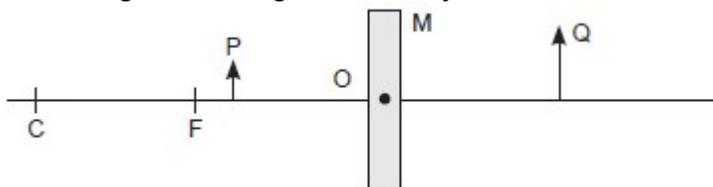


ACHIEVERS FOUNDATION
LIGHT
PHYSICS
CBSE-X

1. (a) Define the following terms in the context of spherical mirrors:
(i) Pole (ii) Centre of curvature (iii) Principal axis (iv) Principal focus
(b) Draw ray diagrams to show the principal focus of a (i) concave mirror (ii) convex mirror
(c) Consider the following diagram in which M is a mirror and P is an object and Q is its magnified image formed by the mirror.



State the type of the mirror M and one characteristic property of the image Q.

Answer:

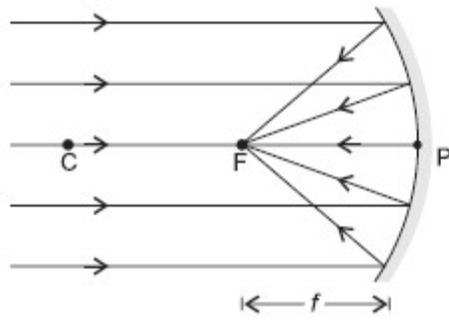
(a) Pole: The central point of the reflecting spherical surface is called the pole (P). It lies on the surface of the mirror.

Centre of Curvature: The centre of the hollow sphere of which the spherical mirror is a part, is called the centre of curvature (C).

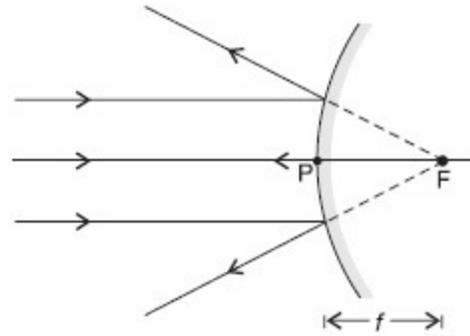
Principal Axis: The straight line joining the pole and the centre of curvature is called the principal axis.

Principal Focus: The point 'F' on the principal axis, where the incident light rays parallel to the principal axis actually meet (converge) (in case of a concave mirror) or appear to diverge or come from (in case of a convex mirror) after reflection, is called its principal focus (F).

For a concave mirror, the focus lies on the same side of the reflecting surface, whereas in case of a convex mirror, it lies on the opposite side of the reflecting surface.



(b) Focus of concave mirror



Focus of convex mirror

(c) The given mirror M is a concave spherical mirror. When the object lies between the pole and the focus of the concave mirror, an erect, virtual and enlarged image is formed. So one characteristic property of the image Q formed in the given figure is that it is virtual.

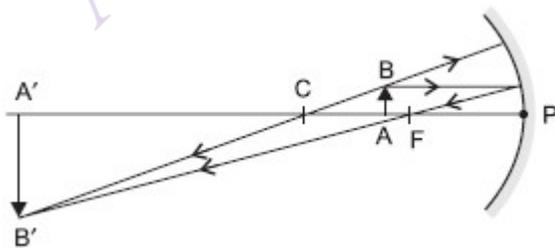
2. (a) To construct a ray diagram, we use two light rays which are so chosen that it is easy to know their directions after reflection from the mirror. List these two rays and state the path of these rays after reflection. Use these rays to locate the image of an object placed between centre of curvature and focus of a concave mirror.
- (b) Draw a ray diagram to show the formation of image of an object placed between the pole and principal focus of a concave mirror. How will the nature and size of the image formed change, if the mirror is replaced by converging lens of same focal length?

Answer:

- (a) Rays which are chosen to construct a ray diagram for reflection are:
- A ray parallel to the principal axis and
 - A ray passing through the centre of curvature of a concave mirror or appears to pass through the centre of curvature of a convex mirror.

Path of these light rays after reflection:

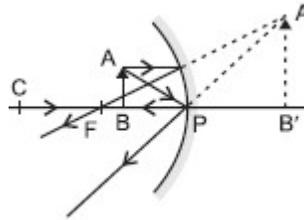
- It will pass through the principal focus of a concave mirror or appear to diverge in case of a convex mirror.
- It gets reflected back along the same path.



(b) When an object is placed between the pole and the principal focus of a concave mirror, a virtual, erect and enlarged image is formed behind the

concave mirror as shown in the adjoining figure.

If the concave mirror is replaced by a converging lens of the same focal length, a virtual, erect and enlarged image is formed on the same side of object for the same position of object, i.e. between the principal focus and the optical centre of the lens.



3. List the sign conventions that are followed in case of refraction of light through spherical lenses. Draw a diagram and apply these conventions in determining the nature and focal length of a spherical lens which forms three times magnified real image of an object placed 16 cm from the lens.

Answer:

Sign conventions for refraction of light through spherical lenses.

- (i) The object is always placed to the left of the lens so that the incident light moves from left to right.
- (ii) All distances are to be measured from the optical centre of the lens.
- (iii) The distances measured in the direction of incident light along +ve x-axis, will be taken as positive, while those measured to the left of the origin along -ve x-axis, will be taken as negative.
- (iv) All measurements of heights above the principal axis (along +ve y-axis) will be considered as positive, while below it (along -ve y-axis) will be taken as negative.

According to question,

$$u = -16 \text{ cm}, m = -3 \text{ (real image)}$$

$$\text{But } m = \frac{v}{u} = -3$$

$$\Rightarrow v = -3u = -3 \times (-16) = 48 \text{ cm}$$

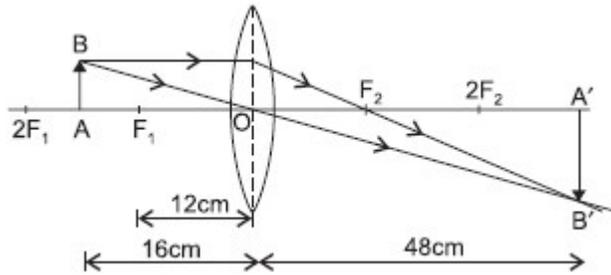
Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{48} - \frac{1}{-16} = \frac{1}{48} + \frac{1}{16} = \frac{1+3}{48} = \frac{4}{48} = \frac{1}{12}$$

$$\Rightarrow f = +12 \text{ cm}$$

So, the focal length of the given spherical lens is 12 cm. The positive sign of focal length shows that the nature of spherical lens is convex.

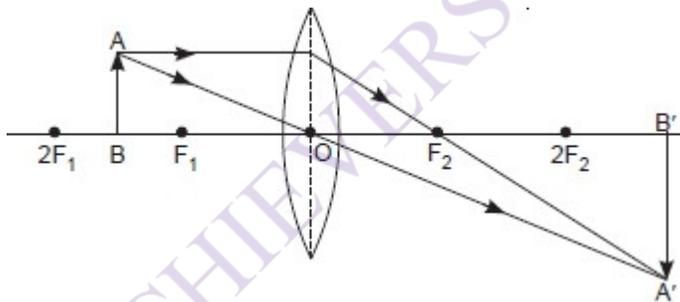
Ray diagram:



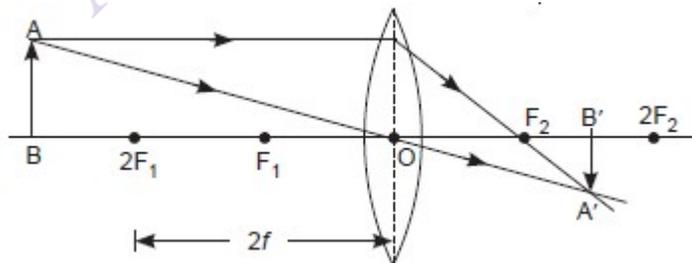
4. A student wants to project the image of a candle flame on the walls of school laboratory by using a lens.
- Which type of lens should he use and why?
 - At what distance in terms of focal length ' f ' of the lens should he place the candle flame so as to get (i) a magnified, and (ii) a diminished image respectively on the wall?
 - Draw ray diagram to show the formation of the image in each case.

Answer:

- He should use a convex lens as it forms a real image.
- He should place the candle flame between F_1 and $2F_1$ (the focus and the centre of curvature of the lens) to get the magnified image on the wall, while the diminished image is obtained when the object is located at a distance greater than $2f$.
- (i) Ray diagram for a magnified image



- Ray diagram for a diminished image



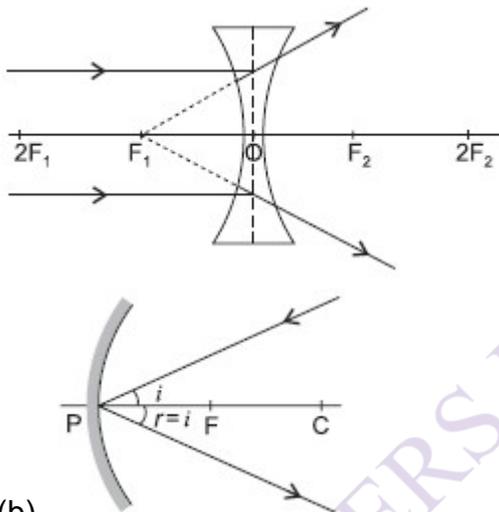
5. (a) A concave lens is called a diverging lens. Explain this property with the help of

diagram.

- (b) For a concave mirror draw a ray diagram to show the reflected ray when the ray of light incident obliquely on the pole of mirror.
 (c) What is the difference between virtual images produced by concave, plane and convex mirrors?

Answer:

(a) A beam of light from an object at infinity, parallel to the principal axis, falls on a concave lens. After refraction through it, the light appears to come from a fixed point on the same side of an object as shown, i.e. the concave lens spreads out parallel beam of light. Due to this property, the concave lens is called a diverging lens.



