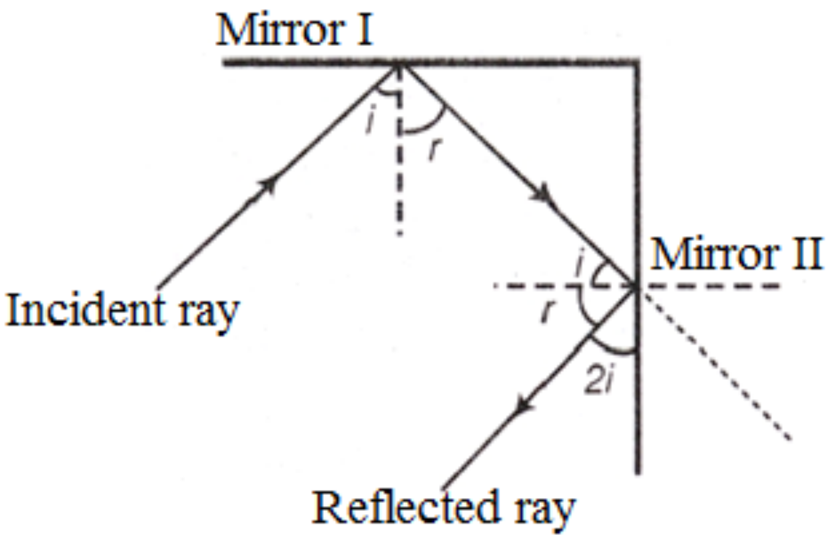
The lens having high power or small focal length will have more converging power. So, the lens to obtain more convergent light is of focal length 20 cm.

Question 9.
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.

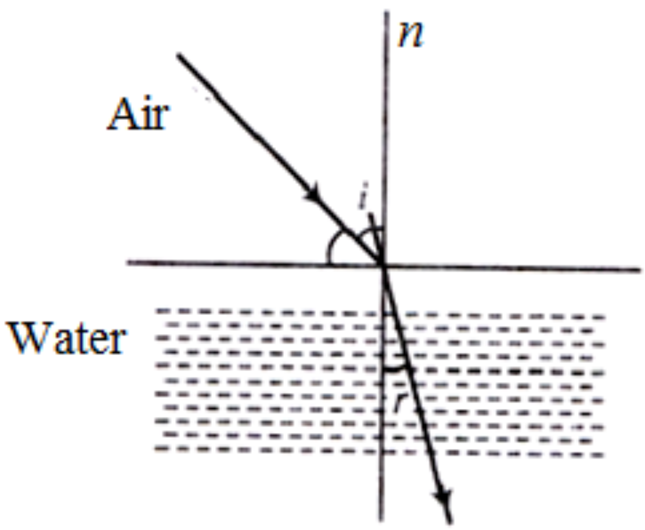
Answer:
The incident ray and reflected ray will always be parallel to each other when the two plane mirrors will be placed at right angle i.e. 900 to each other.

The diagram is as follows:

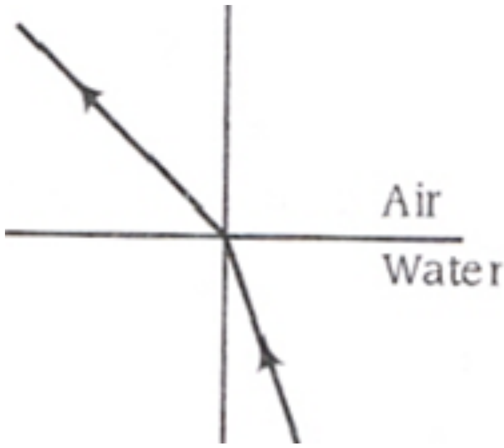


Question 10.
Draw a ray diagram showing the path of rays of light when it enters with oblique incidence (i) from air into water; (ii) from water into air.