- (b)
 (c) Difference between virtual image produced by
 (i) Concave mirror: magnified (ii) Plane mirror: same size
 (iii) Convex mirror: diminished

6. (a) On entering in a medium from air, the speed of light becomes half of its value in air. Find the refractive index of that medium with respect to air?

(b) A glass slab made of a material of refractive index n_1 is kept in a medium of refractive index n_2 . A light ray is incident on the slab. Draw the path of the rays of light emerging from the glass slab, if (i) $n_1 > n_2$ (ii) $n_1 = n_2$ (iii) $n_1 < n_2$.

Answer:

(a) Refractive Index of a medium (n)

$$n = \frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in the medium}}$$

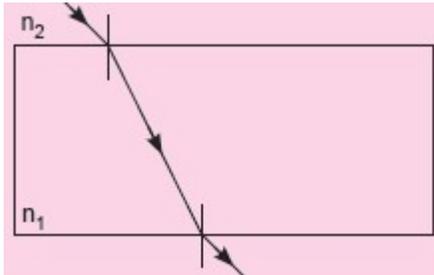
Let the velocity of light in vacuum be v_1 and velocity of light in the medium be v_2 .

Hence
$$\frac{v_1}{2} = v_2$$

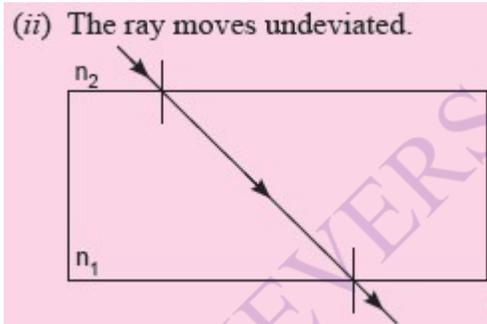
$$n = \frac{v_1}{v_2}$$

$$= \frac{v_1}{(v_1/2)} = 2$$

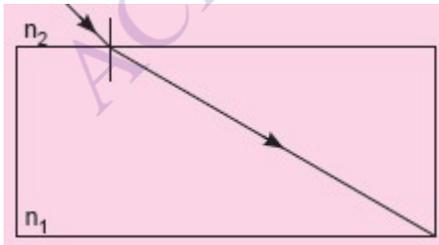
(b) (i) The ray moves towards the normal.



(ii) The ray moves undeviated.



(iii) The ray moves away from the normal.



7. Analyse the following observation table showing variation of image-distance (v) with object distance (u) in case of a convex lens and answer the questions that follow, without doing any calculations:

S. No.	Object distance u (cm)	Image distance v (cm)
1	- 100	+25
2	- 60	+30
3	- 40	+40
4	- 30	+60
5	- 25	+100
6	- 15	+120

(a) What is the focal length of the convex lens? Give reason to justify your answer.

(b) Write the serial number of the observation which is not correct. On what basis have you arrived at this conclusion?

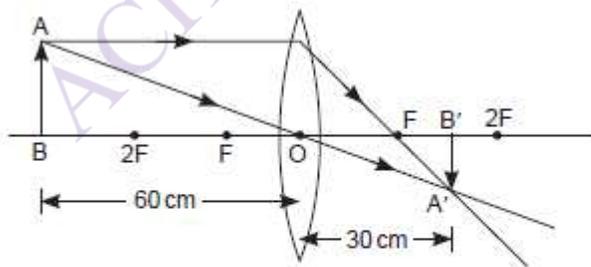
(c) Select an appropriate scale and draw a ray diagram for the observation at S.No. 2. Also find the approximate value of magnification.

Answer:

(a) The focal length of the convex lens is $f = 20$ cm. **Reason:** Objects at S.No. 3 indicates that $u = -40$ cm, $v = +40$ cm Thus, object is at $2F$. Therefore, $2f = 40$ cm $\Rightarrow f = 20$ cm

(b) Observation at S.No. 6 is not correct. The value, $u = -15$ cm, indicates that the object is in between the optical centre and the focus (i.e., less than the focal length) of the lens and hence, the image should be on the same side as the object. Accordingly, the image distance should be negative and cannot be positive (+120 cm) as shown in table.

(c) Ray diagram for the observation at S.No. 2 : Given: $u = -60$ cm; $v = +30$ cm; $f = 20$ cm



$$\text{Magnification, } m = \frac{v}{u} = \frac{30 \text{ cm}}{-60 \text{ cm}} = -\frac{1}{2} = -0.5$$

8. Draw a ray diagram in each of the following cases to show the formation of image,

when the object is placed:

(a) between optical centre and principal focus of a convex lens.

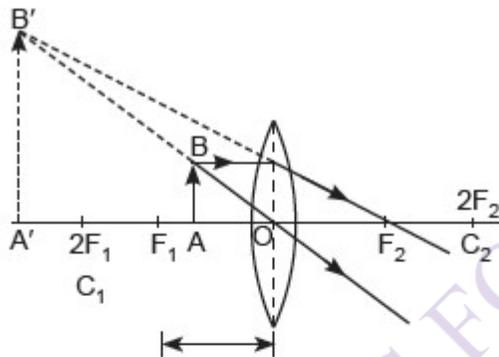
(b) anywhere in front of a concave lens.

(c) at $2F$ of a convex lens. State the signs and values of magnifications in the above mentioned cases (a) and (b).

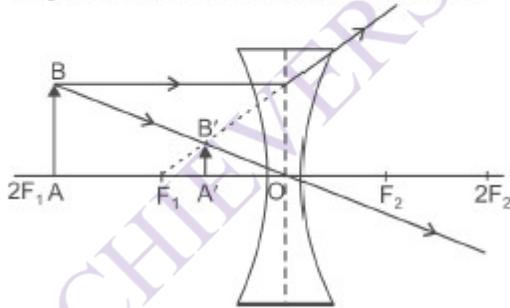
Answer:

When the object is placed:

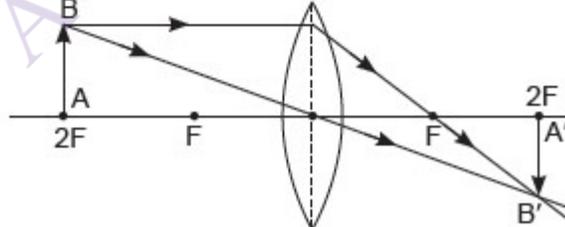
(a) Between optical centre and principal focus of a convex lens:



(b) Anywhere in front of a concave lens



(c) AT $2F$ of a convex lens



Sign and value of Magnification will be: Positive, in case (i) as virtual, erect and magnified image is formed. Therefore, absolute value of magnification will be greater than one.

Positive, in case (ii) as virtual, erect and diminished image is formed. Therefore, absolute value of magnification will be less than one.

9. State the two laws of reflection of light.

Answer:

Laws of reflection of light

- (i) The angle of incidence is equal to the angle of reflection.
- (ii) The incident ray, the normal to the reflecting surface at the point of incidence and reflected ray from that point, all lies in the same plan

10. List four characteristics of the images formed by plane mirrors.

Answer:

Characteristics of image formed by a plane mirror

- (i) It is always virtual and erect.
 - (ii) The size of image is equal to that of the object.
 - (iii) The image is formed at the same distance behind the mirror as the object is in front of the mirror.
 - (iv) The image is laterally inverted.
11. (a) Explain why a ray of light passing through the centre of curvature of a concave mirror, gets reflected along the same path.
- (b) State the type of mirror that can make a parallel beam of light when light from a point source is incident on it. At what location on the principal axis, this point source is placed?

Answer:

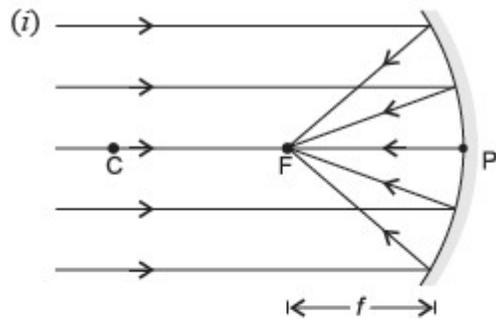
- (a) The ray passing through the centre of curvature incident to the mirror along its normal, so $\angle i = \angle r = 0$. Therefore, the ray retraces its path.
- (b) Concave mirror. At focus.

12. Draw ray diagrams to show the principal focus of a

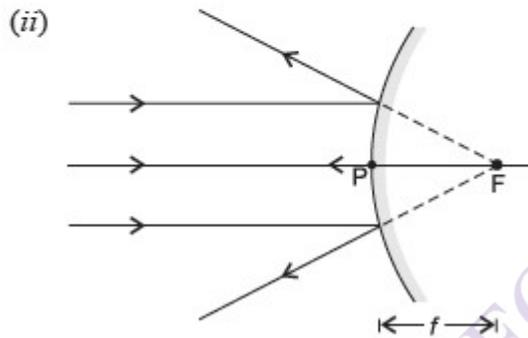
- (i) concave mirror

(ii) convex mirror

Answer:



Focus of concave mirror



Focus of convex mirror

13. Define the radius of curvature of spherical mirrors. Find the nature and focal length of a spherical mirror whose radius of curvature is +24 cm.

Answer:

Radius of Curvature: The separation between the pole (P) and the centre of curvature (C) or the radius of the hollow sphere, of which the mirror is a part, is called radius of curvature (R), i.e., $PC = R$.

Given, $R = 2f = 24 \text{ cm}$

Therefore, $f = +12 \text{ cm}$

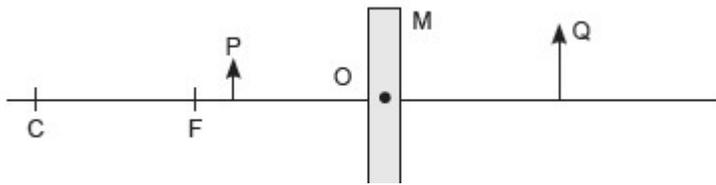
The focal length of the mirror is positive. This indicates that nature of the given spherical mirror is convex/ diverging mirror.

14. List four properties of the image formed by a concave mirror, when object is placed between focus and pole of the mirror.