Answer:
(i) Ray diagram when the path of rays of light enters from air to water:



(ii) Ray diagram when the path of light rays enters from water into air:



Long Answer Questions

Question 1.
Draw ray diagrams showing the image formation by a concave mirror when an object is placed

(a) between pole and focus of the mirror

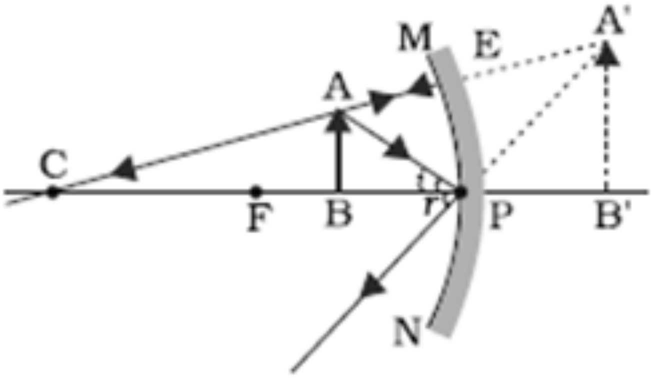
(b) between focus and center of curvature of the mirror

(c) at center of curvature of the mirror

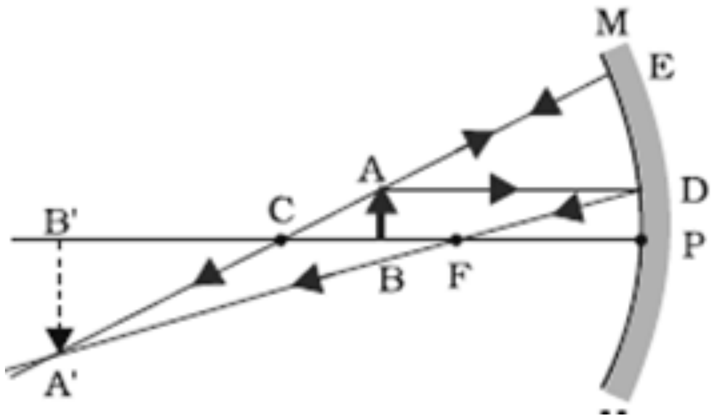
(d) a little beyond center of curvature of the mirror

(e) at infinity

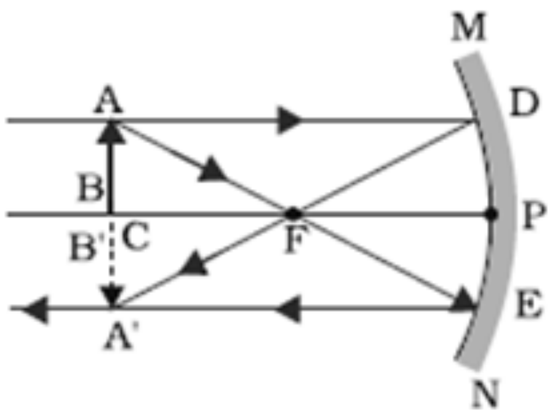
Answer:
(a) Ray diagram when object is placed between the pole and focus of the concave mirror:



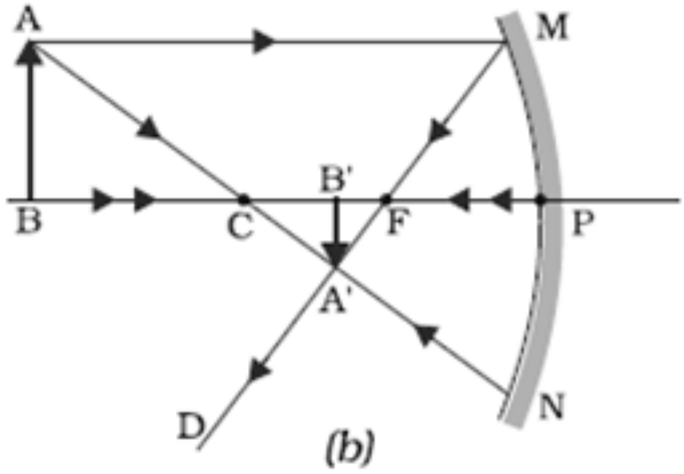
(b) Ray diagram when the object is placed between the focus and centre of curvature of concave mirror:



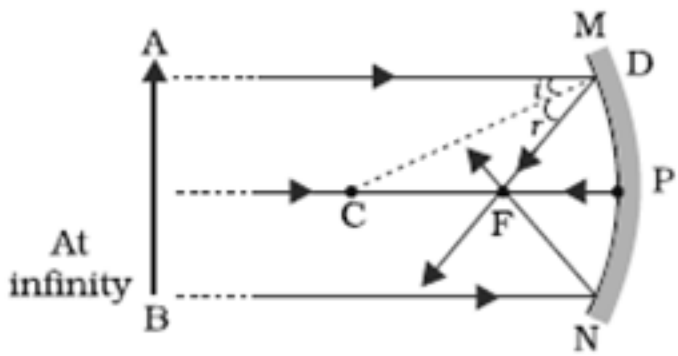
(c) Ray diagram when the object is placed at the centre of curvature of the concave mirror:



(d) Ray diagram when the object is placed at little beyond centre of curvature of the concave mirror:



(e) Ray diagram when the object is placed at infinity of the concave mirror:



Question 2.
Draw ray diagrams showing the image formation by a convex lens when an object is placed

(a) between optical center and focus of the lens

(b) between focus and twice the focal length of the lens

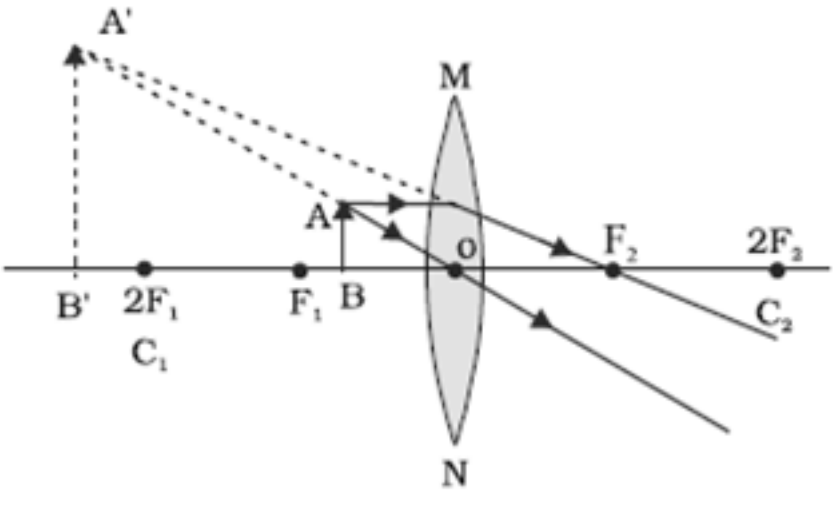
(c) at twice the focal length of the lens

(d) at infinity

(e) at the focus of the lens

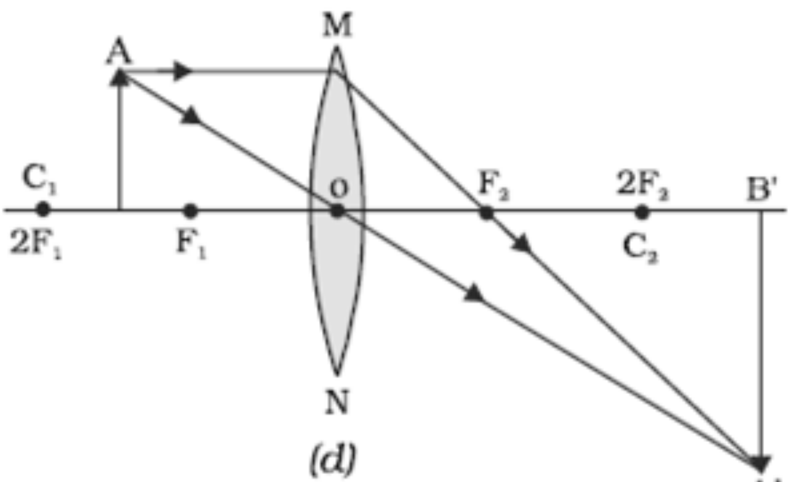
Answer:

(a) Ray diagram when an object is placed between optical centre and focus of the lens:



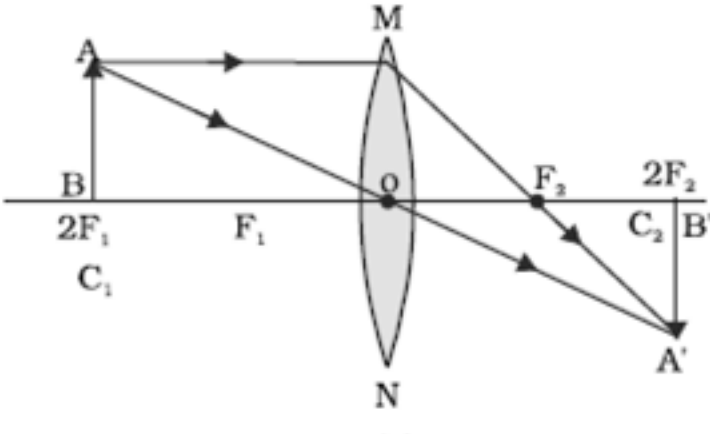
(f)

(b) Ray diagram when an object is placed between focus and twice the focal length of the lens:

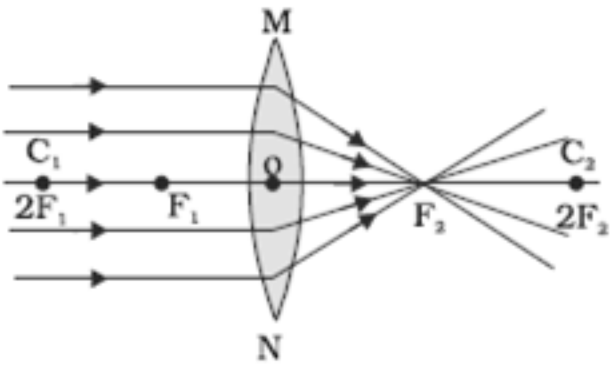


(d)

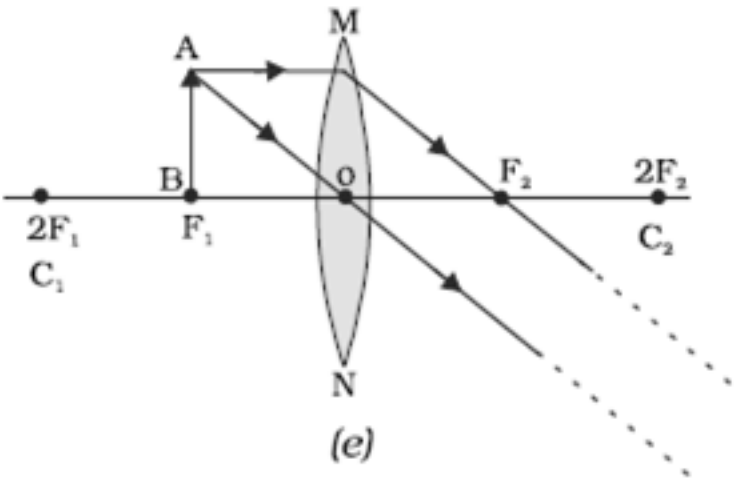
(c) Ray diagram when an object is placed at twice the focal length of the lens



(d) Ray diagram when an object is placed at infinity



(e) Ray diagram when the object is placed at the focus of the lens:



(e)

Question 3.
Write laws of refraction. Explain the same with the help of ray diagram, when a ray of light passes through a rectangular glass slab.

Answer:
The laws of refraction are:

(a) The two laws of refraction of light are as follows:

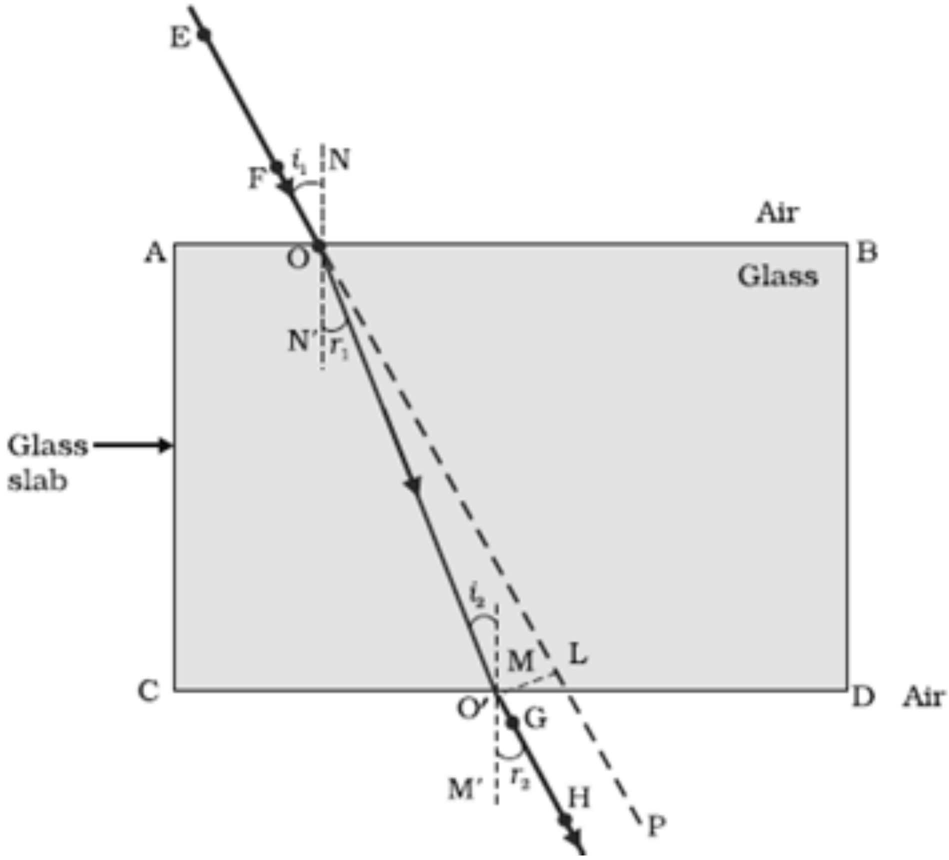
1. The incident ray, the refracted ray and the normal at the point of coincidence, lie in the same plane.

2. The second law of refraction is also known as Snell's law of refraction and it states that: the ratio of Sine of the angle of incidence to the sine of refraction is constant for a given pair of media. It establishes a relation between angle of incidence and angle of refraction.

It can be expressed mathematically as follows:

$$\frac{\sin i}{\sin r} = n$$

It can be shown with the following diagram:



Here, EO is the incident ray, OO’ is the refracted ray and O’H is the emergent ray.

Since the incident ray, refracted ray and the emergent ray are in the same plane which is the first law of refraction. Moreover as light ray enter from a rarer to a denser medium, it bends towards the normal and when it comes out from glass to air, it bends away from the normal. The refractive index can be calculated by taking the ratio of sine of the angle of incidence to the ratio of sine of refraction which is also the Snell’s law.

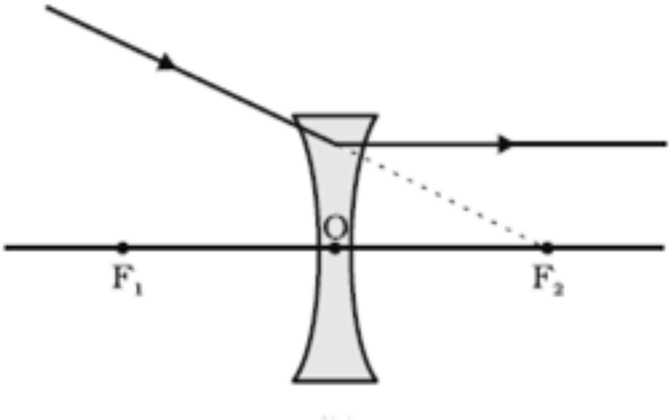
Question 4.
Draw ray diagrams showing the image formation by a concave lens when an object is placed

(a) at the focus of the lens

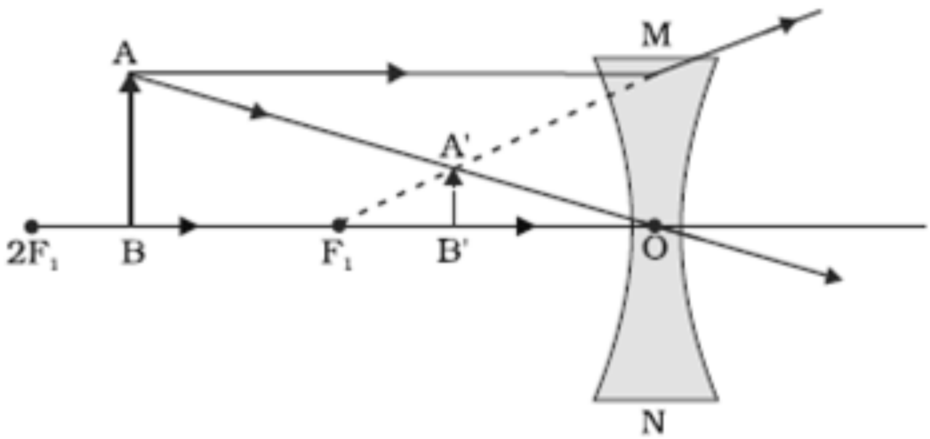
(b) between focus and twice the focal length of the lens