Answer:

- (i) Behind the mirror
- (ii) Enlarged, i.e. magnified
- (iii) Virtual
- (iv) Erect

15. Consider the following diagram in which M is a mirror and P is an object and Q is its magnified image formed by the mirror



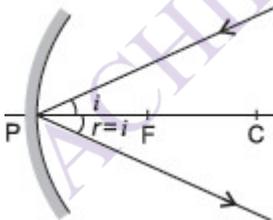
State the type of the mirror M and one characteristic property of the image Q.

Answer:

The given mirror M is a concave spherical mirror. When the object lies between the pole and the focus of the concave mirror, an erect, virtual and enlarged image is formed. So one characteristic property of the image Q formed in the given figure is that it is virtual.

16. For a concave mirror draw a ray diagram to show the reflected ray when the ray of light incident obliquely on the pole of mirror.

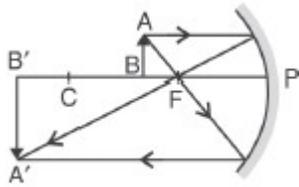
Answer:



17. What is the minimum number of rays required for locating the image formed by a concave mirror for an object? Draw a ray diagram to show the formation of a virtual image by a concave mirror.

Two rays are required.

Answer:



18. List four specific characteristics of the images of the object formed by convex mirrors.

Answer:

Properties of image formed by a convex mirror:

- (i) It always formed behind the mirror, between the pole and its focus.
- (ii) The image is always virtual and erect.
- (iii) The size of image is always smaller than the object.
- (iv) Magnification is always positive.

19. The focal length of a convex mirror is 12.5 cm. How far is its centre of curvature (i) from the pole (ii) from the focus.

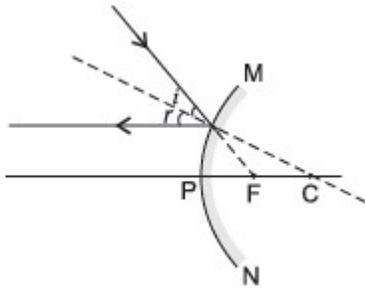
Answer:

The centre of curvature of a mirror is always located at a distance equal to its radius of curvature which is twice of its focal length. So, (i) the centre of curvature is 25 cm away from its pole and (ii) from the focus, it is 12.5 cm away.

20. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed towards the principal focus of a convex mirror. Mark on it the angle of incidence and the angle of reflection.

Answer:

The required ray diagram is as follows:

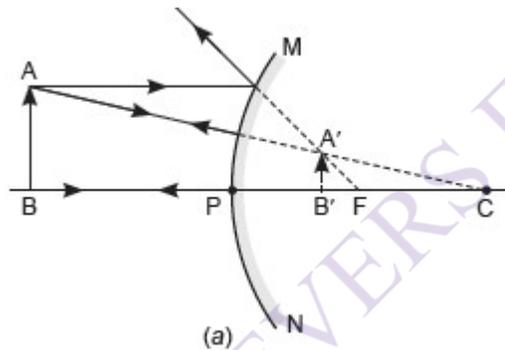


21. If the image formed by a spherical mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it? Draw a labelled ray diagram to support your answer.

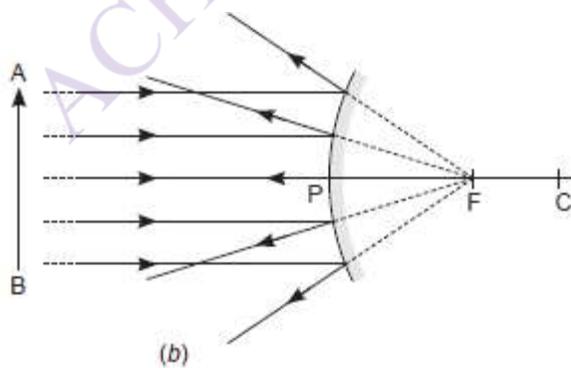
Answer:

The required spherical mirror is convex mirror because the image formed by a convex mirror for all position of the object placed in front of it is always erect and diminished.

(i) Object between pole and infinity



(ii) At infinity



22.

A real image, $\left(\frac{1}{5}\right)^{\text{th}}$ the size of object is formed at a distance of 18 cm from a mirror. What is the nature of mirror? Calculate its focal length.

Answer:

Concave mirror as it forms a real image.

Given $h_i = \frac{1}{5} h_o$ and $v = -18 \text{ cm}$

$$\therefore m = -\frac{v}{u} = -\frac{1}{5}$$

$$\Rightarrow -\left(\frac{-18}{u}\right) = -\frac{1}{5}$$

$$\Rightarrow u = -90 \text{ cm}$$

Using
$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-18} + \frac{1}{-90}$$

$$= \frac{-5}{90} - \frac{1}{90} = -\frac{6}{90} = -\frac{1}{15}$$

$$\therefore f = -15 \text{ cm}$$

Since focal length is negative, therefore spherical mirror is concave mirror.

23. What should be the position of the object, when a concave mirror is used:

- (a) as a shaving mirror?
- (b) in torches as reflecting mirror?

Answer:

(a) Object should be placed between pole and focus.

(b) Object should be placed at focus.

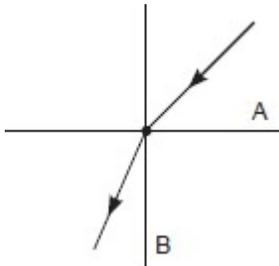
24. "Vehicles in this mirror are closer than they appear". Why is this warning printed on the side view mirror of most vehicles?

Answer:

The phrase "**vehicles in this mirror are closer than they appear**" is a safety warning printed on the side view mirror of most vehicles. It is present because the side view mirror is a convex mirror and it gives a virtual image of wide field behind the vehicle and appears the objects smaller and farther away than they

actually are, and the angular size of the virtual image is also smaller than the angular size of the object. During the lane change, a driver assumes that an adjacent vehicle is at a safe distance behind, when in fact it is quite a bit closer. The warning serves as a reminder to the driver of this potential problem.

25. A ray of light is refracted as per the following diagram. Which media A or B is optically denser than other?



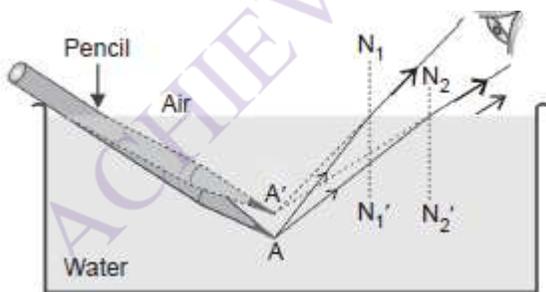
Answer:

The given figure shows that the ray of light bends towards the normal after refraction, when it enters from medium A to medium B and $\angle i > \angle r$. This indicates that medium B is optically denser than A.

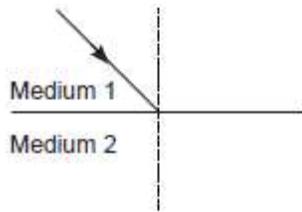
26. Explain with the help of a diagram, why a pencil partly immersed in water appears to be bent at the water surface.

Answer:

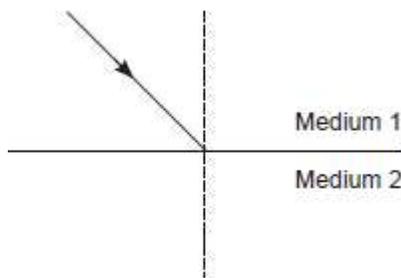
The light from different points on the pencil, immersed in water, refracts and appears to come from a point above the original position.



27. For the following two cases, state whether the obliquely incident ray light on interface of medium 1 and medium 2 will bend towards or away from the normal after refraction, in medium 2.



Case I: (medium 1 having higher refractive index)



Case II: (medium 2 having higher refractive index)

Answer:

Medium with higher refractive index will optically denser medium with respect to other. So obliquely incident light ray will:

Case I: bend away from the normal in medium 2 after refractions.

Case II: bend towards the normal in medium 2 after refraction.

28. (a) Why does the emergent ray in a glass slab is parallel to the incident ray?

(b) Why does the emergent ray shift sideways?

Answer:

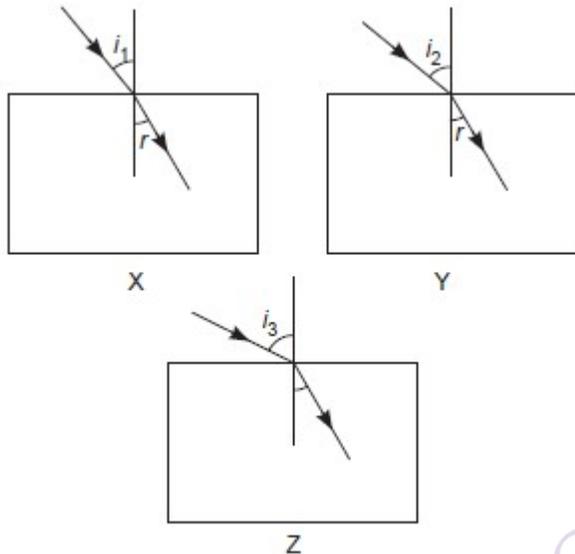
(a) We know that, in case of refraction, when incident ray travels from air to glass, it bends towards normal and bends away from the normal when it travels through glass to air. Thus, the extent of bending of the ray of light at the opposite parallel faces i.e. air-glass and glass-air interface of rectangular glass slab are equal and opposite. Hence, the emergent ray is parallel to the incident ray in case of refraction through rectangular glass slab.

(b) The emergent ray shift sideways slightly because of

(i) angle of incidence, and

(ii) thickness of glass slab

29. The image below shows the refraction of light in three transparent rectangular blocks, X, Y and Z, made of different materials when they are placed in air. The angle of incidence is different in each case such that $i_3 > i_2 > i_1$ but the angle of refraction is the same in all three blocks.



Compare the speed of light in the three blocks. Justify your answer.