(c) beyond twice the focal length of the lens

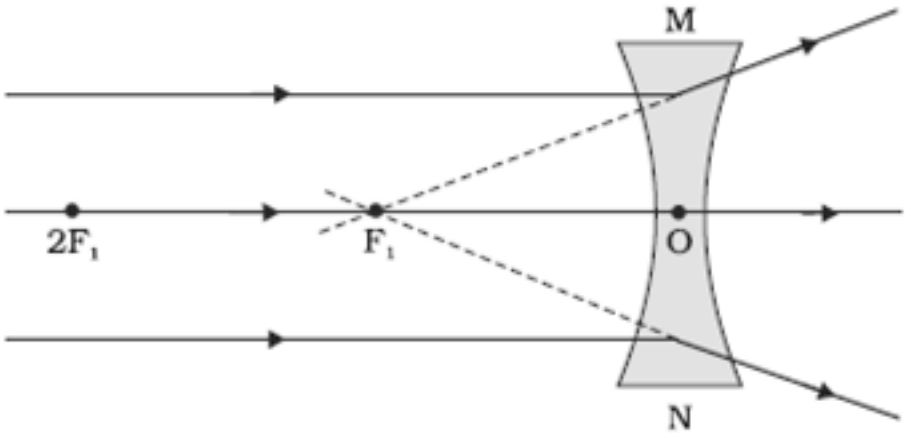
Answer:
(a) The ray diagram when the object is placed at the focus of the concave lens:



(b) The ray diagram when the object is placed between focus and twice the length of focal length of the lens:



(c) Ray diagram when the object is beyond twice the focal length of the concave lens:



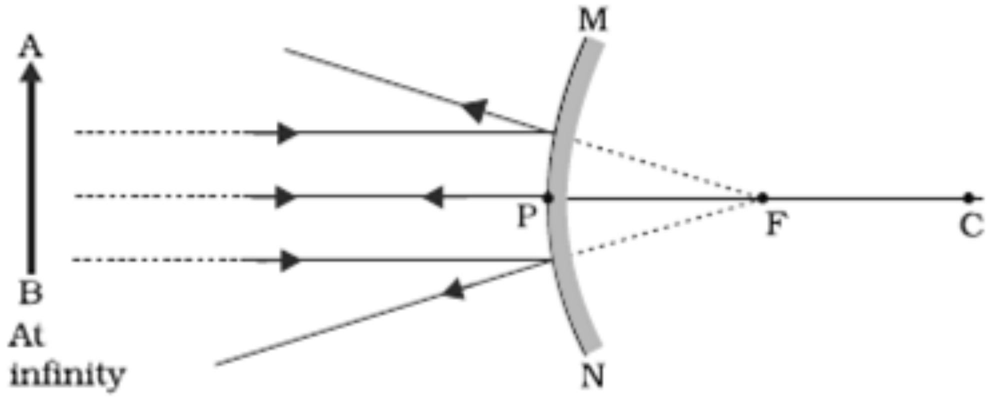
(a)

Question 5.
Draw ray diagrams showing the image formation by a convex mirror when an object is placed