Answer:

According to Snell's law

$$\frac{\sin i}{\sin r} = n \Rightarrow \sin i > n \quad \dots(i)$$

But $n = \frac{c}{v} \Rightarrow n \propto \frac{1}{v} \quad \dots(ii)$

Combining (i) and (ii), we have

$$\sin i \propto \frac{1}{v} \quad \text{or} \quad v \propto \frac{1}{\sin i}$$

Thus, we conclude that if the angle of incidence is minimum, speed of light is maximum. Hence,

$$v_x > v_y > v_z \quad \dots \text{ for } i_3 > i_2 > i_1$$

i.e. Speed of light in x > Speed of light in y > Speed of light in z.

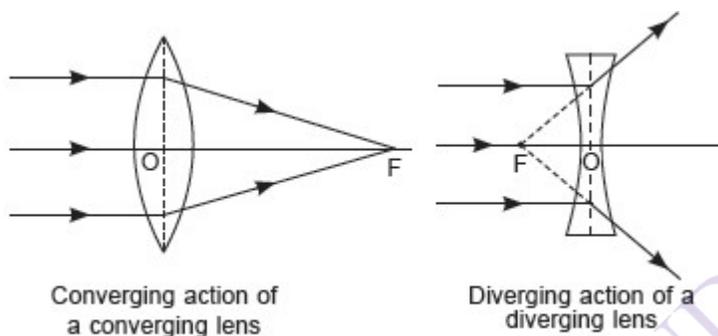
30. The image formed by a convex lens is of the same size as that of the object. What is the position and nature of the image with respect to the lens?

Answer:

The image will be real, inverted and will be formed at the centre of curvature of the given convex lens.

31. With the help of a ray diagrams, differentiate between a converging lens and diverging lens.

Answer:



32. (a) What is a lens?

(b) Distinguish between a double convex lens and a double concave lens.

Answer:

(a) **Lens:** It is a piece of transparent material bound by two surfaces, of which one or both surfaces are spherical.

(b) **Differences:**

Double convex lens	Double concave lens
(i) Both spherical surfaces bulging outwards.	(i) Both spherical surfaces curved inwards.
(ii) It is thicker at the middle as compared to edges.	(ii) It is thicker at the edges than at the middle.
(iii) It is also called converging lens.	(iii) It is also known as diverging lens.

33. State the two factors on which focal length of the spherical lens depends.

Answer:

Focal length of spherical lens depends on the

- (i) refractive index of the glass, and
- (ii) radius of curvature of its two surfaces.

34. The images formed by an ordinary convex lens suffer from a defect, called chromatic defect, which leads to false coloured edges in the images. This happens because light rays of different colours bend differently as they enter and leave the lens. If a parallel white light beam passes through a convex lens, the light of which colour (among violet to red in the spectrum) will converge at a point closest to the lens? Justify your answer.

Answer:

- The violet colour will converge at a point closest to the lens.
- Among the colour components of white light in the spectrum, glass has highest refractive index for violet colour light. Hence, the deviation of violet light will be maximum after refraction through the glass lens.

35. State the meaning of linear magnification. How is it related to object distance and image distance? When is magnification positive or negative?

Answer:

Linear magnification is the ratio of the height of the image to the height of the object. It is represented by the letter 'm'.

$$m = \frac{\text{Height of image } (h_i)}{\text{Height of object } (h_o)} = \frac{h_i}{h_o}$$

where h_i is the height of the image and h_o is the height of the object. If the image formed is virtual and erect, then the magnification is positive and if the image formed is real and inverted, then the magnification is negative.

36. Distinguish between a convex and a concave mirror.

Answer:

A convex mirror always forms a virtual image, which is erect and irrespective of the position of the object, while a concave mirror forms a real or virtual, or erect, inverted image based on the position of the object.

37. Why does a ray falling normally on a plane mirror, retrace its path?

Answer:

When a ray falls normally on a plane mirror, the incident angle is zero. Since the reflected and the incident angles are equal, the reflection angle is also zero. So, it retraces its path.

38. (a) Draw a ray diagram to show the path of a light ray passes from one medium to another if the two media are optically exactly the same.
 (b) Absolute refractive indices of medium 'A' and medium 'B' are ' n_a ' and ' n_b ' respectively. What is the refractive index of medium 'B' with respect to medium 'A'.
 (c) How does the velocity of light vary with change in the optical density of the media?

Answer:

- (a) Since two media are optically exactly the same, no bending of the light rays occur when they pass from one medium to another as their refractive indices are equal.
 (b) Refractive index of medium 'B' with respect to 'A' is

$$n_{BA} = \frac{n_B}{n_A}$$

- (c) Refractive index of the medium n_m is given by

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}} = \frac{c}{v}$$

or

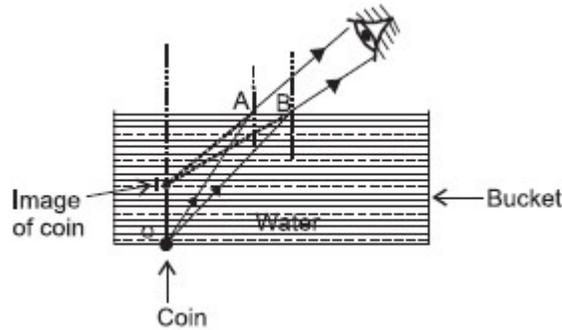
$$v = \frac{c}{n_m}$$

It is obvious from the above relation, that the speed of light decreases with the increase in optical density, i.e. refractive indices of the media.

39. A coin is kept at the bottom of an empty bucket. A student standing near to it cannot see the coin. Another student pours some water into the bucket without disturbing the coin. Now, the first student is able to see the coin from the same position. Explain how it become possible to see the coin now? Draw a ray diagram to illustrate it.

Answer:

When the coin is under water, then due to refraction of light, a virtual image of the coin is formed which is slightly above its actual position nearer to the water surface as shown in the figure. Thus, the coin becomes visible again on pouring some water into the bucket.



40. (a) Differentiate between reflection and refraction.
 (b) A lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides. Explain why it so appears.

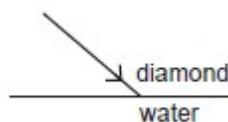
Answer:

- (a) Difference between reflection and refraction

Reflection	Refraction
1. It is the phenomenon of change in the path of light rays in a particular direction into the same medium again is called reflection.	1. When a ray of light enters from one medium into another obliquely, the direction of propagation of the light in the second medium changes. This is called the refraction of light.
2. The reflecting surfaces of all types, obey the laws of reflection.	2. The refracting surfaces obey the laws of refraction.

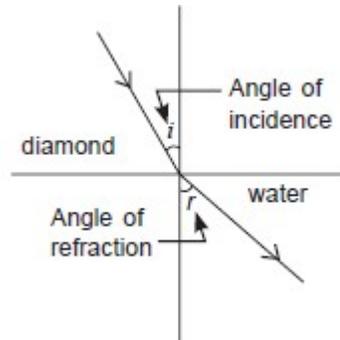
(b) As the ray of light comes into air from the different points on the surface of a lemon kept in water in a glass tumbler, it bends away from the normal, i.e. there is a change in the direction of propagation of light due to refraction. So, the ray of light appears to come from a point different from that of the actual point. Therefore, the lemon in water appears to be bigger than its actual size, when viewed from the sides of the glass tumbler.

41. A ray of light is incident on the interface separating diamond and water. Given that refractive indices of diamond and water with respect to air are 2.42 and 1.33 respectively, complete the diagram by showing a refracted ray and mark the angles of incidence and refraction.



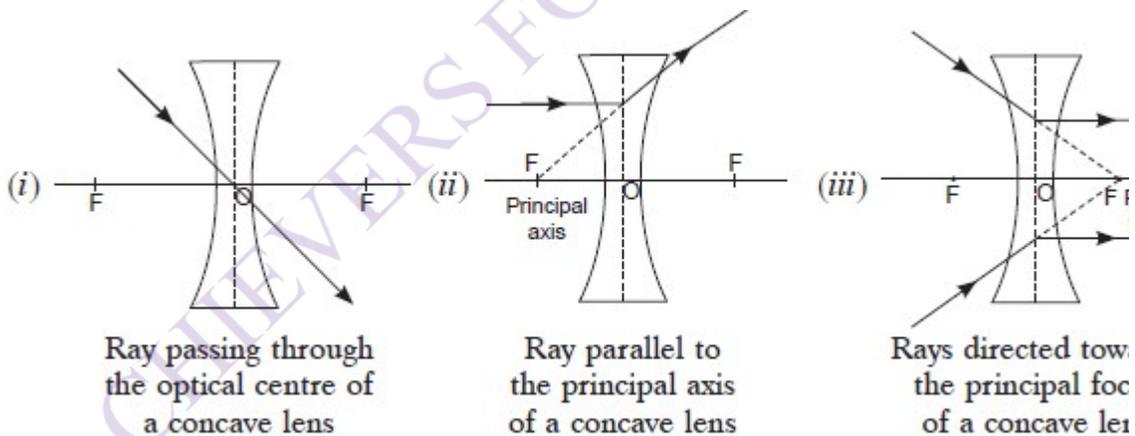
Answer:

Since the refractive index of diamond is more than that of water, so it is optically denser. Hence the light ray moves from a denser medium to a rarer medium and it will bend away from the normal in water as shown below.



- 42 Draw a ray diagram to show the path of the refracted ray in each of the following cases: A ray of light incident on a concave lens is
- passing through its optical centre.
 - parallel to its principal axis.
 - directed towards its principal focus.

Answer:



43. Define the following terms in the context of spherical mirrors:

- Pole
- Centre of curvature
- Principal axis
- Principal focus

Answer:

(i) **Pole:** The central point of the reflecting spherical surface is called the pole (P). It lies on the surface of the mirror.

(ii) **Centre of Curvature:** The centre of the hollow sphere of which the spherical mirror is a part, is called the centre of curvature (C).

(iii) **Principal Axis:** The straight line joining the pole and the centre of curvature is called the principal axis.

(iv) **Principal Focus:** The point 'F' on the principal axis, where the incident light rays parallel to the principal axis actually meet (converge) (in case of a concave mirror) or appear to diverge or come from (in case of a convex mirror) after reflection, is called its principal focus (F).

44. State any three difference between real image and virtual image formed by a spherical mirror.

Answer:

Difference between real image and virtual image

Real Image	Virtual image
(i) After reflection from the mirror, the light rays are actually meet or intersect.	(i) After reflection from the mirror, the light rays do not intersect but appear to meet at a point.
(ii) Image can be obtained on the screen.	(ii) Image cannot be obtained on the screen.
(iii) The real image is always inverted and formed below	(iii) The virtual image is always erect and formed above the principal axis.
(iv) It is always formed in front of the spherical mirror/lens.	(iv) It is always formed behind the spherical mirror/lens.

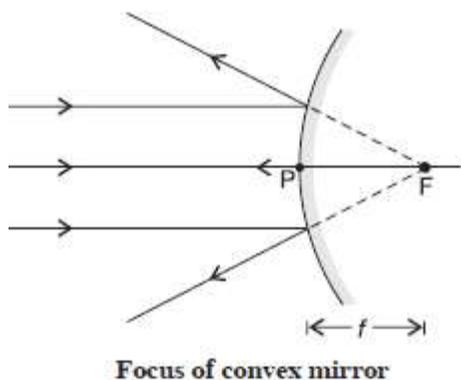
45. Define the following terms in the context of a diverging mirror: (i) Principal focus (ii) Focal length Draw a labelled ray diagram to illustrate your answer.

Answer:

(i) The point 'F' on the principal axis, where the incident light rays parallel to the principal axis appear to diverge or come from after reflection, is called its

principal focus (F) of a diverging mirror. In case of a diverging mirror, principal focus lies on the opposite side of the reflecting surface.

(ii) The distance between the pole and the focus of the mirror is called the focal length of the mirror. For a diverging mirror, focal length is always positive.



46. List the New Cartesian Sign convention for reflection of light spherical mirrors.

Answer:

New Cartesian Sign convention for reflection of light by spherical mirrors:

- (i) The object is always placed to the left of the mirror.
- (ii) All the distances parallel to the principal axis are always measured from the pole of the spherical mirror.
- (iii) All the distances measured along the direction of incident light, i.e. along +ve x-axis, the corresponding quantities are considered to be positive.
- (iv) All the distances measured opposite to the direction of incident light, i.e. along -ve x-axis, the corresponding quantities are taken as negative.
- (v) The distances measured in upward direction, i.e. perpendicular to and above the principal axis along +ve y-axis, are taken as positive.
- (vi) The distances measured in the downward direction, along -ve y-axis, i.e. perpendicular to and below the principal axis, are taken as negative.

47. Name the type of mirror used

- (a) by dentist and
- (b) in vehicles headlights Give reason why such mirrors are used in each case.

Answer:

(a) Dentists use a concave mirror because it converges the light and when the object lies between its pole and principal focus, it forms a virtual, erect and enlarged image behind it. Hence they use the concave mirror so that they could see the cavity or plaque clearly, which is inside the teeth.

(b) Concave mirror is used in the vehicle headlights. The light bulb is placed at its focus. The light rays emitted from the bulb, after reflection from the mirror becomes parallel to the principal axis. This powerful parallel beam of light enabling the driver to see the road ahead clearly.

48. Why do we prefer to use a convex mirror instead of plane mirror as a rear view mirror? Illustrate your answer with the help of a ray diagram.

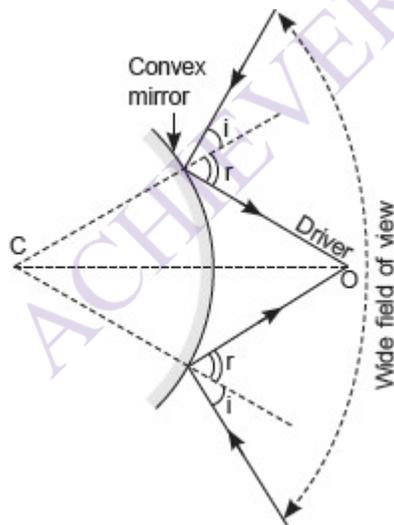
Answer:

Convex mirror is used because

(i) it always produces a virtual and erect image between its pole and focus.

(ii) the size of image formed is smaller than the object irrespective of position of object.

Therefore, it enables the driver to see wide field view of the traffic approaching from behind the vehicle in a small mirror.

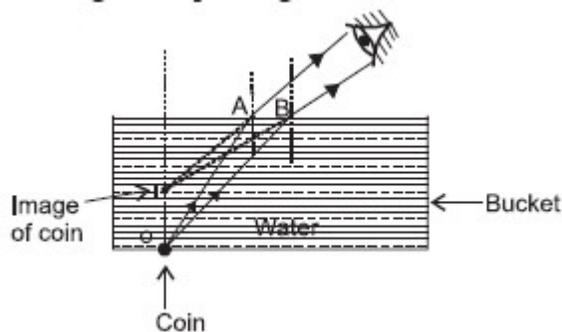


49. A coin is kept at the bottom of an empty bucket. A student standing near to it cannot see the coin. Another student pours some water into the bucket without disturbing the coin. Now, the first student is able to see the coin from the same position. Explain how it become possible to see the coin now? Draw a ray diagram

to illustrate it.

Answer:

When the coin is under water, then due to refraction of light, a virtual image of the coin is formed which is slightly above its actual position nearer to the water surface as shown in the figure. Thus, the coin becomes visible again on pouring some water into the bucket.

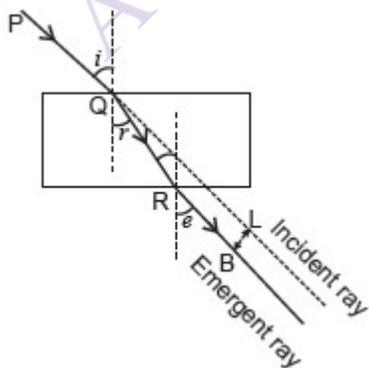


50. When a ray of light passes through the glass slab, then how many times does it change its path and why?

Answer:

- When a ray of light passes through the glass slab, it bends twice.
- First time, at air-glass interface, it bends towards normal at denser medium i.e., inside glass slab. It is due to decrease in the speed of refracted light ray.
- Second time, at glass-air interface, the speed of light of refracted ray in rarer medium increases and the ray bends away from the normal.

51. What is understood by lateral displacement of light? Illustrate it with the help of a diagram. List any two factors on which the lateral displacement of a particular substance depends.

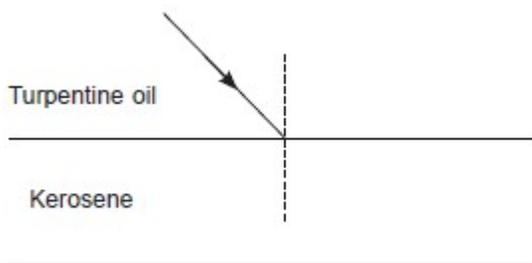


Answer:

Lateral displacement is the perpendicular distance between the incident ray produced and emergent ray. The lateral displacement in the given diagram is BL. The lateral displacement depends on the thickness of the slab, the incident angle and the refractive index of the material.

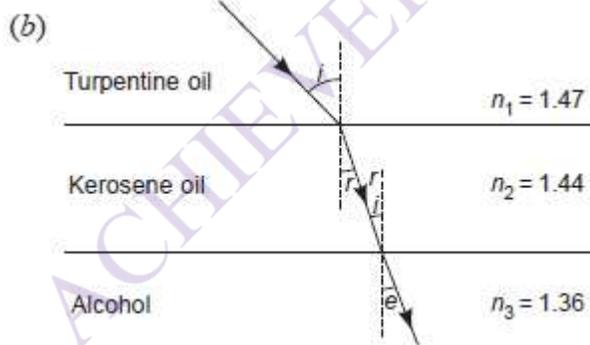
52. (a) What is the unit of refractive index? If not, why?

(b) Complete the following ray diagram by showing the path of ray of light through each medium. The refractive index of turpentine oil, alcohol and kerosene are 1.47, 1.36 and 1.44 respectively.



Answer:

(a) Refractive index has no unit as it is the ratio of two similar quantities.



53. State the laws of refraction of light. Explain the term 'absolute refractive index of a medium' and write an expression to relate it with the speed of light in vacuum.

Answer:

Laws of refraction of light:

(a) The incident ray, the normal at the point of incidence and the refracted ray,

all lie in the same plane for the two given transparent media.

(b) The ratio of sine of angle of incidence, i.e. $\sin i$ to the sine of angle of refraction, i.e. $\sin r$ is always constant, for the light of a given colour and for the given pair of media.

Mathematically, $\frac{\sin i}{\sin r} = \text{constant} = n_{21}$

The constant n_{21} is called the refractive index of the second medium with respect to the first medium. Absolute Refractive Index: The refractive index of medium 2 with respect to vacuum or air is considered to be its absolute refractive index. It is represented by n_2 . It is also equal to the speed of light in vacuum to the speed of light in the medium.

$$\begin{aligned} \text{i.e. } n_2 &= \frac{\text{Speed of light in air or vacuum } (c)}{\text{Speed of light in the medium } (v)} \\ &= \frac{c}{v} \end{aligned}$$

54. To construct a ray diagram, we use two light rays which are so chosen that it is easy to know their directions after refraction from the lens. List these two rays and state the path of these rays after refraction. Use these two rays to locate the image of an object placed between 'F' and '2F' of a convex lens.

Answer:

List of two light rays chosen for refraction

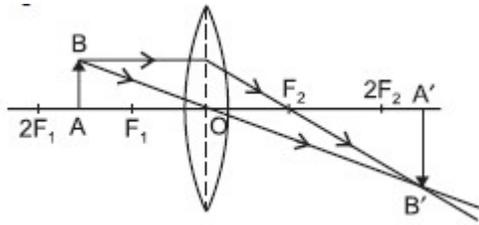
- (i) A ray of light parallel to the principal axis.
- (ii) A ray of light passing through the optical centre of a lens.

Path of these rays after refraction

In case of a convex lens, the ray parallel to principal axis, after refraction, it will pass through the principal focus on the other side of the lens.

In case of a concave lens, the ray will appear to diverge or appear to come from the principal focus positioned on the same side of the object.

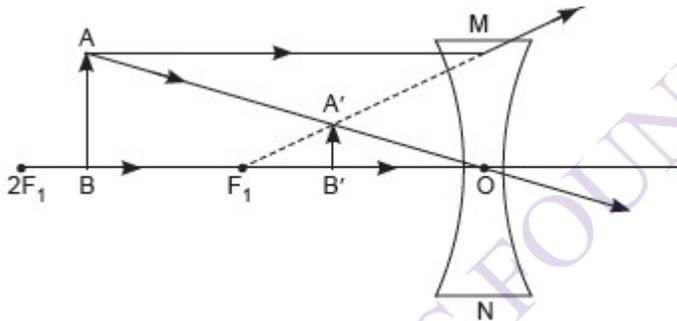
A ray of light passing through the optical centre of a lens will emerge from the lens without any deviation in the path.



55. If the image formed by a lens for all positions of an object placed in front of it is always erect and diminished, what is the nature of this lens? Draw a ray diagram to justify your answer. If the numerical value of the power of this lens is 10 D, what is its focal length in the Cartesian system?

Answer:

It is a concave or diverging lens.

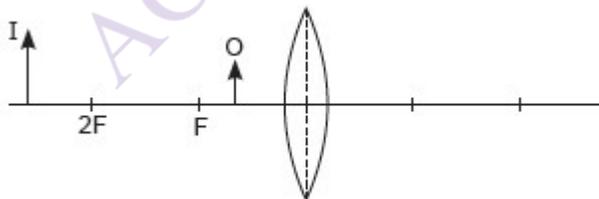


$$f = \frac{1}{P}$$

$$P = -10\text{D}$$

$$f = \frac{1}{-10\text{D}} = -0.1\text{ m Or } f = -10\text{ cm}$$

56. The diagram given below shows an object O and image I.



Without actually drawing the ray diagram, state the following:

(a) Type of lens (Converging/Diverging)

(b) Name two optical instruments where such an image is obtained.

(c) List three characteristics of the image formed if this lens is replaced by concave mirror of focal length 'f' and an object is placed at a distance 'f/2' in front of the mirror

Answer:

(a) Converging lens

(b) (i) Simple microscope (ii) Magnifying glass

(c) The image will be formed behind the mirror, it is enlarged, virtual and erect.

57. Rohit wants to have an erect image of an object using a converging mirror of focal length 40 cm.

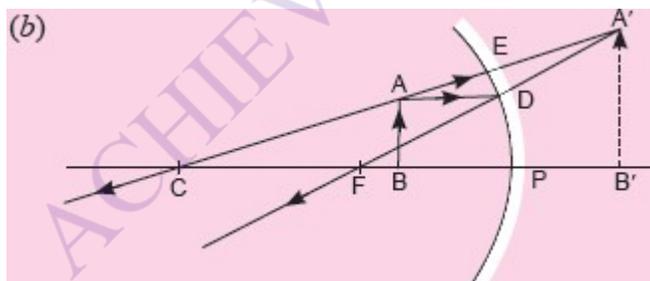
(a) Specify the range of distance where the object can be placed in front of the mirror. Justify.

(b) Draw a ray diagram to show image formation in this case.

(c) State one use of the mirror based on the above kind of image formation.

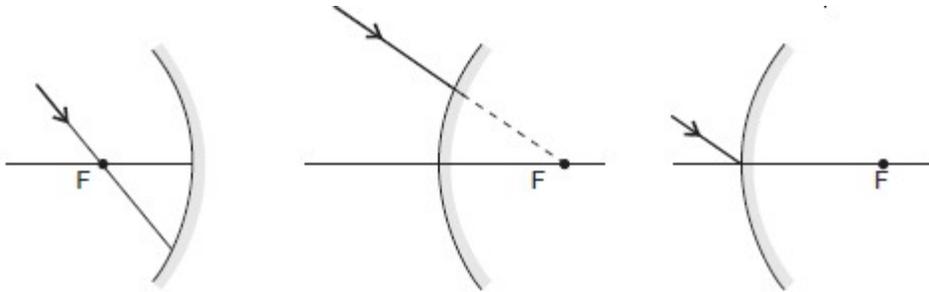
Answer:

(a) The object has to be placed at a distance between 0 - 40 cm. This is because image is virtual, erect and magnified when the object is placed between F and P.

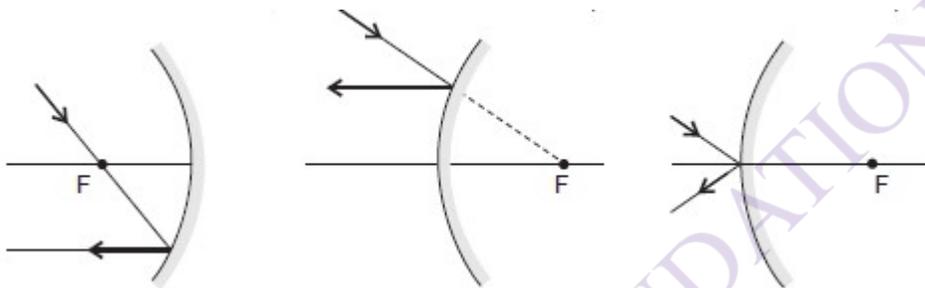


(c) Used as shaving mirror or used by dentists to get enlarged image of teeth (any one)

58. Draw the following diagram in which a ray of light is incident on a concave/convex mirror on your answer sheet. Show the path of this ray, after reflection, in each case.



Answer:



59. For the given data showing the focal lengths of three concave mirrors A, B and C, and the respective distances of different objects from these mirrors.

S.No.	Object distance (cm)	Focal length (cm)
A	45	20
B	30	15
C	20	30

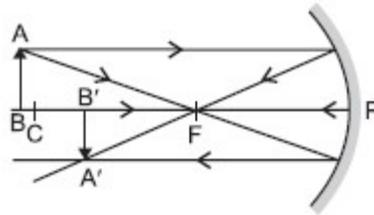
Answer the following questions:

(i) In the given position of object from the mirrors, which mirror will form a diminished image of the object. Draw a ray diagram for image formation by this mirror.

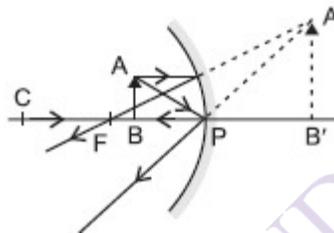
(ii) Which mirror can be conveniently used as a make-up mirror? Draw a ray diagram to illustrate this function.

Answer:

(i) Concave mirror A will form the diminished image of the object as the object is placed beyond the centre of curvature ($> 2f$) of the mirror.



(ii) Concave mirror 'C' can be used as a make-up mirror as the object distance is less than the focal length of concave mirror, i.e. when the object is placed between the focus 'F' and the pole 'P' of the concave mirror, a virtual, erect and enlarged image is formed.



60. Name the type of mirror used (i) by dentists and (ii) shaving mirrors. Give two reasons why such mirrors are used in each case.

Answer:

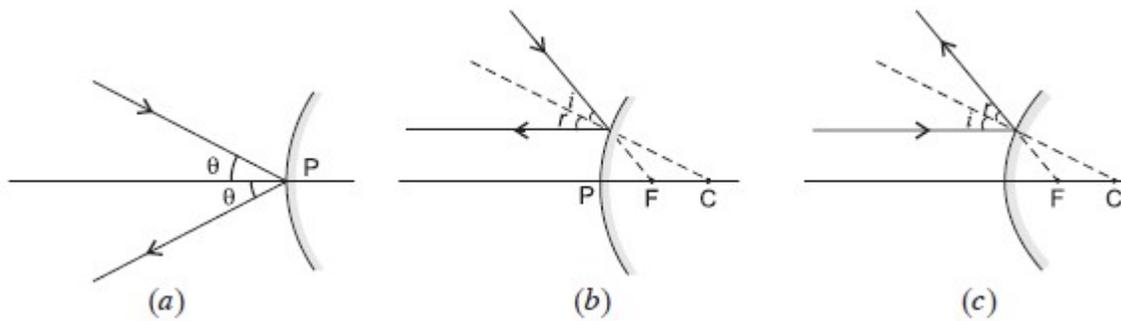
(i) Dentists use a concave mirror because it converges the light and when the object lies between its pole and principal focus, it forms a virtual, erect and enlarged image behind it. Hence they use the concave mirror so that they could see the cavity or plaque clearly, which is inside the teeth.

(ii) When the object lies between the pole and the principal focus of a concave mirror, it forms a virtual, erect and enlarged image behind it. So, the concave mirror can be used as a shaving mirror to see a larger image of the face.

61 Draw a ray diagram to show the path of the reflected ray in each of the following cases. A ray of light incident on a convex mirror.

- strikes at its pole making an angle θ from the principal axis.
- is directed towards its principal focus.
- is parallel to its principal axis.

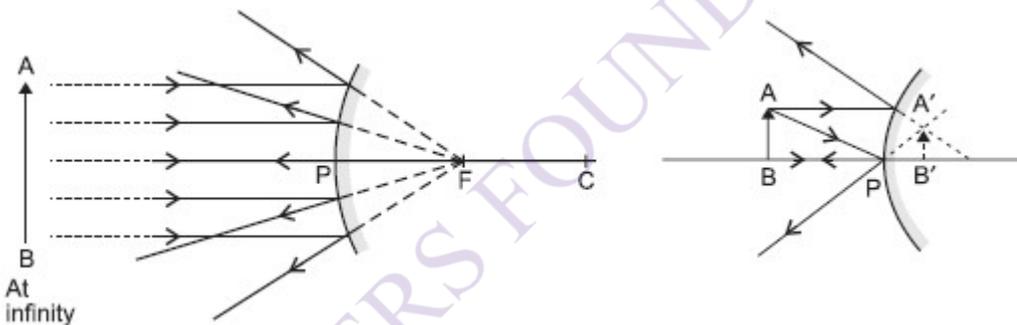
Answer:



62. If the image formed by mirror for all positions of the object placed in front of it is always virtual and diminished, state the type of the mirror. Draw a ray diagram in support of your answer. Where are such mirrors commonly used and why?

Answer:

Convex Mirror



A convex mirror is commonly used as a rear-view mirror in vehicles because it always produces a virtual and erect image whose size is smaller than the object. Therefore, it enables the driver to see a wide field of view of the traffic behind the vehicle in a small mirror.

63. Analyse the following observation table showing variation of image distance (v) with object distance (u) in case of a convex lens and answer the questions that follow, without doing any calculations:

SNo.	Object distance u (cm)	Image distance v (cm)
1	- 90	+ 18
2	- 60	+ 20
3	- 30	+30
4	- 20	+ 60
5	- 18	+90
6	- 10	+100

(a) State the lens formula.

(b) Write the serial number of that observation which is not correct. How did you arrive at this conclusion?

(c) Take an appropriate scale to draw ray diagram for the observation at S. No. 2.

Or

(c) Under what condition does a biconvex lens of glass having a certain refractive index act as a plane glass sheet when immersed in a liquid?

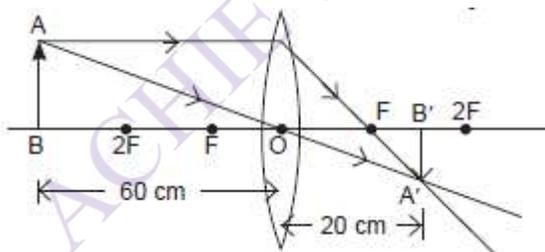
Answer:

(a) The Lens formula gives the relationship between object distance (u), image-distance (v) and the focal length (f) is given by

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

(b) Observation at S.No. 6 is not correct. The value, $u = -10$ cm, indicates that the object is in between the optical centre and the focus (i.e., less than the focal length) of the lens and hence, the image should be on the same side as the object. Accordingly, the image distance should be negative and cannot be positive (+100 cm) as shown in table.

(c) Ray diagram for the observation at S.No. 2 : Given: $u = -60$ cm; $v = +20$ cm; $f = +15$ cm



Or

(c) When the refractive index of a lens is equal to the refractive index of a liquid in which it is immersed, then the focal length of a lens becomes infinite and hence it acts as a plane glass sheet.

64.



The above images are that of a specialized slide projector. Slides are small transparencies mounted in sturdy frames ideally suited to magnification and projection, since they have a very high resolution and a high image quality. There is a tray where the slides are to be put into a particular orientation so that the viewers can see the enlarged erect images of the transparent slides. This means that the slides will have to be inserted upside down in the projector tray.

To show her students the images of insects that she investigated in the lab, Mrs. Iyer brought a slide projector. Her slide projector produced a 500 times enlarged and inverted image of a slide on a screen 10 m away.

(a) Based on the text and data given in the above paragraph, what kind of lens must the slide projector have?

(b) If v is the symbol used for image distance and u for object distance then with one reason state what will be the sign for $\frac{v}{u}$ in the given case?

(c) A slide projector has a convex lens with a focal length of 20 cm. The slide is placed upside down 21 cm from the lens. How far away should the screen be placed from the slide projector's lens so that the slide is in focus?

Or

(c) When a slide is placed 15 cm behind the lens in the projector, an image is formed 3 m in front of the lens. If the focal length of the lens is 14 cm, draw a ray diagram to show image formation. (not to scale)

Answer:

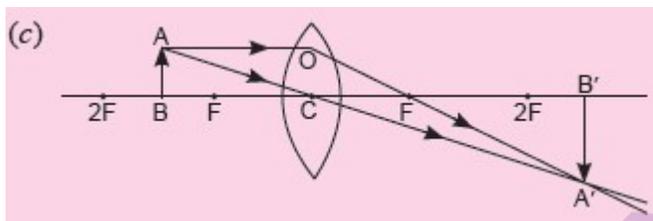
(a) Convex Lens

(b) Negative as the image is real and inverted.

$$\begin{aligned}
 (c) \quad \frac{1}{f} &= \frac{1}{v} - \frac{1}{u} \\
 \frac{1}{20} &= \frac{1}{v} - \frac{1}{-21} \\
 \Rightarrow \frac{1}{v} &= \frac{1}{20} + \frac{1}{-21} = \frac{1}{20} - \frac{1}{21} \\
 &= \frac{21 - 20}{420} = \frac{1}{420}
 \end{aligned}$$

$$v = 420 \text{ cm}$$

or



65. With the help of mirrors, we can form a variety of images. For example, in plane mirrors, images are the same size as the object and are located behind the mirror. Dental mirrors may produce a magnified image while security mirror in shops, on the other hand, form images that are smaller than the object. These images can be either real or virtual depending upon the position of object. The real image can be obtained on the screen only when the reflected rays meet actually. Virtual image does not form on the screen because after reflection, the reflected rays appear to meet.

(a) What are the advantages and disadvantages of using a convex mirror for seeing traffic at the rear?

(b) Name the mirror that can give an erect and enlarged image of the object.

(c) An object is placed at the distance of 10 cm, 20 cm, 30 cm and 40 cm respectively from a concave mirror of focal length 15 cm. Which position of the object will produce (i) virtual image and (ii) an image of same size?

Or

(c) What does the negative sign in the value of magnification produced by a mirror indicate about a image?

Answer:

(a) Advantage of convex mirror: It provides a wide field of view of the traffic behind the vehicle. Disadvantage of convex mirror: It does not give the correct distance of the approaching vehicle at the rear.

(b) Concave mirror

(c) (i) Virtual image is obtained when the object is at 10 cm from the mirror, i.e. less than focal length.

(ii) An image of same size is obtained when the position of object is at C, i.e. at 30 cm.

Or

(c) Negative sign in the value of magnification produced by a mirror indicates that image is real.

66. The absolute refractive index of a medium is simply called its refractive index. The ability of a medium to refract light is also expressed in terms of its optical density. We have been using 'rarer medium' and 'denser medium' which actually means 'optically rarer medium' and 'optically denser medium'. In comparing two media the one with larger refractive index is optically denser and vice-versa.

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

(a) Name the medium which have lowest and highest optical density.

(b) You are given water, kerosene, benzene and dense flint glass. In which of

these media a ray of light incident obliquely at same angle would bend the most?

(c) How the absolute refractive index related to speed of light?

Or

(c) Draw a ray diagram to show the path of ray of light passing obliquely from water to alcohol.

Answer:

(a) Lowest optical density : Air

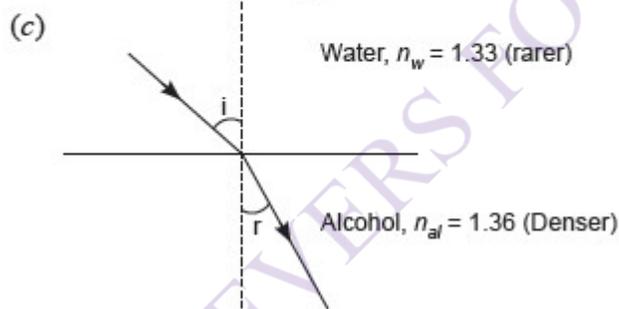
Highest optical density : Diamond

(b) Dense flint glass as it has highest refractive index among the given media

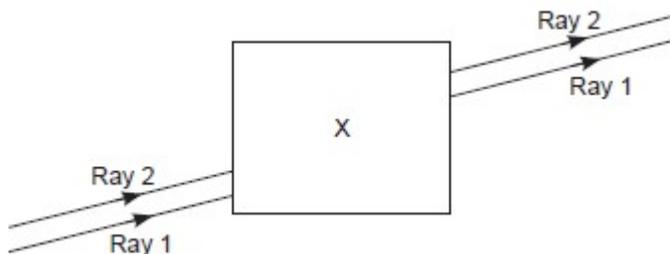
(c) Absolute refractive index

$$= \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} \Rightarrow n = \frac{c}{v}$$

Or



67. The science teacher told the students to demonstrate some properties of light in their science project. One of the student, Alankrita, kept 'X' inside the box as shown in figure and with the help of a laser pointer, made light rays pass through the holes on one side of the box. She has a small butter paper screen to see the rays of light cast as they emerged.



(a) What could be the X that she placed inside the box to make the rays behave as shown?

(b) She measured the angle of incidence for both rays on the left side of the box to be 48.6° . She knew the refractive index of the material 'X' inside the box was 1.5. What will be the approximate value of angle of refraction? (Given: $\sin 48.6^\circ = 0.75$)

(c) What would she observe in the lateral shift of the emergent ray if the object inside the box was made of a material with a refractive index less than 1.5?

Or

(c) Draw the label diagram for the path of refracted ray through the material 'X' inside the box for the incident ray 1.

Answer:

(a) The material 'X' placed inside the box – a parallel sided glass block

(b) Given: $n = 1.5$, $\angle i = 48.6^\circ$

$$\sin 48.6^\circ = 0.75$$

From Snell's law of refraction

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

$$\Rightarrow \sin r = \frac{\sin i}{n} = \frac{\sin 48.6}{1.5} = \frac{0.75}{1.5} = 0.5 = \frac{1}{2}$$

$$\Rightarrow \sin r = \sin 30^\circ \quad (\sin 30^\circ = \frac{1}{2})$$

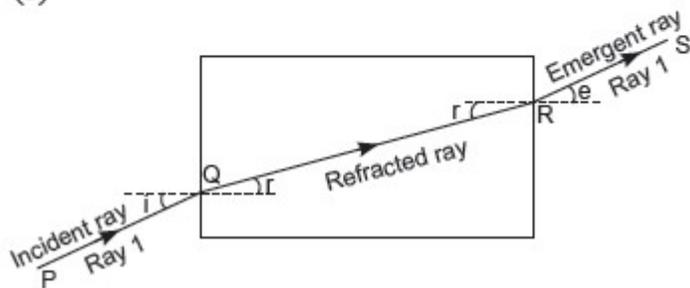
$$\Rightarrow r = 30^\circ$$

Hence, angle of refraction = 30° .

(c) She observed that the lateral shift of the rays would have been less.

Or

(c)



68. A compound microscope is an instrument which consists of two lenses L_1 and L_2 . The lens L_1 called objective, forms a real, inverted and magnified image of the given object. This serves as the object for the second lens L_2 ; the eye piece. The eye piece functions like a simple microscope or magnifier. It produces the final image, which is inverted with respect to the original object, enlarged and virtual.

(a) What types of lenses must be L_1 and L_2 ?

(b) What is the value and sign of magnification (according to the New Cartesian Sign convention) of the image formed by L_1 ?

(c) If the power of the eye piece (L_2) is 5 D and it forms an image at a distance 80 cm from its optical centre, at what distance should the object be?

Or

(c) If the power of lenses L_1 and L_2 are in the ratio of 4 : 1, what would be ratio of the focal length of L_1 and L_2 ?

Answer:

(a) Both L_1 and L_2 are convex lenses.

(b) Since L_1 forms a real and magnified image. Hence, the value of magnification is more than 1. As the image is inverted, the magnification will be negative.

(c) Given: Power eye piece $L_2 = 5D$

$$\therefore f = \frac{1}{P} = \frac{1}{5} = 0.2 \text{ m} = 20 \text{ cm}$$

and image distance, $v = -80 \text{ cm}$

Using lens formula,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{u} = \frac{1}{v} - \frac{1}{f} \\ \Rightarrow \frac{1}{u} &= \frac{1}{-80} - \frac{1}{20} \\ &= -\frac{1+4}{80} = -\frac{5}{80} = -\frac{1}{16} \end{aligned}$$

$$\therefore u = -16 \text{ cm}$$

So, object should be at a distance of 16 cm to the left of lens L_2 .

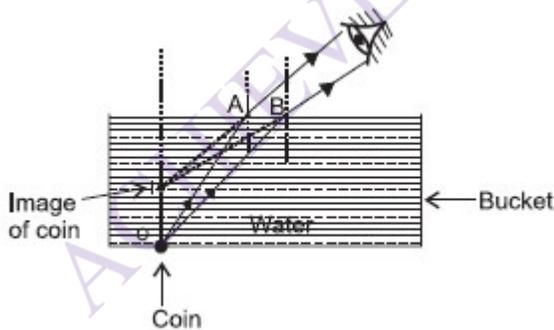
Or

$$(c) \text{ For lens } L_1, f_{L_1} = \frac{1}{P_{L_1}} = \frac{1}{4} = 0.25 \text{ m} = 25 \text{ cm}$$

$$\text{For lens } L_2, f_{L_2} = \frac{1}{P_{L_2}} = \frac{1}{1} = 1 \text{ m} = 100 \text{ cm}$$

$$\text{So, } f_{L_1} : f_{L_2} = 25 : 100 = 1 : 4$$

69. When the coin is under water, then due to refraction of light, a virtual image of the coin is formed which is slightly above its actual position nearer to water surface as shown in figure. This is because the light rays coming from coin and then go from water to air, they deviate from their path and get deflected away from the normal. Backward extension of these refracted ray appear to meet at point 'I', the image of the coin.



- (a) State the relationship between angle of incidence and angle of refraction formed by the ray at the point B of water-air interface.
- (b) Why does the coin appear raised when kept in water at the bottom of bucket?
- (c) The medium is changed from water (refractive index of water = 1.33) to a new medium having refractive index 1.5. State what your observation will be about the

image of the coin in the new medium? Give a reason.

Or

(c) On what basis can we distinguish a medium as being optically rarer or optically denser?

Answer:

$$(a) n = \frac{\sin i}{\sin r}$$

(b) The coin appear slightly raised above its actual position due to refraction of light.

(c) **Observation:** The coin will appear to be raised more in new medium having refractive index 1.5.

Reason: Higher the refractive index, more bending of the light rays after refraction. Thus, the light rays will bend more in new medium ($n_m = 1.5$) as compared to water ($n_w = 1.33$)

Or

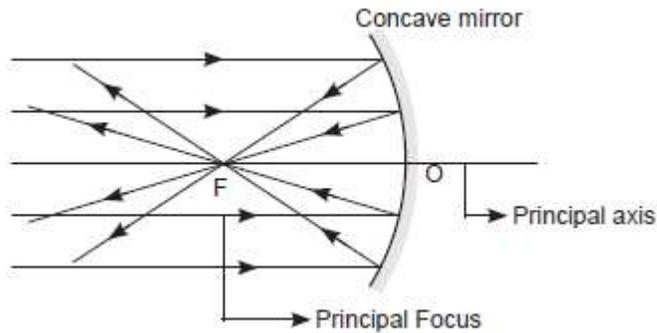
(c) We can distinguish between them on the basis of

(i) **Refractive index of the medium:** Medium of high refractive index has an optically denser medium.

(ii) **Speed of light** in rarer medium is faster than in denser medium.

(iii) **Bending of light in the medium:** When light bends towards the normal then it is an optically denser medium and when it bends away from the normal then it is an optically rarer medium.

70. Hold a concave mirror in your hand and direct its reflecting surface towards the sun. Direct the light reflected by the mirror on to a white card-board held close to the mirror. Move the card-board back and forth gradually until you find a bright, sharp spot of light on the board. This spot of light is the image of the sun on the sheet of paper; which is also termed as "Principal Focus" of the concave mirror.



- (a) List two applications of concave mirror.
- (b) If the distance between the mirror and the principal focus is 15 cm, find the radius of curvature of the mirror.
- (c) Draw a ray diagram to show the type of image formed when an object is placed between pole and focus of a concave mirror.

Or

(c) An object 10 cm in size is placed at 100 cm in front of a concave mirror. If its image is formed at the same point where the object is located, find:

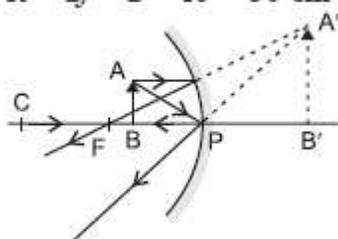
- (i) focal length of the mirror, and
- (ii) magnification of the image formed with sign as per Cartesian Sign convention.

Answer:

(a) **Two applications of concave mirror**

- (i) Shaving mirror
- (ii) Head mirror used by dentist and in ophthalmoscope
- (iii) Astronomical telescope
- (iv) Reflector in head lights of vehicles. (Any two)

(b) $R = 2f = 2 \times 15 = 30 \text{ cm}$
 (c)



Or

(c) **Given:** The image is formed at the same point where the object is located. It means object is placed at the centre of curvature of the concave mirror. Image is also formed at the centre of curvature

i.e., $R = -100 \text{ cm}$... as ($u = -100 \text{ cm}$)

$\Rightarrow 2f = -100 \text{ cm} \Rightarrow f = -50 \text{ cm}$

(i) Hence, focal length of concave mirror = 50 cm

(ii) Magnification, $m = -\frac{v}{u}$

(Here, $u = -100 \text{ cm}$ and $v = -100 \text{ cm}$)

$\therefore m = -\left(\frac{-100}{-100}\right) = -1$

Therefore, sign of magnification as per Cartesian Sign Convention = Negative. The negative sign shows that the image formed by the concave mirror at the centre of curvature is real and inverted.

71. The ability of a medium to refract light is expressed in terms of its optical density. Optical density has a definite connotation. It is not the same as mass density. On comparing two media, the one with the large refractive index is optically denser medium than the other. The other medium with a lower refractive index is optically rarer. Also the speed of light through a given medium is inversely proportional to its optical density.

(a) Determine the speed of light in diamond if the refractive index of diamond with respect to vacuum is 2.42. Speed of light in vacuum is $3 \times 10^8 \text{ m/s}$.

(b) Refractive indices of glass, water and carbon disulphide are 1.5, 1.33 and 1.62 respectively. If a ray of light is incident in these media at the same angle (say θ), then write the increasing order of the angle of refraction in these media.

(c) The speed of light in glass is $2 \times 10^8 \text{ m/s}$ and in water is $2.25 \times 10^8 \text{ m/s}$. (i)

Which one of the two is optically denser and why? (ii) A ray of light is incident normally at the water-glass interface when it enters a thick glass container filled with water. What will happen to the path of the ray after entering the glass? Give reason.

Or

(c) The absolute refractive indices of water and glass are $\frac{4}{3}$ and $\frac{3}{2}$ respectively. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (i) vacuum and (ii) water.

Answer:

(a) The absolute refractive index of diamond is given by

$$n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in diamond}}$$

$$2.42 = \frac{3 \times 10^8}{v}$$

$$v = 1.24 \times 10^8 \text{ ms}^{-1}$$

(b) From Snell's law,

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

$$\therefore \sin r = \frac{\sin \theta}{n}$$

Since, $\sin \theta$ is constant

$$\therefore \sin r \propto \frac{1}{n}$$

Since the value of n is least for water and maximum for carbon disulphide, hence, the increasing order of the angle of refraction in these media will be Carbon disulphide < Glass < Water

(c) (i) Refractive index of glass

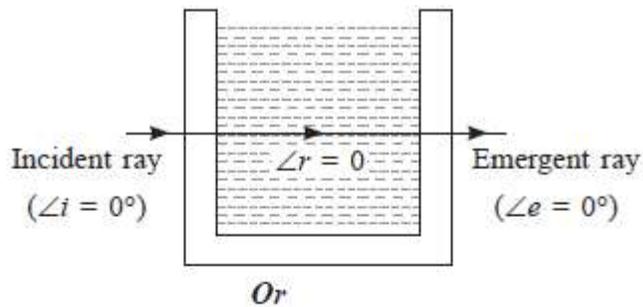
$$n_g = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{c}{2 \times 10^8}$$

Refractive index of water

$$n_w = \frac{c}{2.25 \times 10^8}$$

(ii) The ray of light which is incident normally at the water-glass interface passes without any deviation when it enters a thick glass container filled with

water. It is because here the angle of incidence is 0° and the angle of refraction and hence angle of emergence is also 0° .



- (c) (i) Absolute refractive index of glass is given by

$$n_g = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in glass } (v_g)}$$

$$\frac{3}{2} = \frac{c}{2 \times 10^8}$$

$$\Rightarrow c = 3 \times 10^8 \text{ ms}^{-1}$$

- (ii) Absolute refractive index of water is given by

$$n_w = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in water } (v_w)}$$

$$\frac{4}{3} = \frac{3 \times 10^8}{v_w}$$

$$v_w = 2.25 \times 10^8 \text{ ms}^{-1}$$