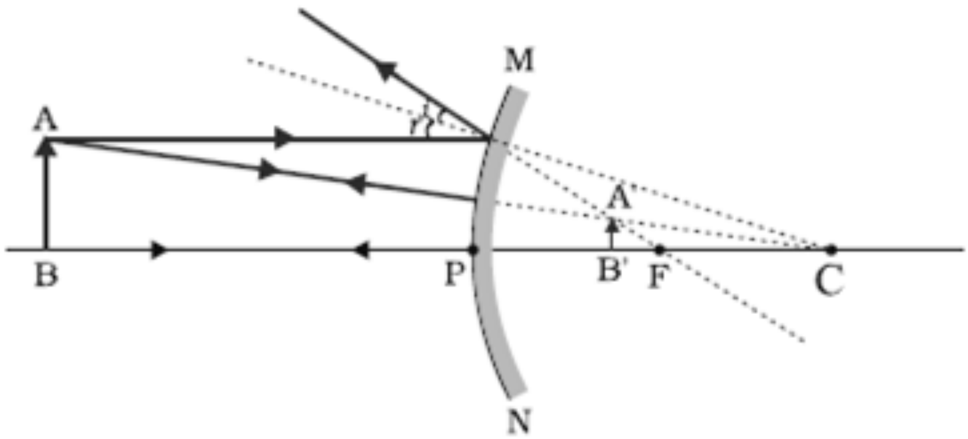
(a) at infinity

(b) at finite distance from the mirror

Answer:
(a) Ray diagram when the object is placed at infinity of the convex mirror:



(b) Ray diagram when the object is placed at finite distance from the convex mirror:



Question 6.
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?

Answer:
Given: Magnification = 3

Distance of image from the lens = -80 cm

Now, Magnification m is given by $m = \frac{v}{u}$

$$3 = \frac{80}{u}$$

u=26.67 cm

So, the object is to be placed at 26.67 cm from the lens.

The nature of the image is virtual, erect and larger than the object size.

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

$$\frac{1}{80} + \frac{3}{80} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{1+3}{80} = \frac{4}{80}$$

F = 20 cm

Since focal length of the lens is positive, so the lens is convex lens.

Question 7.
Size of image of an object by a mirror having a focal length of 20 cm is observed to be reduced to 1/3rd of its size. At what distance the object has been placed from the mirror? What is the nature of the image and the mirror?

Answer:
Focal length of the mirror f =20 cm

hi/h0 = 1/3

if the mirror is a concave mirror, then the focal length of the mirror, f= -20 cm

Magnification is given by

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

$$-\frac{v}{u} = -\frac{1}{3} = \frac{h_i}{h_o}$$

Object distance u = -3v or v= - u/3

Applying the mirror formula

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

$$\frac{1}{20} = -\frac{3}{u} + \frac{1}{u}$$

$$\frac{1}{20} = -\frac{2}{u}$$

$$u = -40\ cm$$

v = 40/3

So, the image is virtual, erect and diminished and the mirror is a concave mirror.

Question 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?

Answer:
Power is defined as the degree of divergence of convergence achieved by the lens and it is reciprocal of the focal length.

The unit of Power is Dioptre.

Focal length = 50 cm

In meter, focal length is : 0.5 m

Power = 1/f = 1/0.5

Power of the lens = +2D

The lens will be a convex lens

Focal length = -50 cm

In meter, focal length will be = -0.5 m

Power = 1/-0.5 = -2D

In this case, the lens will be a concave lens.

Question 9.
A student focused the image of a candle flame on a white screen using a convex lens. He noted down the position of the candle screen and the lens as under Position of candle = 12.0 cm Position of convex lens = 50.0 cm Position of the screen = 88.0 cm

(i) What is the focal length of the convex lens?

(ii) Where will the image be formed if he shifts the candle towards the lens at a position of 31.0 cm?

(iii) What will be the nature of the image formed if he further shifts the candle towards the lens?

(iv) Draw a ray diagram to show the formation of the image in case

(iii) as said above.

Answer:
(i)object distance u = position of convex lens – position of candle

u = - (50 -12)= -38 cm

image distance v = position of screen –position of convex lens

v= 88-50 cm

v= 38 cm

Applying the lens formula:

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

$$\frac{1}{f} = \frac{1}{38} - \frac{-1}{38}$$

$$\frac{1}{f} = 1/19$$

on calculating focal length will be f = 19 cm

(ii) When the candle is shifted towards the lens at a position of 31.0 cm:

Object distance u =-(50-31)

u = -19 cm

Applying the lens formula

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

$$\frac{1}{19} = \frac{1}{v} - \frac{1}{-19}$$

$$\frac{1}{v} = 0$$

Therefore, v is infinity

(iii) If the candle is further shifted towards the lens, then the nature of the image formed will be virtual, erect and magnified

(iv) The ray diagram will be as follows: