9 Light-Reflection and Refraction

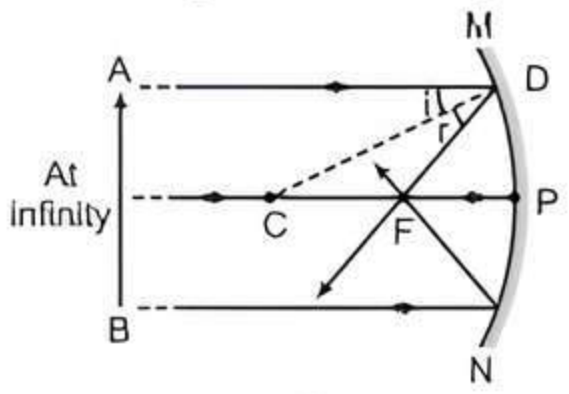
Fastrack Revision

- **Reflection of Light:** The process of bouncing back of the light rays which fall on the polished surface of an object is called reflection of light.
- **Laws of Reflection:** The laws of reflection of light are:
  (i) The angle of reflection is equal to the angle of incidence *i.e.*, $\angle r = \angle i$.
  (ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.
- **Object:** Anything which gives out light rays is called an object *e.g.*, a bulb, a candle etc.
- **Images:** The point at which the reflected rays converge or the point from where the reflected rays appear to diverge is known as 'Image'. Images are of two types–real image and virtual image. The image which can be obtained on a screen is called real image while the image which cannot be obtained on a screen is called a virtual image.
- **Mirror:** The mirror is a shiny polished surface which can reflect the rays of light. Mirrors can be plane (reflecting surface is plane) or spherical (reflecting surface is a part of hollow sphere). Spherical mirrors can be of two types:
  (i) Concave mirror (reflecting surface is curved inwards) and
  (ii) Convex mirror (reflecting surface is curved outwards).
- **Characteristics of Image Formed by a Plane Mirror:** Image formed by a plane mirror is:
  (i) virtual and erect.
  (ii) laterally inverted.
  (iii) of the same size as the object.
  (iv) as far behind the mirror as the object is in front of it.
- **Special Rays for Formation of Image:** The intersection of at least two reflected rays gives the position of image of the point object. Any two of the following rays can be considered for locating the image.
  (i) A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.
  (ii) A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, after reflection, will emerge parallel to the principal axis.
  (iii) A ray passing through the centre of curvature of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path.
  (iv) A ray incident obliquely to the principal axis, towards the pole of the mirror, on the concave mirror or a convex mirror is reflected obliquely.

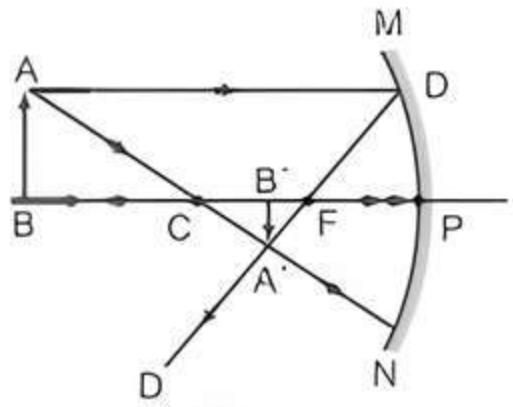
Formation of Image by Concave Mirror for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Nature and Size of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the focus or in the focal plane	Real, inverted, extremely diminished in size
2.	Object beyond the centre of curvature but at a finite distance [see fig. (b)]	Image is formed between the focus and the centre of curvature	Real, inverted and diminished
3.	Object at the centre of curvature [see fig. (c)]	Image is formed at the centre of curvature	Real, inverted and of the same size as that of object
4.	Object between the focus and the centre of curvature [see fig. (d)]	Image is formed beyond the centre of curvature	Real, inverted and larger than object
5.	Object at the focus [see fig. (e)]	Image is formed at infinity	Real, inverted and extremely magnified
6.	Object between the pole and the focus [see fig. (f)]	Image is formed behind the mirror	Virtual, erect and magnified

Ray Diagrams for the Image Formation by a Concave Mirror:



(a)



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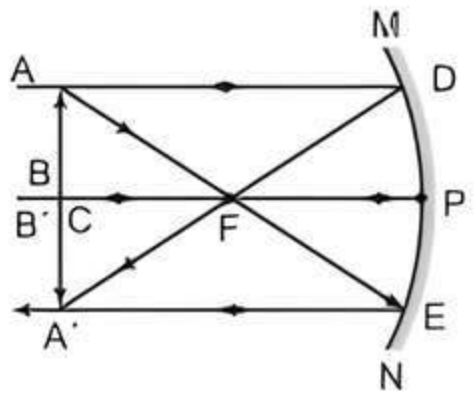

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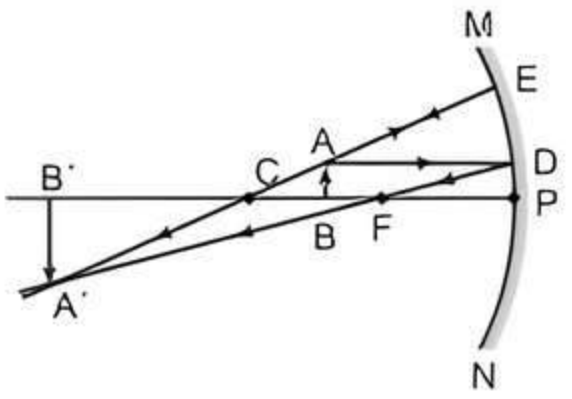

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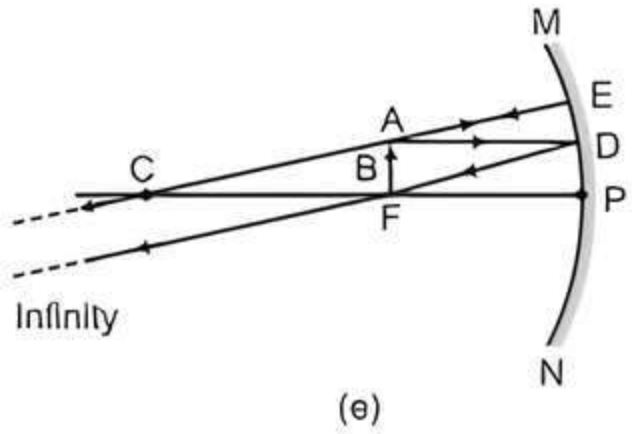
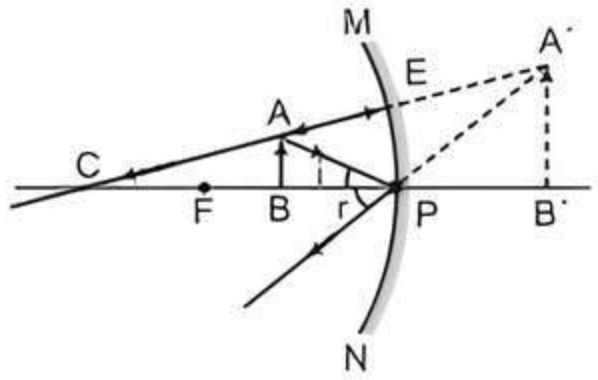


(e)

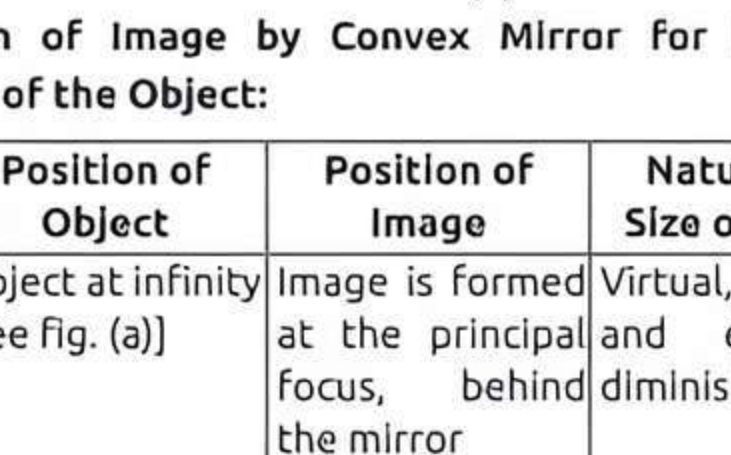


(f)

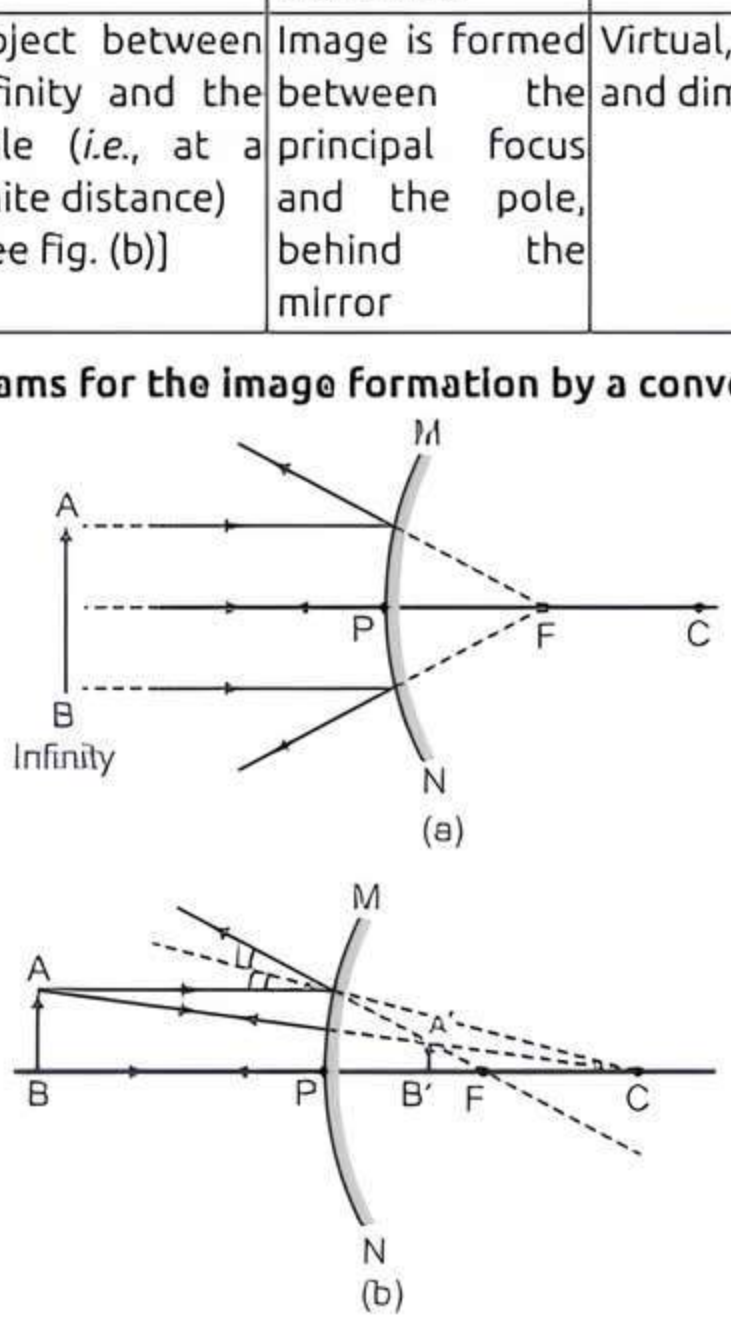
Formation of Image by Convex Mirror for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Nature and Size of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the principal focus, behind the mirror	Virtual, erect and extremely diminished
2.	Object between infinity and the pole (*i.e.*, at a finite distance) [see fig. (b)]	Image is formed between the principal focus and the pole, behind the mirror	Virtual, erect and diminished

Ray diagrams for the image formation by a convex mirror:



(a)



(b)

- **Uses of Concave Mirrors:**
  (i) Used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
  (ii) Used as shaving mirrors to see a larger image of the face.
  (iii) Used by dentists to see large images of the teeth of patients.
  (iv) Used to concentrate sunlight to produce heat in solar furnaces.

- **Use of Convex Mirrors:** Used as rear-view (wing) mirrors in vehicles because they always give an erect and diminished image. Also, they have a wider field of view as they are curved outwards.
- **Mirror Formula:** It is a relation between distance of object, distance of image from the pole of the mirror and its focal length *i.e.*, relation between '*u*', '*v*' and '*f*' is given by

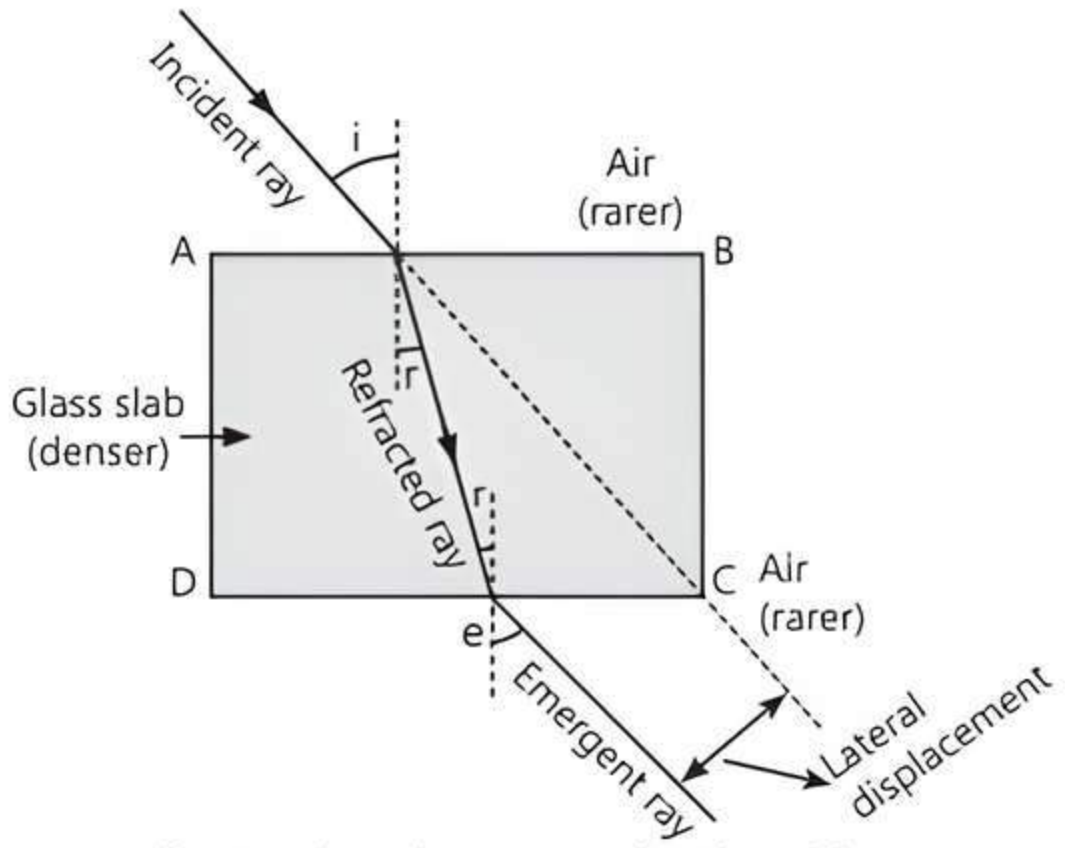
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

- **Magnification or Linear Magnification:** It is defined as the ratio of height of image to the height of the object. It is represented by '*m*'. It is also related to the distance of object (u) and distance of image (v) *i.e.*,

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

$$= -\frac{\text{Image distance}}{\text{Object distance}} = \frac{-v}{u}$$

- **Refraction:** Bending of light ray when it passes from one medium to another is called refraction. When light travels from a rarer medium to a denser medium, it bends towards the normal ($i > r$) and when it travels from a denser medium to a rarer medium, it bends away from the normal ($i < r$), where, i = Angle of incidence, r = Angle of refraction.
- **Refraction through a Rectangular Glass Slab:** When a light ray is obliquely incident on a glass slab, then the emergent ray is parallel to the direction of incident ray, but it is shifted slightly sidewards. Here, refraction takes place twice, first, when the ray enters the glass slab from air and second, when it exits from the glass slab to air. Both the cases of refraction have been shown in the given figure. The extent of bending of the ray of light at opposite parallel faces AB and CD of rectangular glass slab is equal and opposite. Hence, the ray emerging from face CD becomes parallel to the incident ray, but shifts slightly sidewards.



Refraction through a Rectangular Glass Slab

Here, i = Angle of incidence,
r = Angle of refraction,
e = Angle of emergence.

- **Laws of Refraction:** Refraction of light occurs according to the following laws:
  (i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.
  (ii) The ratio of sine of angle of incidence to the sine of angle of refraction for light of a given colour is constant for a given pair of media (Snell's law). It is expressed as,

$$\frac{\sin i}{\sin r} = \text{Constant } (\mu \text{ or } \eta)$$

This constant is known as refractive index (μ). It can also be expressed as:

$$\mu \text{ or } \eta = \frac{\text{Speed of light in vacuum or air}}{\text{Speed of light in medium}}$$

- **Lens:** The transparent refracting medium bounded by two surfaces in which at least one surface is curved, is called lens. Lenses are of two types:
  (i) Convex lens is thicker at the centre and thinner at the edges.
  (ii) Concave lens is thinner at the centre and thicker at the edges.

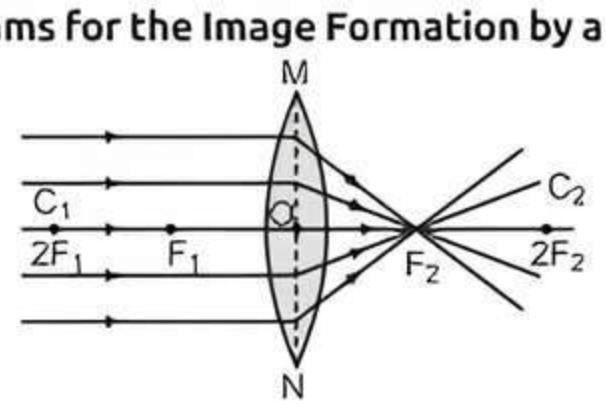
Concave lens is a diverging lens (diverges the light) and convex lens is a converging lens (converges the light).

- **Special Rays for Formation of Image:** For drawing ray diagrams in lenses, alike of spherical mirrors, we consider any two of the following rays:
  (i) A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens. In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens.
  (ii) A ray of light passing through a principal focus, after refraction from a convex lens, will emerge parallel to the principal axis. A ray of light appearing to meet at the principal focus of a concave lens, after refraction, will emerge parallel to the principal axis.
  (iii) A ray of light passing through the optical centre of a lens will emerge without any deviation.

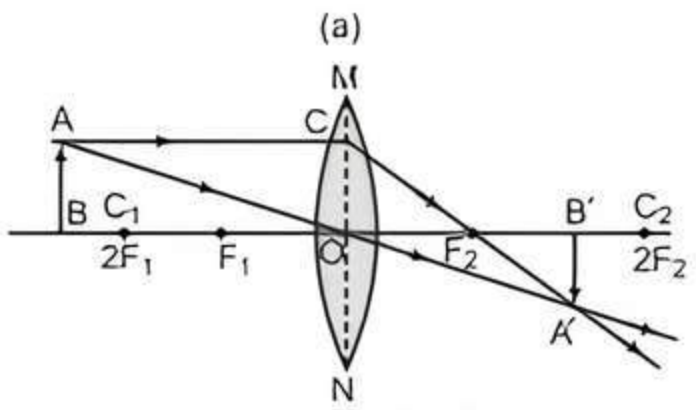
Formation of Image by Convex Lens for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Size of Image	Nature of Image
1.	Object at infinity [see fig. (a)]	Image is formed at F_2	Extremely diminished	Real and inverted
2.	Object beyond $2F_1$ (at a finite distance) [see fig. (b)]	Image is formed between F_2 and $2F_2$	Diminished	Real and inverted
3.	Object at $2F_1$ [see fig. (c)]	Image is formed at $2F_2$	Same size	Real and inverted
4.	Object between F_1 and $2F_1$ [see fig. (d)]	Image is formed beyond $2F_2$	Magnified	Real and inverted
5.	Object at F_1 [see fig. (e)]	Image is formed at infinity	Highly magnified	Real and inverted
6.	Object between lens and F_1 [see fig. (f)]	Image is formed on the same side of the lens as the object	Magnified	Virtual and erect

- **Ray Diagrams for the Image Formation by a Convex Lens:**



(a)



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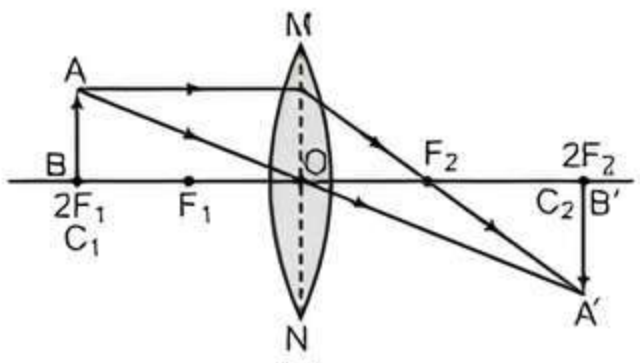

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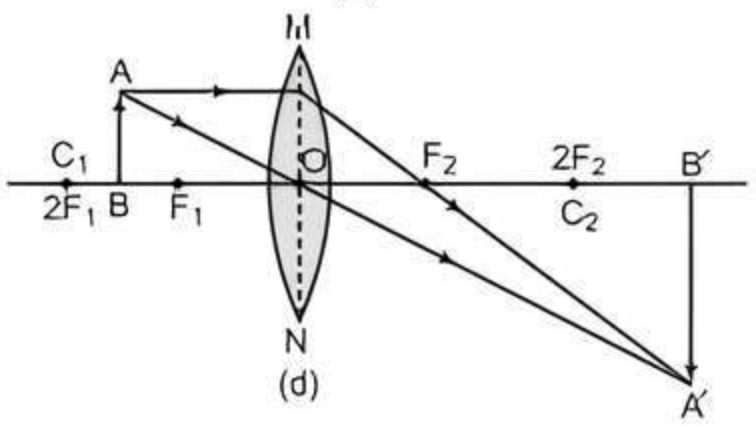

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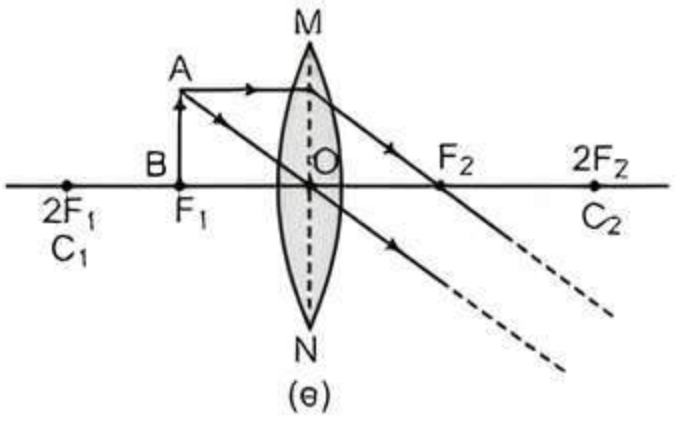
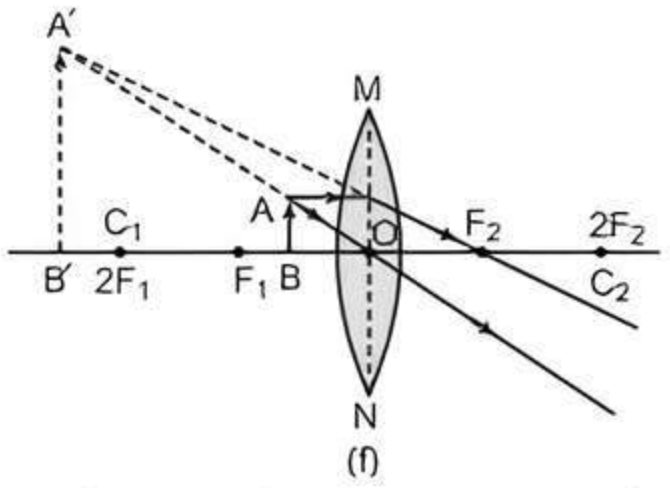


(e)

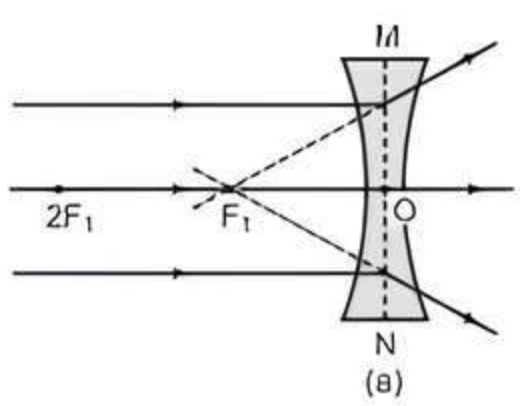


(f)

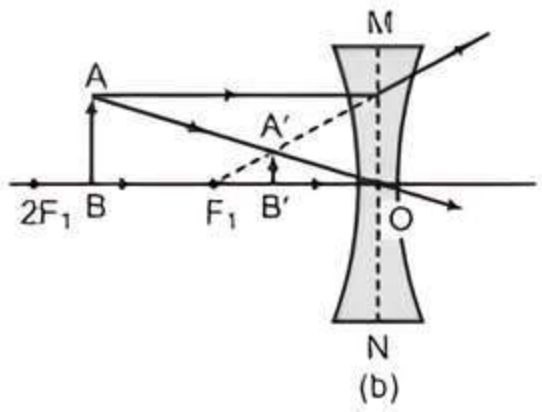
▶ **Formation of Image by Concave Lens for Different Positions of the Object:**

S.No.	Position of Object	Position of Image	Size of Image	Nature of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the focus on the same side of lens as the object	Highly diminished	Virtual and erect
2.	Object anywhere between optical centre and infinity [see fig. (b)]	Image is formed between the focus and the optical centre and on the same side of lens as the object	Diminished	Virtual and erect

▶ **Ray diagrams for the Image Formation by a Concave Lens:**



(a)



(b)

▶ **Lens Formula:** It represents the relationship between the object distance (u), the image distance (v) and the focal length (f). It can be expressed as,

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

▶ **Linear Magnification:** The ratio of the height of image to the height of object is known as linear magnification (m).

$$\text{Linear magnification } (m) = \frac{h_i}{h_o} \text{ or } \frac{v}{u}$$

▶ **Power of a Lens:** The ability of a lens to converge or diverge light rays after refraction is known as power (P) of the lens. It is always the reciprocal of focal length.

$$P = \frac{1}{f(\text{m})} = \frac{100}{f(\text{cm})}$$

(i) The unit of power of lens is dioptre (D).

(ii) One dioptre is the power of a lens whose focal length is 1 m and is represented by 'D'. Power of a convex lens is positive and that of a concave lens is negative.

Practice Exercise

Multiple Choice Questions

Q 1. The laws of reflection hold true for: *(CBSE 2020)*

a. plane mirrors only b. concave mirrors only
c. convex mirrors only d. all reflecting surfaces

Q 2. When an object is kept within the focus of a concave mirror, an enlarged image is formed behind the mirror. This image is: *(CBSE 2020)*

a. real b. inverted
c. virtual and inverted d. virtual and erect

Q 3. Three students A, B and C focussed a distant building on a screen with the help of a concave mirror. To determine focal length of the concave mirror they measured the distances as given below: *(CBSE 2017)*

Student A: From mirror to the screen

Student B: From building to the screen

Student C: From building to the mirror

Who measured the focal length correctly?

a. Only A b. Only B
c. A and B d. B and C

Q 4. In torches, search lights and headlights of vehicles, the bulb is placed: *(NCERT EXEMPLAR)*

a. between the pole and the focus of the reflector
b. very near to the focus of the reflector
c. between the focus and centre of curvature of the reflector
d. at the centre of curvature of the reflector

Q 5. An object is placed in front of a convex mirror. Its image is formed: *(CBSE SQP 2023-24)*

a. at a distance equal to the object distance in front of the mirror.
b. at twice the distance of the object in front of the mirror.
c. half the distance of the object in front of the mirror.
d. behind the mirror and it's position varies according to the object distance.

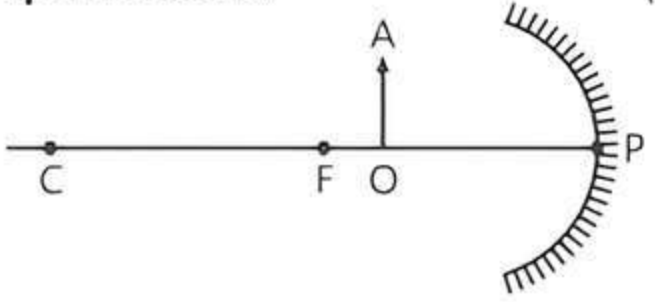
Q 6. An object is placed in front of a convex mirror at infinity. According to the New Cartesian Sign Convention, the sign of the focal length and the sign of the image distance in this case are respectively:

(CBSE 2023)

a. +, – b. –, +
c. –, – d. +, +

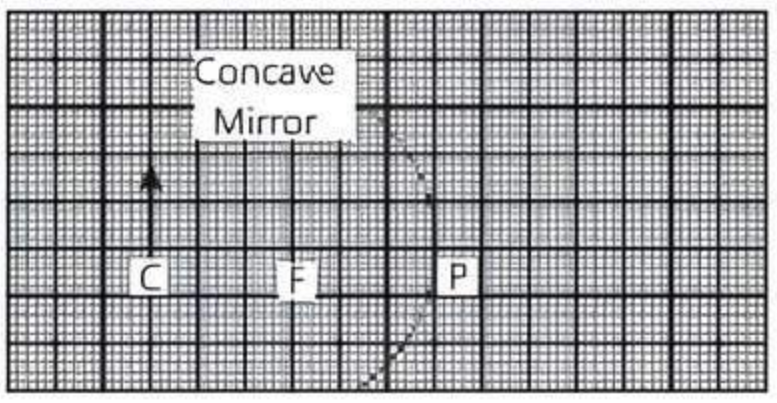
Q 7. For the diagram shown, according to the new Cartesian sign convention, the magnification of the image formed will have the following specifications:

(CBSE 2021 Term-1)



a. Sign – Positive, Value – Less than 1
b. Sign – Positive, Value – More than 1
c. Sign – Negative, Value – Less than 1
d. sign – Negative, Value – More than 1

Q 8.



Examine the above figure and state which of the following option is correct? (one small box in the figure is equal to 1 cm) *(CBSE SQP 2021 Term-1)*

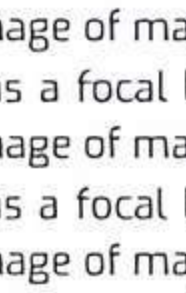
a. The mirror has a focal length of –6 cm and will produce an image of magnification +1.
b. The mirror has a focal length of –3 cm and will produce an image of magnification –1.
c. The mirror has a focal length of –3 cm and will produce an image of magnification +1.
d. The mirror has a focal length of –6 cm and will produce an image of magnification –1.

Q 9. **The radius of curvature of a converging mirror is 30 cm. At what distance from the mirror should an object be placed so as to obtain a virtual image?**

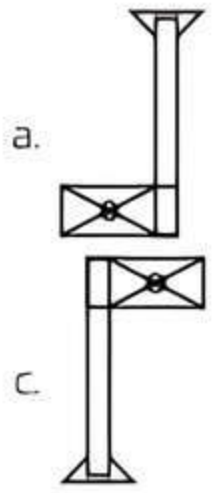
(CBSE 2021 Term-1)

a. Infinity
b. 30 cm
c. Between 15 cm and 30 cm
d. Between 0 cm and 15 cm

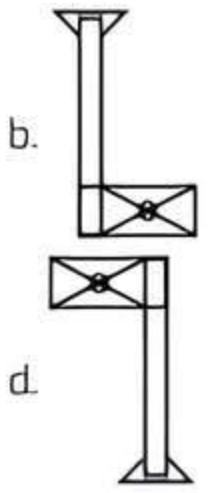
Q 10. **When you focus the image of a distant flag, whose shape is given below, on a screen using a convex lens, the shape of the image as it appears on the screen is:** *(CBSE 2017)*



a.



b.



c.

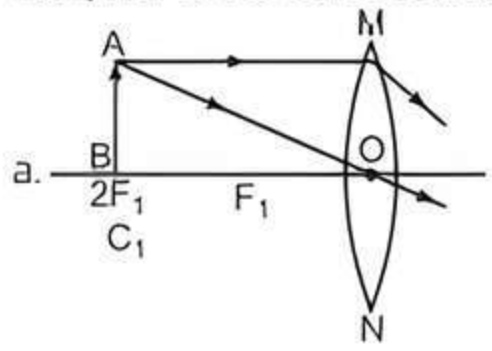
d.

Q 11. **Which of the following can make a parallel beam of light when light from a point source is incident on it?** *(CBSE SQP 2021 Term-1)*

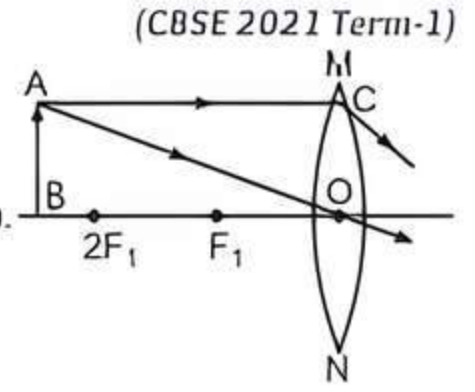
a. Concave mirror as well as convex lens.
b. Convex mirror as well as concave lens.
c. Two plane mirrors placed at 90° to each others.
d. Concave mirror as well as concave lens.

Q 12. **A student wants to obtain magnified image of an object AB as on a screen. Which one of the following arrangements shows the correct position of AB for him/her to be successful?** *(CBSE 2021 Term-1)*

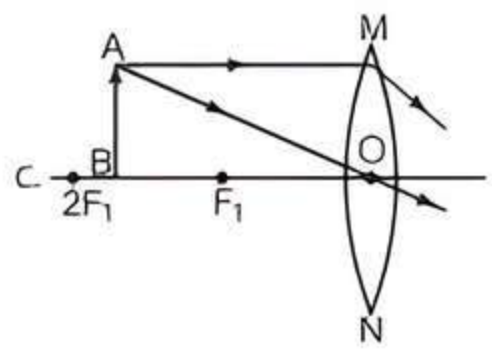
a.



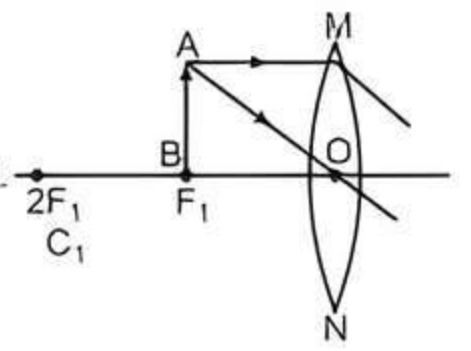
b.



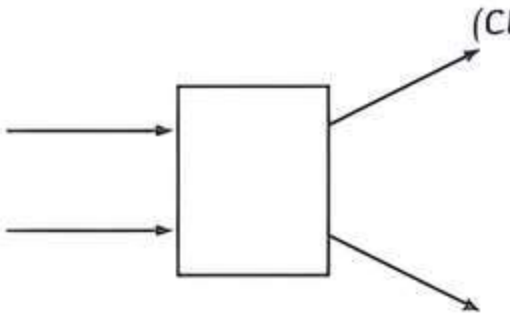
c.



d.



Q 13. **The following diagram shows the use of an optical device to perform an experiment of light. As per the arrangement shown, the optical device is likely to be a:** *(CBSE 2021 Term-1)*



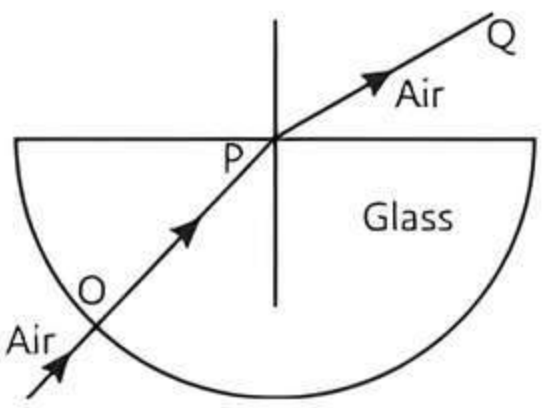
a. concave mirror b. concave lens
c. convex mirror d. convex lens

Q 14. **If the real image of a candle flame formed by a lens 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?**

(CBSE SQP 2021 Term-1)

a. –80 cm b. –40 cm c. –40/3 cm d. –80/3 cm

Q 15.



The angle of incidence from air to glass at the point O on the hemispherical glass slab is:

(CBSE SQP 2021 Term-1)

a. 45°
b. 0°
c. 90°
d. 180°

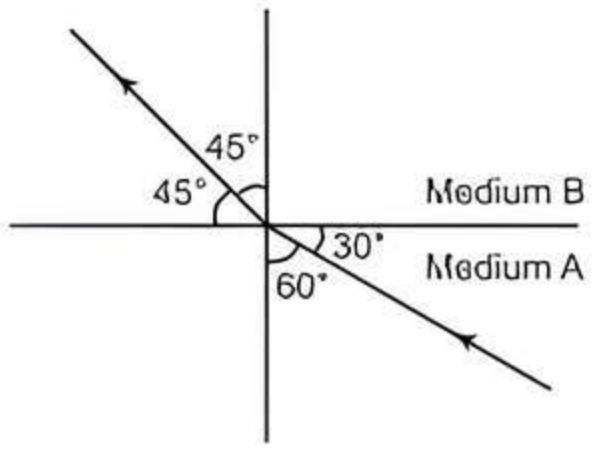
Q 16. A ray of light starting from air passes through medium A of refractive index 1.50, enters medium B of refractive index 1.33 and finally enters medium C of refractive index 2.42. If this ray emerges out in air from C, then for which of the following pairs of media the bending of light is least?

(CBSE 2021 Term-1)

a. air- A
b. A-B
c. B-C
d. C-air

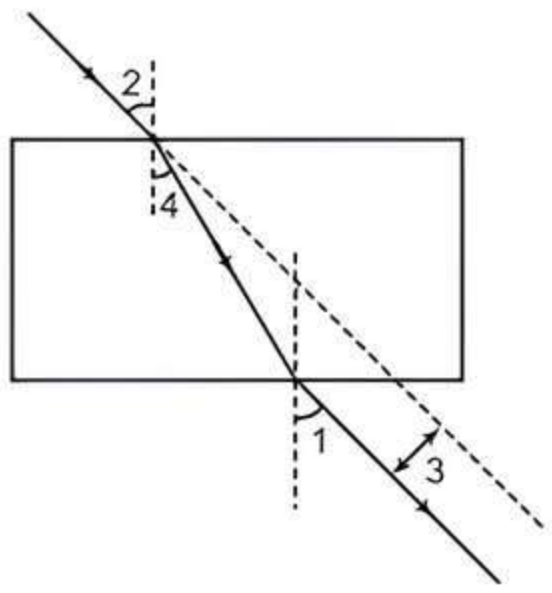
Q 17. The given figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is:

(NCERT EXEMPLAR)



a. $\sqrt{3}/\sqrt{2}$
b. $\sqrt{2}/\sqrt{3}$
c. $1/\sqrt{2}$
d. $\sqrt{2}$

Q 18. The correct sequencing of angle of incidence, angle of emergence, angle of refraction and lateral displacement shown in the following diagram by digits 1, 2, 3 and 4 is: *(CBSE 2017)*

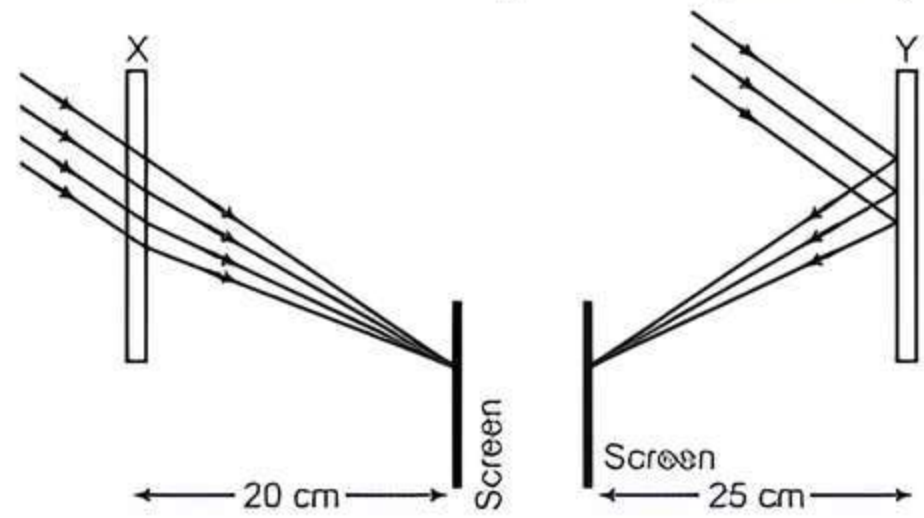


a. 2, 4, 1, 3
b. 2, 1, 4, 3
c. 1, 2, 4, 3
d. 2, 1, 3, 4

Q 19. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen, he should move the lens: *(CBSE 2017)*

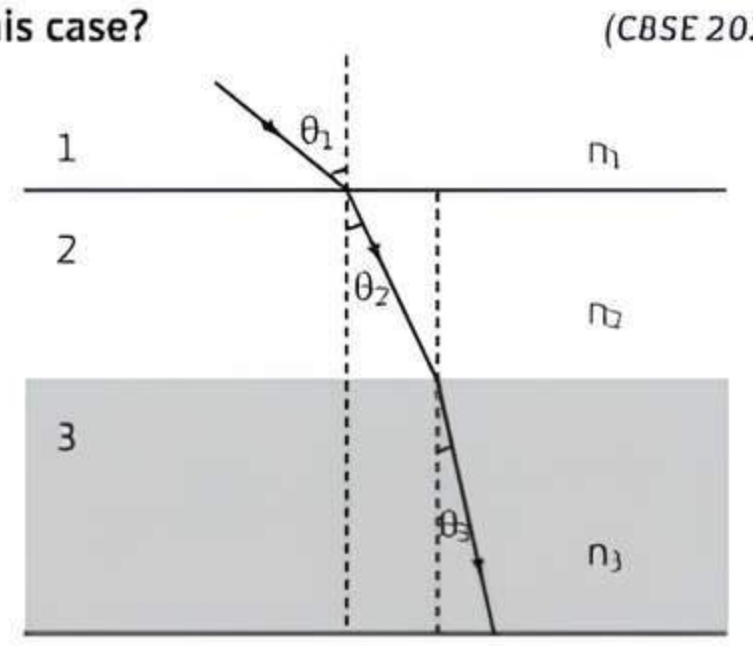
a. away from the screen
b. towards the screen
c. to a position very far away from the screen
d. either towards or away from the screen depending upon the position of the object

Q 20. Study the given ray diagrams and select the correct statement from the following: *(CBSE 2017)*



a. Device *X* is a concave mirror and device *Y* is a convex lens, whose focal lengths are 20 cm and 25 cm respectively.
b. Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 10 cm and 25 cm respectively.
c. Device *X* is a concave lens and device *Y* is a convex mirror, whose focal lengths are 20 cm and 25 cm respectively.
d. Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively.

Q 21. In the diagram shown below n_1, n_2 and n_3 are refractive indices of the media 1, 2 and 3 respectively. Which one of the following is true in this case? *(CBSE 2021 Term-1)*



a. $n_1 = n_2$
b. $n_1 > n_2$
c. $n_2 > n_3$
d. $n_3 > n_1$

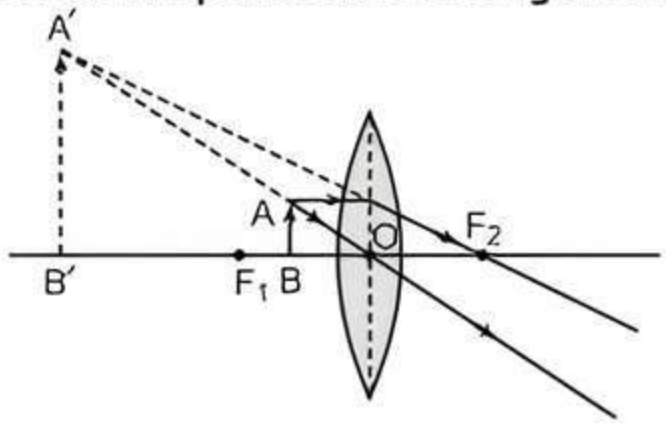
Q 22. The refractive index of medium A is 1.5 and that of medium B is 1.33. If the speed of light in air is 3×10^8 m/s, what is the speed of light in medium A and B respectively? *(CBSE 2021 Term-1)*

a. 2×10^8 m/s and 1.33×10^8 m/s
b. 1.33×10^8 m/s and 2×10^8 m/s
c. 2.25×10^8 m/s and 2×10^8 m/s
d. 2×10^8 m/s and 2.25×10^8 m/s

Q 23. The refractive index of flint glass is 1.65 and that for alcohol is 1.36 with respect to air. What is the refractive index of the flint glass with respect to alcohol? *(CBSE SQP 2021 Term-1)*

a. 0.82
b. 1.21
c. 1.11
d. 1.01

Q 24. The given lens has a focal length of 10 cm. The object of height 2 mm is placed at a distance of 5 cm from the pole. Find the height of the image.



a. 4 cm b. 6.67 mm c. 4 mm d. 3.33 mm

Q 25. Consider these indices of refraction: glass: 1.52; air: 1.0003; water: 1.333. Based on the refractive indices of three materials, arrange the speed of light through them in decreasing order.

(CBSE SQP 2021 Term-1)

a. The speed of light in water > the speed of light in air > the speed of light in glass.
b. The speed of light in glass > the speed of light in water > the speed of light in air.
c. The speed of light in air > the speed of light in water > the speed of light in glass.
d. The speed of light in glass > the speed of light in air > the speed of light in water.

Assertion & Reason Type Questions

Directions (Q. Nos. 26-30): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 26. Assertion (A): A ray incident along normal to the mirror retraces its path.

Reason (R): In reflection, angle of incidence is always equal to angle of reflection.

Q 27. Assertion (A): Large concave mirrors are used to concentrate sunlight to produce heat in solar cookers.

Reason (R): Concave mirror converges the light rays falling on it to a point.

Q 28. Assertion (A): A pencil partly immersed in water appears to be bent at the water surface.

Reason (R): Light from different points on the pencil immersed in water refracts and appears to come from a point above the original position.

Q 29. Assertion (A): Higher is the refractive index of a medium or denser the medium, lesser is the velocity of light in that medium.

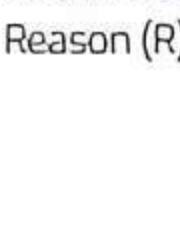
Reason (R): Refractive index is inversely proportional to velocity.

Q 30. Assertion (A): A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it.

Reason (R): A magnified and inverted image can be obtained by a convex lens when an object is kept between F and C.

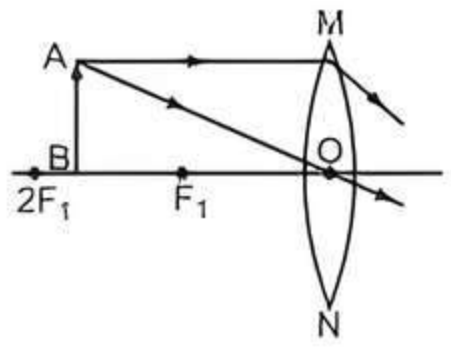
Answers

1. (d) all reflecting surfaces
2. (d) virtual and erect
3. (a) Only A
4. (b) very near to the focus of the reflector
5. (d) behind the mirror and it's position varies according to the object distance.
6. (d) +, +
7. (b) Sign — Positive. Value — More than 1
8. (b) When object is placed at centre of curvature, image is formed at the centre of curvature, *i.e.*; $m = -1$.
9. (d) Between 0 cm and 15 cm
10. (a)



11. (a) When light rays from a point source is incident on concave mirror and convex lens, emergent beams are parallel and the image is formed at infinity. Convex mirror and concave lens on the other hand always form a virtual image. Emergent beams from these are not parallel but diverging when the object is kept at focus.

12. (c)



13. (b) concave lens
14. (d) –80/3cm

Given. $m = -3$

$v = 80$ cm

We know that. $m = \frac{v}{u}$

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

$$u = \frac{80}{-3} = \frac{-80}{3} \text{ cm}$$

15. (b) for a normal incident light on the surface.

$\angle i = 0$

16. (b) A-B
17. (a) The Snell's law simply relates $\angle i$ and $\angle r$ to the refraction indices of two medium A and B.

Therefore, refractive index of medium B relative to medium A is

$$n = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 45°} = \frac{\sqrt{3}}{\sqrt{2}}$$

18. (b) From the figure, angle 2 is angle of incidence, as it is formed between the incident ray and the normal. Angle 1 is angle of emergence, as it is formed between the emergent ray with normal. Angle 4 is angle of refraction as it is formed between the refracted ray and the normal. 3 shows the lateral displacement. Hence, the correct answer is 2 , 1 , 4, 3.

19. (d) either towards or away from the screen depending upon the position of the object.

20. (d) Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively.

21. (d) $n_3 > n_1$

22. (d) Given, $c = 3 \times 10^8$ m/s

Refractive index of medium $A(\mu_A) = 1.5$

$\therefore$ Speed of light of medium $A = \frac{c}{\mu_A}$

$$= \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m/s}$$

and refractive index of medium B $(\mu_B) = 1.33$

$\therefore$ Speed of light of medium B

$$= \frac{c}{\mu_B} = \frac{3 \times 10^8}{1.33} = 2.25 \times 10^8 \text{ m/s}$$

23. (b) Refractive index of flint glass w.r.t. alcohol

$$= \frac{\text{Refractive index of flint glass}}{\text{Refractive index of alcohol}}$$

$$= \frac{1.65}{1.36} = 1.21$$

24. (c) Given, $f = +10$ cm (Convex lens)

$h_1 = 2$ mm $= 0.2$ cm,

$u = -5$ cm

$$\frac{1}{f} = \frac{1}{v} - \left(\frac{1}{-5}\right)$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{5} \Rightarrow \frac{1-2}{10} = \frac{-1}{10}$$

$v = -10$ cm

Also, $m = \frac{v}{u} = \frac{h_2}{h_1} \Rightarrow m = \frac{-10}{-5} = \frac{h_2}{0.2}$

$\Rightarrow h_2 = 0.4$ cm

$\Rightarrow h_2 = 4$ mm

25. (c) The speed of light in air > the speed of light in water > the speed of light in glass.
Higher the refractive index, lesser is the speed of light in that medium and *vice-versa*.

26. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

27. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

28. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

29. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

30. (c) Assertion (A) is true but Reason (R) is false.

Case Study Based Questions

Case Study 1

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.

(CBSE 2021 Term-1)

Read the above passage carefully and give the answer of the following questions:

Q 1. What types of lenses must be L_1 and L_2?

a. Both concave
b. Both convex
c. L_1—concave and L_2—convex
d. L_1—convex and L_2—concave

Q 2. What is the value and sign of magnification (according to the new Cartesian sign convention) of the image formed by L_1?

a. Value = Less than 1 and Sign = Positive
b. Value = More than 1 and Sign = Positive
c. Value = Less than 1 and Sign = Negative
d. Value = More than 1 and Sign = Negative

Q 3. What is the value and sign of (according to new Cartesian sign convention) magnification of the image formed by L_2?

a. Value = Less than 1 and Sign = Positive
b. Value = More than 1 and Sign = Positive
c. Value = Less than 1 and Sign = Negative
d. Value = More than 1 and Sign = Negative

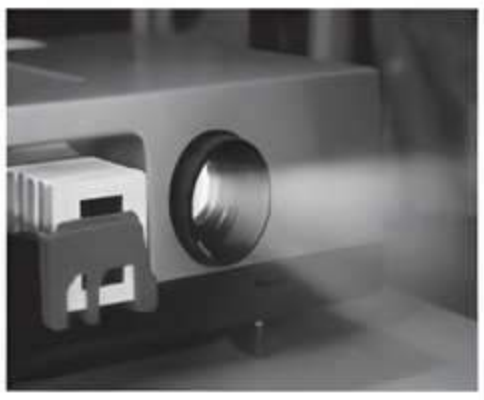
Q 4. If power of the eyepiece (L_2) is 5 diopters and it forms an image at a distance of 80 cm from its optical centre, at what distance should the object be?

a. 12 cm b. 16 cm c. 18 cm d. 20 cm

Answers

1. (b) Both convex
2. (d) Value = More than 1 and Sign = Negative
3. (b) Value = More than 1 and Sign = Positive
4. (b) 16 cm

Case Study 2



The above images are that of a specialised 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.

Read the above passage carefully and give the answer of the following questions:

Q 1. Based on the text and data given in the above paragraph, What kind of lens must the slide projector have?

Q 2. 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?

Q 3. 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

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) *[CBSE SQP 2022-23]*

Answers

1. Convex lens
2. Negative as the image is real and inverted.
3. $1/f = 1/v - 1/-21$

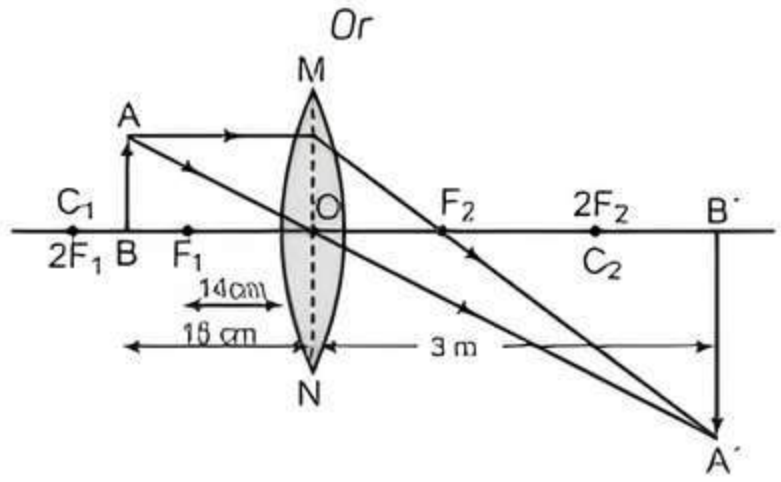
   $\Rightarrow \quad 1/20 = 1/v - 1/u$

   $\Rightarrow \quad 1/v = 1/20 - 1/21$

   $= (21 - 20)/420 = 1/420$

   $v = 420$ cm

Or



Case Study 3

Ravi wanted to fix the rear-view mirror of his scooter. He knows that rear-view mirror is an essential safety device in the vehicle and allows him to see objects at the backside of his vehicle.

He bought two mirrors M_1 and M_2, out of which M_1 is curved inwards and M_2 is curved outwards.

Read the above passage carefully and give the answer of the following questions:

Q 1. Based on the given situation, which mirror should Ravi need to fix as his rear-view mirror and why?

Q 2. Ravi did some preliminary experiment with mirror M_1 and found that magnification of the real image of an object placed at 10 cm in front of it is 3, at what distance is the image located?

Q 3. What is the formula for magnification obtained with a mirror?

Q 4. An object is placed at the centre of curvature of M_1. Find the distance between its image and pole.

Q 5. An object is placed 60 cm in front of M_2. The image formed by the mirror is located 30 cm behind the mirror. What is the object's magnification?

Answers

1. M_2 because it gives an erect and diminished image.
2. Given, $m = -3$ (image is real), $u = -10$

   We know that, $m = \frac{-v}{u} \Rightarrow -3 = \frac{-v}{-10}$

   $\Rightarrow \quad v = -30$ cm
3. Magnification $(m) = \frac{\text{Height of image } (h_i)}{\text{Height of object } (h_o)}$

   $= \frac{\text{Image distance } (-v)}{\text{Object distance } (u)}$
4. When object is at C of M_1 (concave mirror), image is formed at C, *i.e.*, $v = -C = -2f$

   Hence, distance between image and pole is $2f$.

5. Given, $u = -60$ cm and $v = 30$ cm
We know that, $m = -v/u$

$$= \frac{-30}{-60}$$

$$= \frac{1}{2} \text{ or } +0.5$$

Case Study 4

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.

Read the above passage carefully and give the answer of the following questions:

Q 1. 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 3×10^8 m/s.

Q 2. 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.

Q 3. The speed of light in glass is 2×10^8 m/s and in water is 2.25×10^8 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

The absolute refractive indices of water and glass are 4/3 and 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. *(CBSE 2023)*

Answers

1. Given, $\mu = 2.42$, $c = 3 \times 10^8$ m/s

Speed of light in diamond $= \frac{c}{\mu} = \frac{3 \times 10^8}{2.42}$

$= 1.24 \times 10^8$ m/s

2. Carbon disulphide, glass, water.

3. (i) Glass is denser than water because speed of light in glass is less than that of water.

(ii) A ray of light incident normally at the water-glass interface does not suffer any refraction and goes straight on entering the thick glass container filled with water. This is so because all parts of the light waves reach the interface at the same time, enter the glass at the same time and hence get slowed down at the same time.

Or

Given, $\mu_w = \frac{4}{3}$, $\mu_g = \frac{3}{2}$, $v_g = 2 \times 10^8$ m/s

We know that

$$\text{Speed of light in medium} = \frac{c}{\mu}$$

where, c = speed of light in vacuum

μ = refractive index of medium

(i) $\therefore$ c = speed of light in glass × refractive index of glass

$= v_g \times \mu_g$

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

$= 3 \times 10^8$ m/s

(ii) Speed of light in water $= \frac{c}{\text{refractive index of water}}$

$= \frac{c}{\mu_w}$

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

$= 2.25 \times 10^8$ m/s

Very Short Answer Type Questions

Q 1. What is the magnification of the images formed by plane mirrors and why? *(CBSE 2015)*

Ans. The magnification of the images formed by plane mirrors is 1 because the size of the image is equal to the size of object.

Q 2. What is the radius of curvature of a plane mirror? *(CBSE 2015)*

Ans. The radius of curvature of a plane mirror is infinity.

Q 3. How can a concave mirror be identified without touching? *(CBSE 2020)*

Ans. If the object is placed close to the mirror, the image will be erect and magnified.

Q 4. Define pole of a spherical mirror. *(CBSE 2020)*

Ans. The centre of the reflecting surface of a spherical mirror is a point called the pole.

Q 5. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?

Ans. Focal length, $f = R/2 = 20/2 = 10$ cm

Q 6. What are the advantage and disadvantage of using a convex mirror for seeing traffic at the rear? *(CBSE 2015)*

Ans. Advantage: Convex mirror always gives an erect image and has a wider field of view.

Disadvantage: It does not give the correct distance of the vehicle at the rear.

Q 7. State the cause of refraction of light.

Ans. The cause of the refraction of light is that light travels at different speeds in different media.

Q 8. A ray of light falls normally on a face of a glass slab. What are the values of angle of incidence and angle of refraction of this ray?

Ans. When a ray of light falls on a glass slab normally then, $\angle i = 0$ and $\angle r = 0$.

Q 9. If 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?

Ans. The image will be real and inverted and will be formed at the centre of curvature of the lens.

Q 10. What is the minimum number of rays required for locating an image formed by a concave lens for an object?

Ans. We require minimum two rays for locating an image formed by a concave lens for an object.

Q 11. If on applying Cartesian sign convention for spherical lenses, the image distance obtained is negative, state the significance of the negative sign.

Ans. This means that the image is formed at the same side of the object. *i.e.*, virtual and erect. Also, the lens is concave in nature.

Q 12. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Ans. $$f = \frac{1}{P}\text{m} = \frac{1}{+1.5}\text{m} = +\frac{10}{15}\text{m} = +\frac{2}{3}\text{m}$$

$+f$ means that the lens is convex or diverging in nature.

Short Answer Type-I Questions

Q 1. State the laws of reflection. *(CBSE 2019)*

Ans. Laws of Reflection:

(i) The angle of incidence is equal to the angle of reflection, and

(ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

Q 2. List four characteristics of the image formed by a concave mirror of focal length 40 cm when the object is placed in front of it at a distance of 20 cm from its pole. *(CBSE 2019)*

Ans.

TiP

Here, object distance = 20 cm and focal length = 40 cm, i.e., object is placed between pole and focus of the concave mirror.

Four characteristics of image formed by the given concave mirror are:

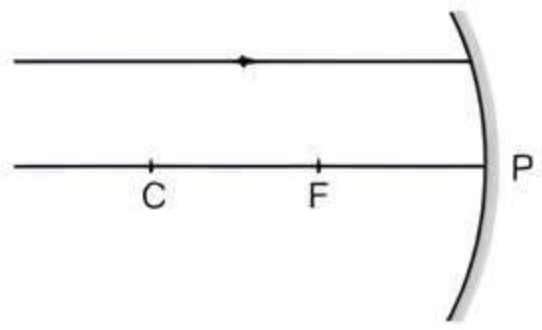
(i) Image is virtual

(ii) Image is erect

(iii) Image is enlarged/magnified

(iv) Image is formed behind the mirror.

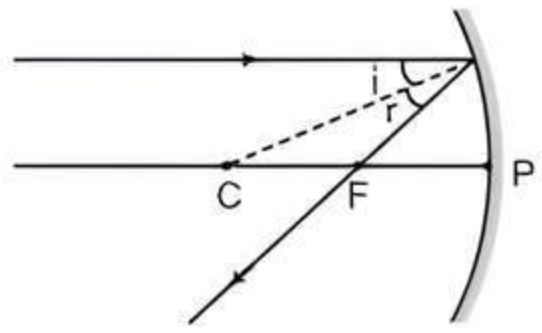
Q 3. Redraw the following diagram on your answer-sheet and show the path of the reflected ray. Also mark the angle of incidence ($\angle i$) and the angle of reflection ($\angle r$) on the diagram: *(CBSE 2017)*



Ans.

TiP

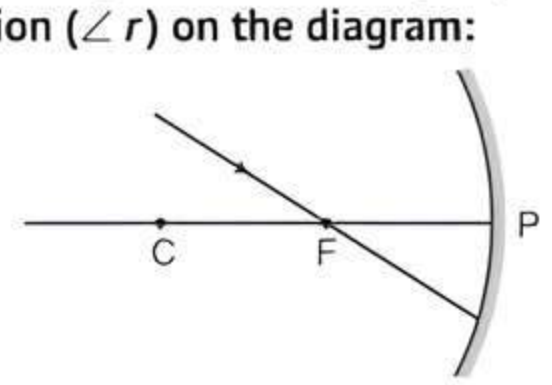
A ray parallel to the principal axis, after reflection, will pass through the principal focus of concave mirror.



COMMON ERROR

Usually students forget to label the angle of incidence and angle of reflection.

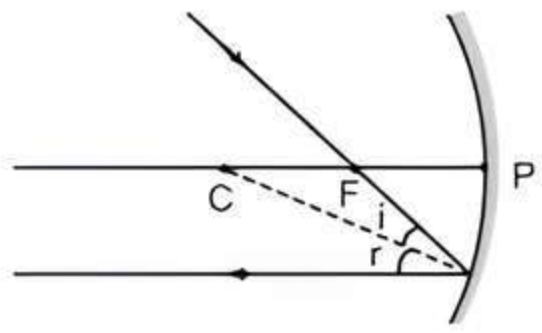
Q 4. Redraw the following diagram on your answer-sheet and show the path of the reflected ray. Also mark the angle of incidence ($\angle i$) and the angle of reflection ($\angle r$) on the diagram: *(CBSE 2017)*



Ans.

TiP

A ray passing through the principal focus of a concave mirror, after reflection, will emerge parallel to the principal axis.



Q 5. An object is placed at a distance of 30 cm in front of a convex mirror of focal length 15 cm. Write four characteristics of the image formed by the mirror. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given convex mirror are:

(I) Image is virtual (II) Image is erect

(III) Image is diminished

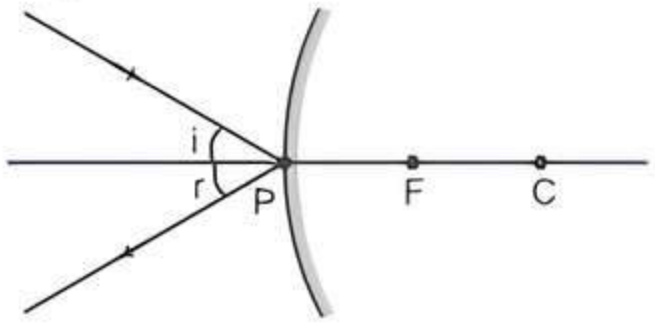
(iv) Image is formed between P and F, i.e., behind the mirror.

COMMON ERROR

Usually students get confused between convex and concave mirror and write characteristics of image formed by concave mirror.

Q 6. Draw a labelled ray diagram to show the path of the reflected ray corresponding to the ray which is incident obliquely to the principal axis, towards the pole of a convex mirror. Mark the angle of incidence and angle of reflection on it. *(CBSE 2019)*

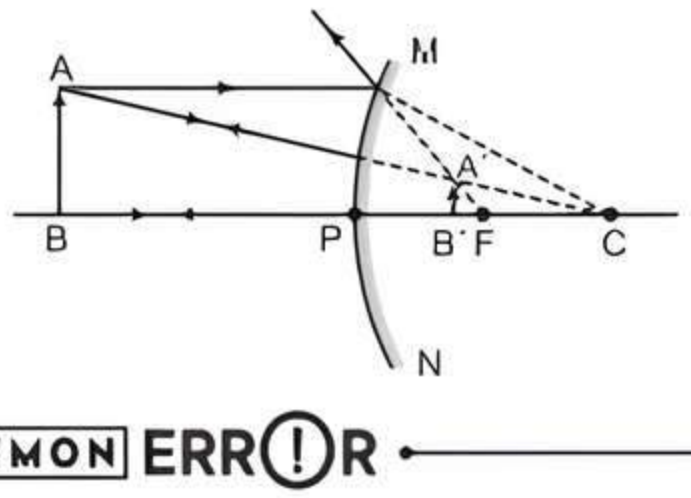
Ans. Ray Diagram:



Q 7. 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. *(CBSE 2017)*

Ans. The mirror is convex mirror.

Ray Diagram:



COMMON ERROR

Students forget to mark the arrows on the rays to indicate their direction of travel.

Q 8. An object of height 1.2 cm is placed before a concave mirror of focal length 20 cm so that a real image is formed at a distance of 60 cm from it. Find the position of an object. What will be the height of the image formed?

Sol. Given that, $h_o = 1.2$ cm, $f = -20$ cm and $v = -60$ cm

Using mirror formula,

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

$$\frac{1}{u} = \frac{1}{-20} - \frac{1}{-60}$$

$$u = -60/2 = -30 \text{ cm}$$

We know that

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

$$h_I = \frac{-60}{-30} \times 1.2 = -2.4 \text{ cm}$$

Q 9. State laws of refraction of light. *(CBSE 2019)*

Ans. Laws of refraction of light:

(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

Q 10. Define absolute refractive index and express it mathematically. *(CBSE 2019)*

Ans. Refractive index of a transparent medium with respect to vacuum or air is called absolute refractive index.

Mathematically,

Absolute refractive index of a medium (μ)

$$= \frac{\text{Speed of light in vacuum or air } (c)}{\text{Speed of light in the medium } (v)}$$

Q 11. The absolute refractive index of Ruby is 1.7. Find the speed of light in Ruby. The speed of light in vacuum is 3×10^8 m/s. *(CBSE 2019)*

Sol. We know that,

$$\mu = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in Ruby}} = \frac{c}{v}$$

or $v = c/\mu$

where, c = velocity of light and μ = refractive index

$$v = \frac{3 \times 10^8}{1.7} = 1.76 \times 10^8 \text{ m/s}$$

Q 12. The refractive indices of three media are given below:

Medium	Refractive Index
A	1.6
B	1.8
C	1.5

A ray of light is travelling from A to B and another ray is travelling from B to C.

(i) In which of the two cases the refracted ray bends towards the normal?

(ii) In which case does the speed of light increase in the second medium?

Give reasons for your answer. *(CBSE SQP 2023-24)*

Ans.

TiP

In comparing two media, the one with the larger refractive index is optically denser medium than the other. The other medium of lower refractive index is optically rarer.

Out of media A and B,

A is optically rarer medium and

B is optically denser medium $(\because \mu_B > \mu_A)$

Similarly, out of media B and C,

B Is optically answer medium and

C is optically rarer medium $(\because \mu_B > \mu_C)$

(i) We know that a ray of light travelling from a rarer to denser medium bends towards the normal. Hence, ray of light travelling from A to B will bend towards the normal.

(ii) We know that when a ray of light travels from a denser medium to a rarer medium, it speeds up. Hence, the speed of light will increase when it travels from B to C.

Q 13. For the same angle of incidence in media A, B and C, the angles of refraction are 20°, 30° and 40° respectively. In which medium will the velocity of light be maximum? Give reason in support of your answer.

Ans. From Snell's law,

$$\mu = \frac{\sin i}{\sin r} = \frac{c}{v}$$

Since c and sin i are constant therefore

$$\sin r \propto v.$$

Therefore, velocity of light is maximum in medium C.

Q 14. An object is placed at a distance of 15 cm from a convex lens of focal length 20 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given convex lens are:

(I) Image is virtual

(ii) Image is erect

(iii) Image is enlarged

(iv) Image is formed on the same side of the lens as the object.

Q 15. An object is placed at a distance of 15 cm from a concave lens of focal length 30 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given concave lens are:

(I) Image is virtual

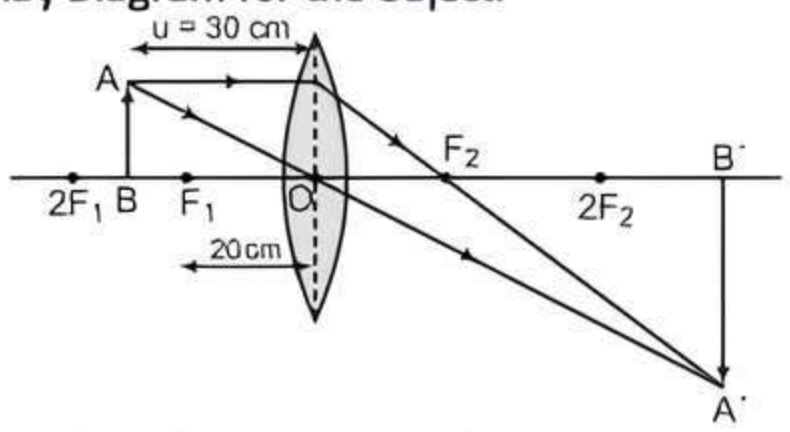
(ii) Image is erect

(iii) Image is diminished

(iv) Image is formed between focus F_1 and optical centre O, *i.e.*, on the same side of the lens as the object.

Q 16. An object of height 4.0 cm is placed at a distance of 30 cm from the optical centre 'O' of a convex lens of focal length 20 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical centre 'O' and principal focus 'F' on the diagram. Also find the ratio of size of the image to the size of the object. *(CBSE 2018)*

Ans. Ray Diagram for the Object:



Position of image: Beyond $2F_2$

Size of image: Enlarged

Given, $h_o = 4.0$ cm,

$u = -30$ cm

and $f = 20$ cm

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \left(\frac{1}{-30}\right) = \frac{1}{20}$$

$$\Rightarrow \quad \frac{1}{v} + \frac{1}{30} = \frac{1}{20}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$$

$$\Rightarrow \quad v = 60 \text{ cm}$$

Now, $$m = \frac{h_I}{h_o} = \frac{v}{u} = \frac{60}{-30}$$

$$\Rightarrow \quad h_I/h_o = -2/1$$

Q 17. The power of a lens is +5 diopters. What is the nature and focal length of this lens? At what distance from this lens should an object be placed so as to get its inverted image of the same size? *(CBSE 2019)*

Ans. Given, $P = +5$ D

We know that, $f = 100/P = 100/5 = +20$ cm

$+f$ indicates that the lens is convex (converging) in nature.

Object should be placed at a distance of 40 cm (at $2F_1$) from the given convex lens to obtain an inverted image of same size.

Short Answer Type-II Questions

Q 1. Define the following terms in the context of a diverging mirror:

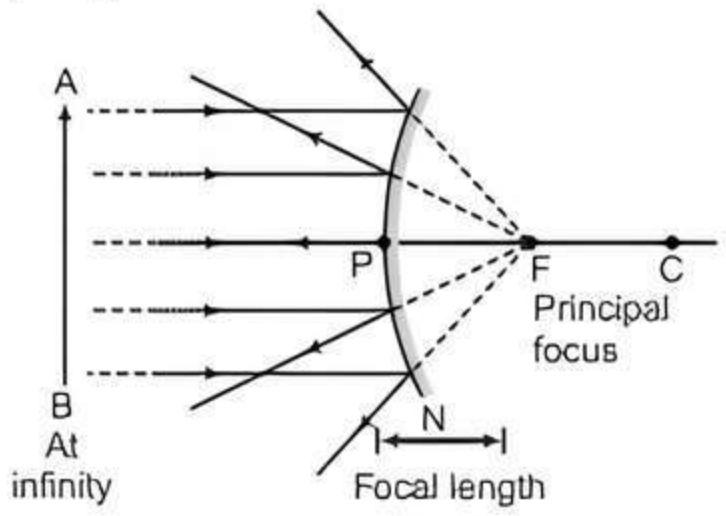
(i) Principal focus **(ii) Focal length**

Draw a labelled ray diagram to illustrate your answer. *(CBSE 2023)*

Ans. (I) The principal focus of a diverging (convex) mirror is a point on its principal axis from which a beam of light rays, initially parallel to the axis, appears to diverge after being reflected from the convex mirror.

(II) The distance between the pole and the principal focus of diverging mirror is called focal length of diverging (convex) mirror.

Ray Diagram:



Q 2. 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. Explain the construction of the magic mirror using different types of mirrors. Also state the reasons in support of your answer. *(CBSE 2020)*

Ans. The top part of the mirror is concave because it forms enlarged, erect and virtual image when the object is closer to the mirror.

The middle part is a plane mirror because it forms image of the same size.

The lower part is a convex mirror because it forms erect and diminished image.

TiP

Students should learn the image formation by plane, convex and concave mirrors.

Q 3. A student holding a mirror in his hand, directed the reflecting surface of the mirror towards the Sun. He then directed the reflected light on to a sheet of paper held close to the mirror.

(i) What should he do to burn the paper?

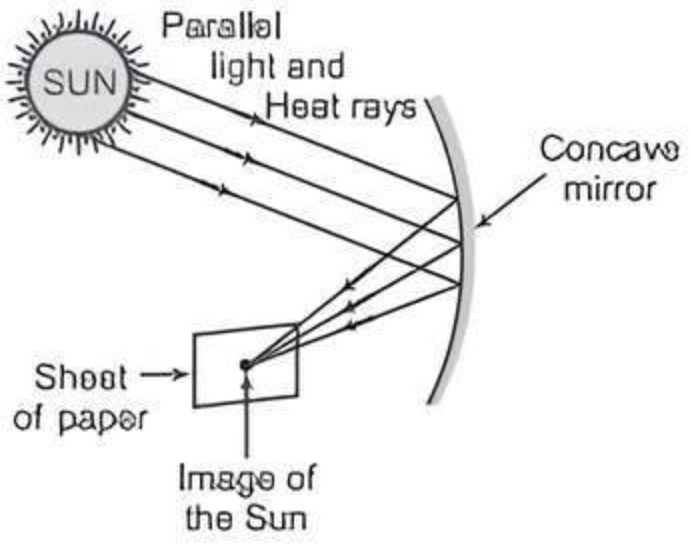
(ii) Which type of mirror does he have?

(iii) Will he be able to determine the approximate value of focal length of this mirror from this activity? Give reason and draw ray diagram to justify your answer in this case. *(CBSE 2019)*

Ans. (i) To burn the paper, student should move the mirror/sheet of paper to focus the rays at one point, *i.e.*, at the focus of the mirror.

(ii) Student is having a converging type of mirror that is a concave mirror.

(iii) Yes, he can measure the approximate value of focal length from this activity. The distance between mirror and focal point gives approximate focal length.



Q 4. Name the type of mirror which facilitates:

(i) Shaving,

(ii) Observing large images of the teeth of a patient, and

(iii) Observing the rear view in vehicles.

Give reason to justify your answer in each case. *(CBSE 2020)*

Ans. (i) Concave mirror facilitates shaving because when the face is held within the focus of concave mirror, then an erect and enlarged image of the face is seen in it.

(ii) Concave mirrors are used for observing large images of the teeth of a patient because they produce enlarged and erect images.

(iii) Convex mirrors are used as rear-view (wing) mirrors in vehicles because they have a wider field of view and give an erect image.

COMMON ERROR

Students get confused between the uses of concave and convex mirrors.

Q 5. Rohit wants to have an erect image of an object using a converging mirror of focal length 40 cm.

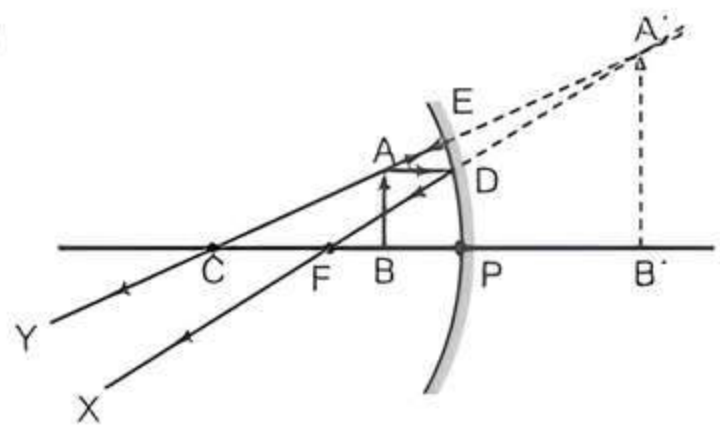
(i) Specify the range of distance where the object can be placed in front of the mirror. Justify.

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

(iii) State one use of the mirror based on the above kind of image formation. *(CBSE SQP 2022-23)*

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

(ii)



(iii) Used as shaving mirror or used by dentists to get enlarged image of teeth.

Q 6. The magnification produced when an object is placed at a distance of 20 cm from a spherical mirror is + 1/2. Where should the object be placed to reduce the magnification to + 1/3? *(CBSE 2023)*

Ans.

TiP

While solving numericals, it is advisable that the formula should be written in the beginning.

Given, $u = -20$ cm, $m = +\frac{1}{2}$, $m' = +\frac{1}{3}$

We know that, $m = \frac{-v}{u} \Rightarrow \frac{1}{2} = \frac{-v}{-20} \Rightarrow v = +10$ cm

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{10} + \frac{1}{(-20)}$

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

$\therefore \quad f = +20$ cm

Again, $m' = \frac{-v}{u} \Rightarrow \frac{+1}{3} = \frac{-v}{u} \Rightarrow v = -u/3$

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \quad \frac{1}{20} = \frac{1}{\left(\frac{-4}{3}\right)} + \frac{1}{u} = \frac{-3}{u} + \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{20} = \frac{-3+1}{u} = \frac{-2}{u}$$

$$\Rightarrow \quad u = 20 \times -2 \text{ or } u = -40 \text{ cm}$$

Thus, the object should be placed at a distance of 40 cm from the spherical mirror to reduce the magnification to + 1/3.

Q 7. A student has focussed the image of an object of height 3 cm on a white screen using a concave mirror of focal length 12 cm. If the distance of the object from the mirror is 18 cm, find the values of the following:

(i) Distance of the image from the mirror

(ii) Height of the image *(CBSE 2023)*

Ans. Given, $h_o = +3$ cm, $f = -12$ cm (concave mirror) and $u = -18$ cm

(i) Using mirror formula, $1/f = 1/v + 1/u$

$$\therefore \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-12)} - \frac{1}{(-18)}$$

$$= \frac{-1}{12} + \frac{1}{18} = \frac{-3+2}{36} = \frac{-1}{36}$$

$\therefore \quad v = -36$ cm

Therefore, distance of image from mirror is 36 cm.

(ii) We know that,

$$m = \frac{-v}{u} = \frac{h_1}{h_o}$$

$$\Rightarrow \quad h_1 = \frac{-v}{u} \times h_o = \frac{36}{-18} \times 3$$

$$= -6 \text{ cm}$$

Therefore, height of image is 6 cm.

Q 8. It is desired to obtain an erect image of an object, using concave mirror of focal length of 12 cm.

(i) What should be the range of the object distance in the above case?

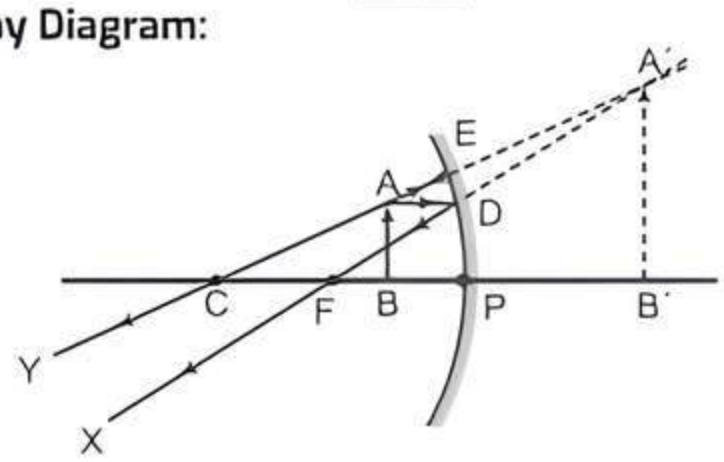
(ii) Will the image be smaller or larger than the object? Draw a ray diagram to show the formation of image in this case.

(iii) Where will the image of this object be, if it is placed 24 cm in front of the mirror?

Ans. (i) Range of object distance should be between 0 to 12 cm to obtain an erect image.

(ii) The image will be larger than the object.

Ray Diagram:



(iii) If the object is placed 24 cm in front of the mirror, *i.e.*, at C, then the image will be formed at the same position, *i.e.*, at C.

Q 9. A student wants to project the image of a candle flame on a screen 80 cm in front of a mirror by keeping the candle flame at a distance of 20 cm from its pole.

(i) Which type of mirror should the student use?

(ii) Find the magnification of the image produced.

(iii) Find the distance between the object and its image.

(iv) Draw a ray diagram to show the image formation in this case and mark the distance between the object and its image. *(CBSE 2015)*

Ans. Given that, $v = -80$ cm and $u = -20$ cm

(i) The student should use concave mirror because the image is real.

(ii) Magnification,

$$m = -\frac{v}{u} = -\frac{-80}{-20} = -4$$

(iii) Distance between the object and its image

$$= 80 - 20 = 60 \text{ cm}$$

Hence, the image is formed at a distance of 60 cm from the object.

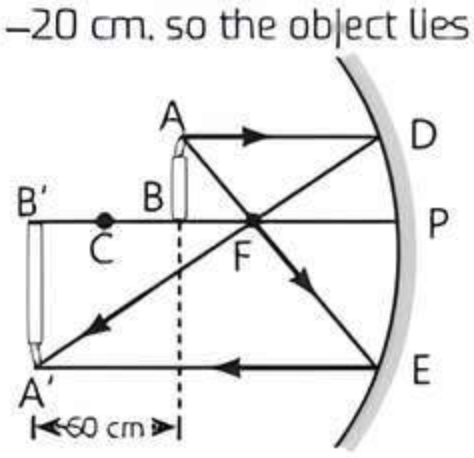
(iv) The focal length of the concave mirror can be calculated as follows:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-80} + \frac{1}{-20}$$

$$= -\frac{5}{80} = -\frac{1}{16}$$

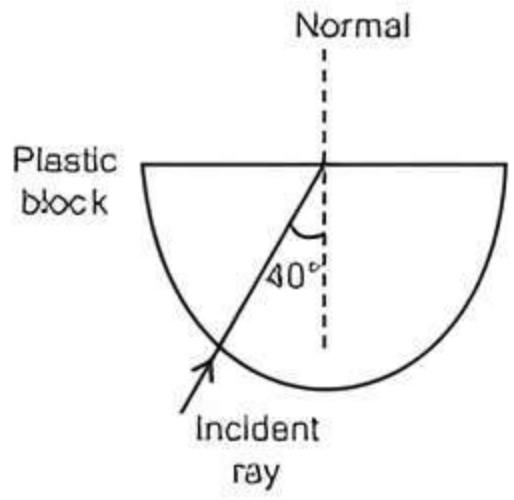
$\therefore \quad f = -16$ cm

Since, $u = -20$ cm, so the object lies between F and C.



Q 10. (i) Explain why the refractive index of any material with respect to air is always greater than 1.

(ii) In the given figure, a light ray travels from air into the semi-circular plastic block. Give a reason why the ray does not deviate at the semi-circular boundary of the plastic block.



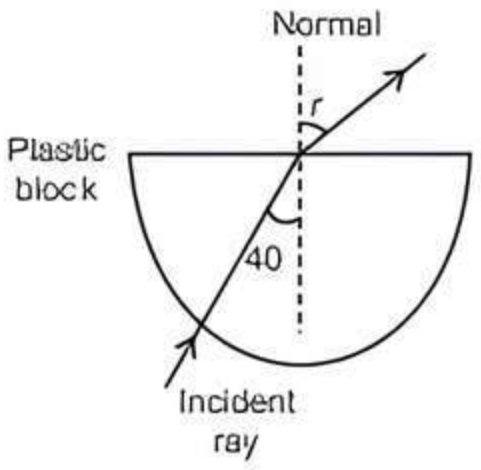
(iii) Complete the ray diagram of the above scenario when the light ray comes out of the plastic block from the top flat end. *(CBSE SQP 2023-24)*

Ans. (i) The refractive index of a medium with respect to air is given by $\frac{\text{speed of light in air}}{\text{speed of light in the medium}}$.

Since speed of light in the medium is always less than the speed of light in air, hence the above ratio is always greater than 1.

(ii) The ray of light is undergoing normal incidence at the air-plastic block interface. We know that if the incident ray falls normally, then there is no bending of the ray of light and it goes straight without any deviation.

(iii)



Q 11. (i) Water has refractive index 1.33 and alcohol has refractive index 1.36. Which of the two mediums is optically denser? Give reason for your answer.

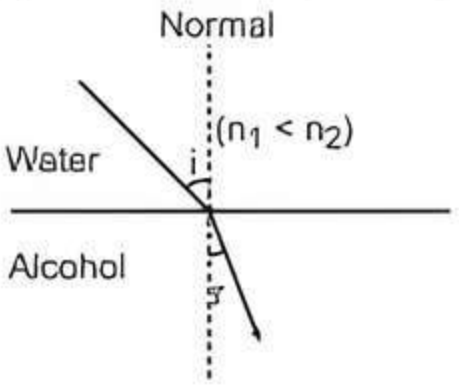
(ii) Draw a ray diagram to show the path of a ray of light passing obliquely from water to alcohol.

(iii) State the relationship between angle of incidence and angle of refraction in the above case. *(CBSE 2020)*

Ans. (i) Refractive index of alcohol is greater than refractive index of water. So, alcohol is optically denser than water.

(ii) When a ray of light enters from water to alcohol, it bends towards the normal.

(iii) Angle of incidence is greater than angle of refraction.



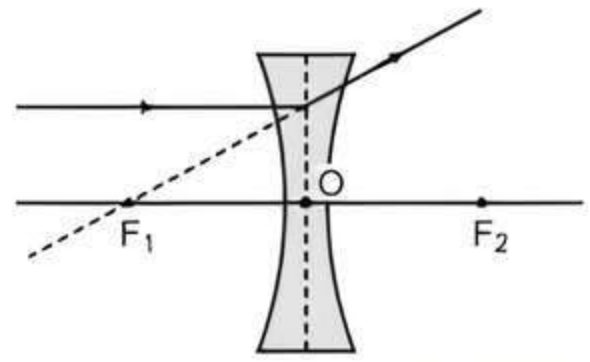
Q 12. What happens after refraction, when:

(i) a ray of light parallel to the principal axis passes through a concave lens?

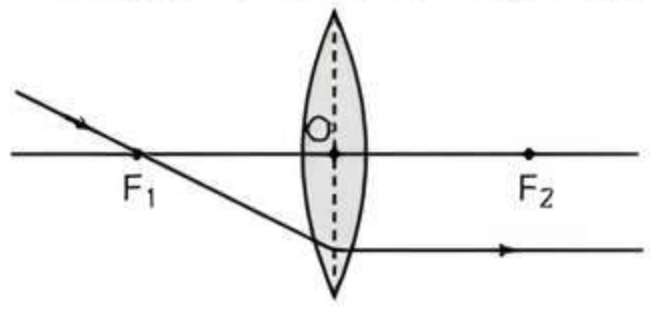
(ii) a ray of light falls on a convex lens while passing through its principal focus?

(iii) a ray of light passes through the optical centre of a convex lens ? *(CBSE 2020)*

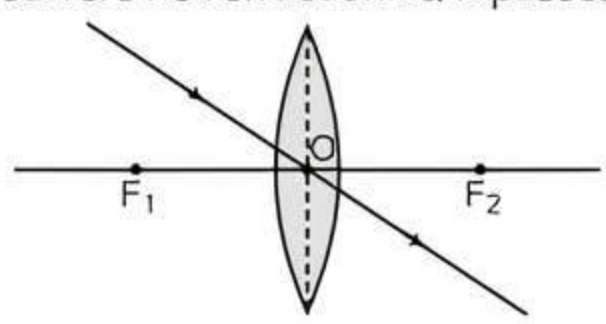
Ans. (i) It appears to be coming from focus after refraction through the lens.



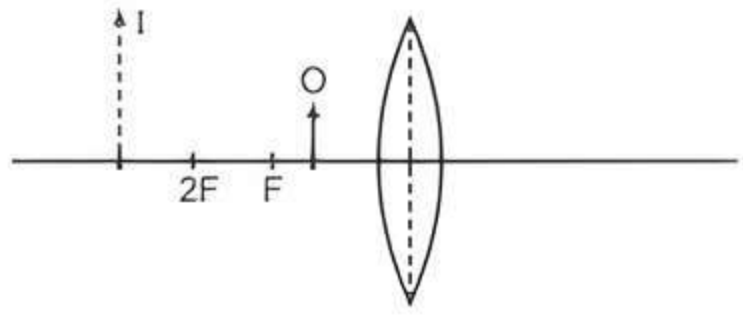
(ii) It will appear parallel to the principal axis.



(iii) It suffers no refraction *i.e.* it passes undeviated.



Q 13. The diagram given below shows an object *O* and its image *I*.



Without actually drawing the ray diagram, state the following:

(i) Type of lens (converging / diverging)

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

(iii) List three characteristics of the image formed if this lens is replaced by a concave mirror of focal length '*f*' and an object is placed at a distance '*f*/2' in front of the mirror. *(CBSE 2020)*

Ans.

TiP

Image formed by a concave (diverging) lens is always virtual and diminished in size. So, the given lens can't be diverging in nature as the given image is virtual but enlarged.

(i) Converging lens

(ii) In microscope and telescope

(iii) Three characteristics of the image formed by a concave mirror:

(a) Virtual and erect image

(b) Enlarged image

(c) Image will be formed behind the mirror

COMMON ERROR

Students get confused between converging and diverging lens.

Q 14. **"A lens can form a magnified erect image as well as magnified inverted image of an object placed in front of it." State the nature of this lens and draw ray diagrams to justify the above statement. Mark the positions of O, F and 2F in the diagram.**

(CBSE 2017)

Or

Draw ray diagrams to show the formation of three times magnified (a) real, and (b) virtual image of an object by a converging lens. Mark the positions of O, F and 2F in each diagram. *(CBSE 2017)*

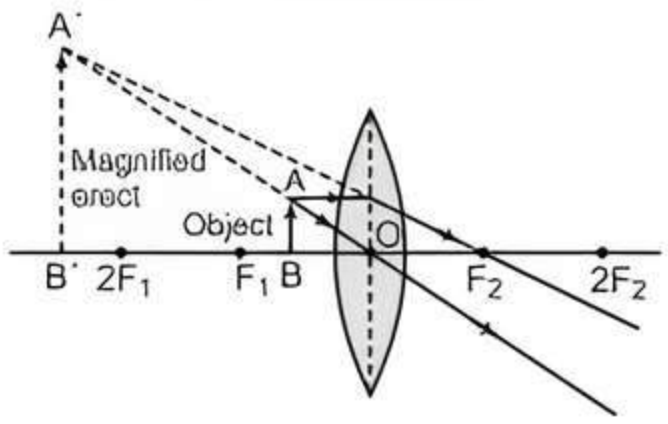
Ans.

TiP

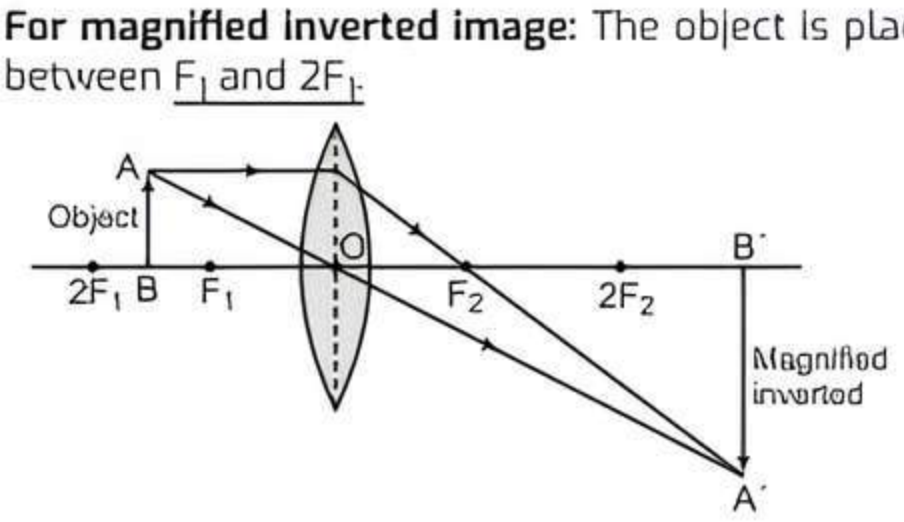
Practice drawing the ray diagrams carefully with proper labellings. Make sure that the arrows are properly marked.

The lens is convex in nature.

For magnified erect image: The object is placed between F_1 and optical centre O.



For magnified inverted image: The object is placed between F_1 and $2F_1$.



Q 15. **The magnification of an image formed by a lens is −1. If the distance of the image from the optical centre of the lens is 25 cm, where is the object placed? Find the nature and focal length of the lens. If the object is displaced 15 cm towards the optical centre of the lens, where would the image be formed? Draw a ray diagram to justify your answer.** *(CBSE 2017)*

Sol. Given, magnification $(m) = -1$

and $v = +25$ cm (real image as m is negative)

Also, $m = \frac{v}{u}$

$\Rightarrow \quad -1 = \frac{25}{u} \Rightarrow u = -25$ cm

Using lens formula,

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

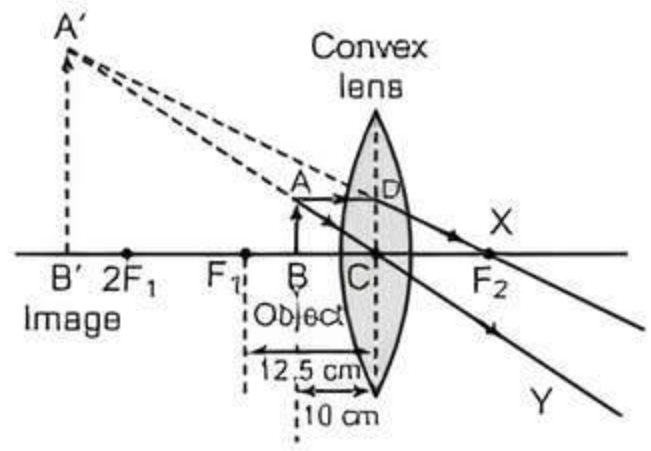
$$= \frac{1}{25} - \left(\frac{1}{-25}\right) = \frac{1+1}{25}$$

$$= \frac{25}{2} = 12.5 \text{ cm}$$

The given lens is a convex lens as its focal length is positive.

On moving the object to a distance of 15 cm towards the lens, the object distance becomes 10 cm (25 − 15) from the optical centre of the lens, *i.e.*, object is now placed between optical centre and focus of the lens. The image formed is virtual and on the same side of the lens as object.

Ray Diagram:



Q 16. **(i) A lens of focal length 5 cm is being used by Debashree in the laboratory as a magnifying glass. Her least distance of distinct vision is 25 cm.**

(a) What is the magnification obtained by using the glass?

(b) She keeps a book at a distance 10 cm from her eyes and tries to read. She is unable to read. What is the reason for this?

(ii) Ravi kept a book at a distance of 10 cm from the eyes of his friend Hari. Hari is not able to read anything written in the book. Give reason for this. *(CBSE SQP 2022-23)*

Sol. (i) (a) Given, image distance $v = -25$ cm, focal length, $f = 5$ cm, magnification $m = ?$

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

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

$\Rightarrow$ $$\frac{1}{u} = \frac{1}{-25} - \frac{1}{5} = \frac{-1-5}{25} = \frac{-6}{25}$$

or object distance $u = \frac{-25}{6}$ cm

COMMON ERROR

Sometimes students forget to write 'unit' in answer that leads to deduction in marks.

We know that, $m = \frac{v}{u} = \frac{-25 \times 6}{-25} = 6.$

(b) This is because her least distance of distinct vision is 25 cm.

(ii) This is because the least distance of distinct vision is 25 cm.

Q 17. An object of height 10 cm is placed 25 cm away from the optical centre of a converging lens of focal length 15 cm. Calculate the image-distance and height of the image formed. *(CBSE 2023)*

Sol.

TiP

Students should learn the correct sign convention and lens formula.

Given, $h_o = 10$ cm, $f = +15$ cm (convex lens).
$u = -25$ cm

Using lens formula,

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

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \left(\frac{1}{-25}\right)$$

$$= \frac{5-3}{75} = \frac{2}{75}$$

$$\Rightarrow \quad v = \frac{75}{2} = 37.5 \text{ cm}$$

Therefore, image is formed at a distance of 37.5 cm from the lens.
We know that

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

$$\Rightarrow \quad \frac{37.5}{-25} = \frac{h_I}{10}$$

$$\Rightarrow \quad h_I = \frac{375}{25} = 15$$

Therefore, height of image formed is 15 cm.

Q 18. Rohit 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 lens as under:
Position of candle = 26.0 cm
Position of convex lens = 50.0 cm
Position of screen = 74.0 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 38 cm?
(iii) Draw a ray diagram to show the formation of the image in case (ii) as said above.

Sol. (i) $u = 50 - 26 = 24$ cm.

$v = 74 - 50 = 24$ cm

Since, $u = v$, this means that the object is placed at $2F_1$

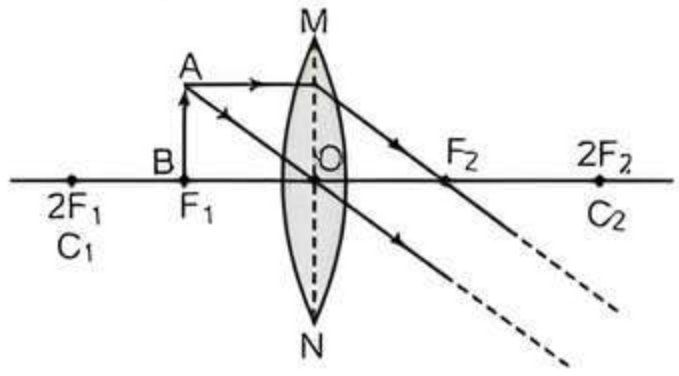
$$\Rightarrow \quad 2f = 24 \text{ cm}$$

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

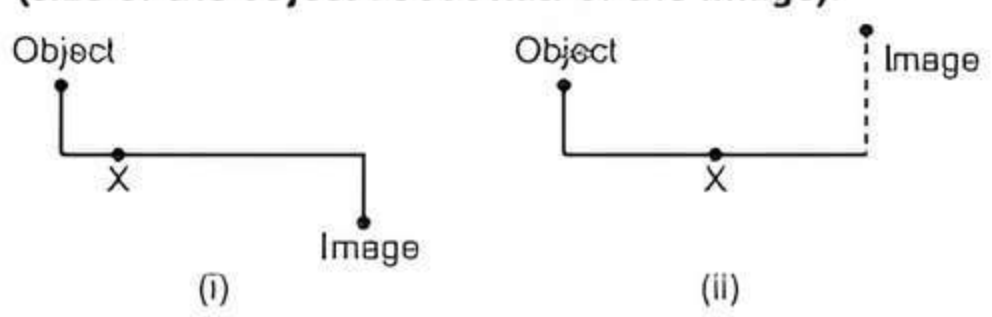
(ii) $u = 50 - 38 = 12$ cm

This implies that the object (candle) is placed at F_1, which means that the image is formed at infinity.

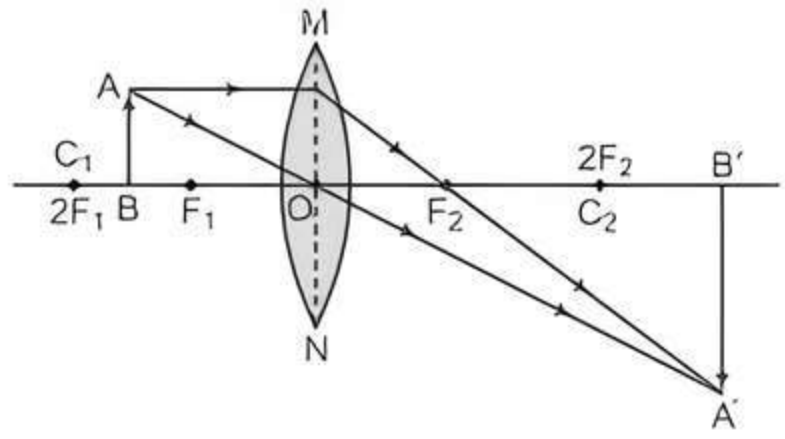
(iii) Ray diagram:



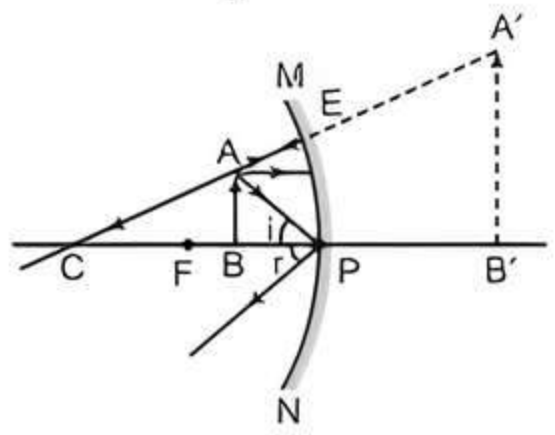
Q 19. The nature, size and position of image of an object produced by a lens or mirror are as shown below. Identify the lens/mirror (*X*) used in each case and draw the corresponding complete ray diagram, (size of the object about half of the image).



Ans. (i) Convex lens is used in this case. When object is placed between F_1 and $2F_1$, its magnified, real and inverted image is formed.



(ii) Concave mirror is used in this case. When object is placed between P and F, its enlarged, erected and virtual image is formed.



Q 20. Define power of a lens. The focal length of a lens is – 10 cm. Write the nature of the lens and find its power. If an object is placed at a distance of 20 cm from the optical centre of this lens, according to the New Cartesian Sign Convention, what will be the sign of magnification in this case? *(CBSE 2023)*

Ans. The ability of a lens to converge or diverge light rays after refraction, is known as power of the lens.

The lens is concave in nature because power of a concave lens is negative.

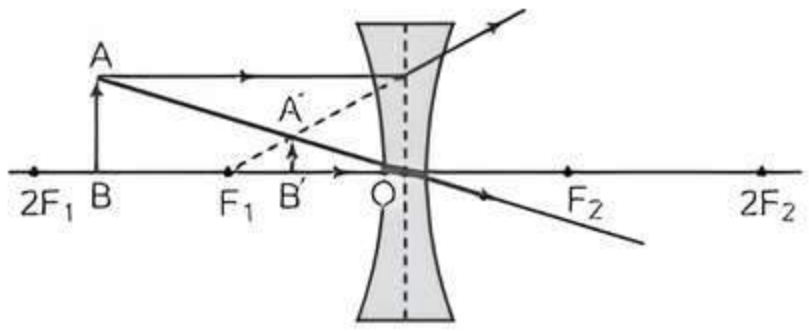
$$\text{Power} = \frac{100}{f} = \frac{100}{-10} = -10\,\text{D}$$

A concave lens forms virtual images for all positions of the object, so magnification produced by a concave lens is always positive.

Q 21. 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? *(CBSE 2017)*

Ans. A concave lens always gives an erect and diminished image irrespective of the position of the object.

Ray Diagram:



Given. $P = -10$ D (power of concave lens is negative)

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

$$\Rightarrow \quad f = \frac{1}{P} = \frac{1}{-10} = -0.1 \text{ m}$$

$\therefore$ Focal length $= -0.1$ m or -10 cm

COMMON ERROR

Generally, students get confused between sign convention for concave and convex lens.

Q 22. The power of a lens is + 4D. Find the focal length of this lens. An object is placed at a distance of 50 cm from the optical centre of this lens. State the nature and magnification of the image formed by the lens and also draw a ray diagram to justify your answer.

Sol. We know that $P = \frac{100}{f \text{ (in cm)}}$

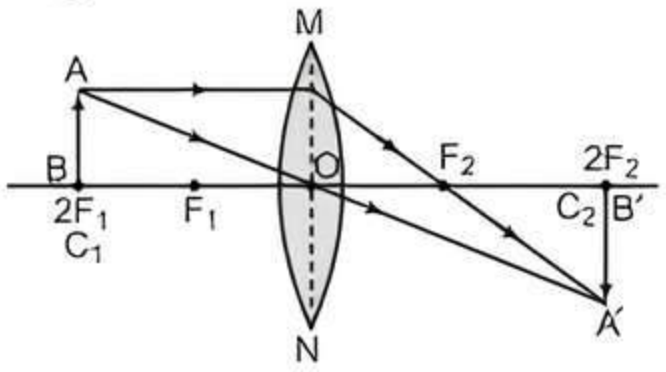
$$\therefore \quad f = \frac{100}{P} = \frac{100}{+4} = +25 \text{ cm (convex lens)}$$

Given. $u = -50$ cm. *i.e.*, object is placed at $2F_1$.

Nature of image : Real, Inverted and of same size.

Magnification: -1.

Ray Diagram:



Long Answer Type Questions

Q 1. (i) List four characteristics of the images formed by plane mirrors.

(ii) A 5 cm tall object is placed at a distance of 20 cm from a concave mirror of focal length 30 cm. Use mirror formula to determine the position and size of the image formed. *(CBSE 2019)*

Ans. (i) Characteristics of image formed by plane mirrors are:

(a) virtual and erect.

(b) laterally inverted.

(c) of the same size as the object.

(d) as far behind the mirror as the object is in front of it.

(ii) Given that.

$h = 5$ cm. $\quad u = -20$ cm. $\quad f = -30$ cm.

Using mirror formula,

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

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

$$\frac{1}{v} = \frac{1}{-30} - \frac{1}{-20}$$

$$= \frac{-1}{30} + \frac{1}{20} = \frac{-2+3}{60}$$

$v = 60$ cm

We know that.

$$\frac{h'}{h} = \frac{-v}{u} = -60/-20$$

$h' = 3 \times h = 3 \times 5$

$h' = 15$ cm

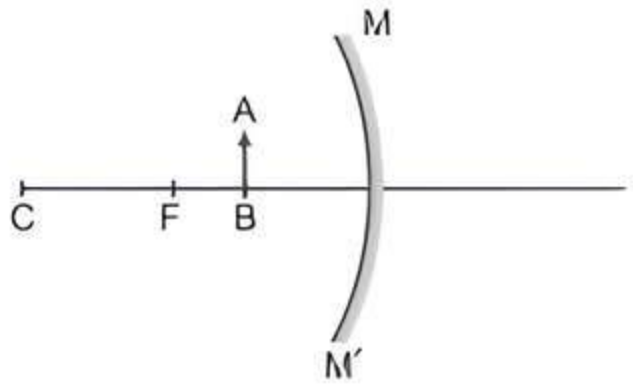
Q 2. (i) Define the following terms in the context of spherical mirrors:

(a) Pole **(b) Centre of curvature**

(c) Radius of curvature **(d) Principal axis**

(ii) Draw ray diagram to show the principal focus of: (a) a concave mirror, and (b) a convex mirror.

(iii) In the following diagram, MM′ is a concave mirror and AB is an object. Draw on your answer sheet a ray diagram to show the formation of image of this object. *(CBSE 2017)*



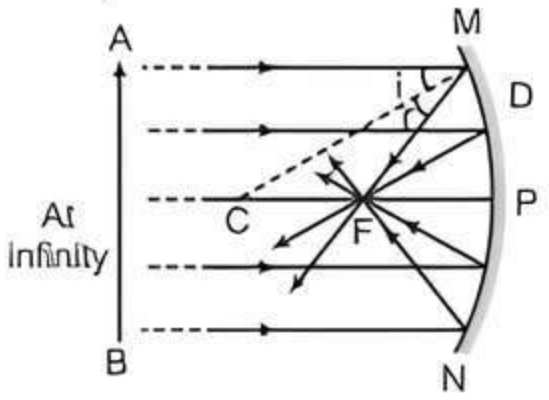
Ans. (i) **(a) Pole:** The centre of the reflecting surface of a spherical mirror is a point called the pole.

(b) Centre of Curvature: It is the centre of the sphere of which mirror forms a part.

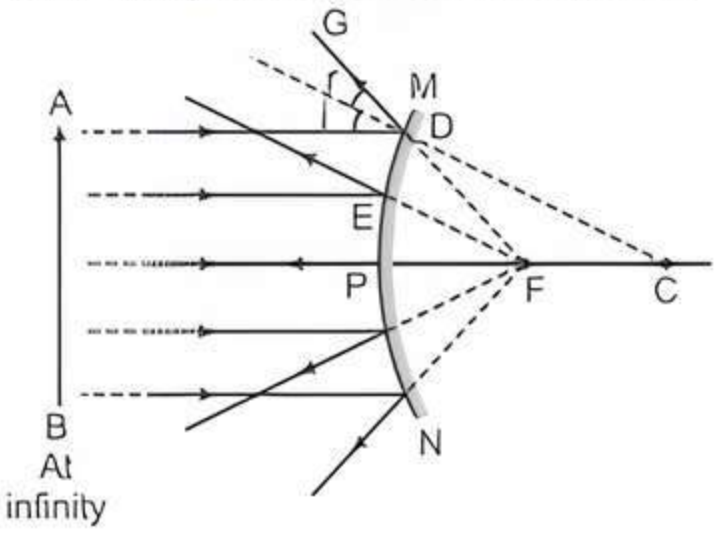
(c) Radius of Curvature: It is the radius of the sphere of which the reflecting surface of a spherical mirror forms a part.

(d) Principal Axis: It is an imaginary straight line passing through the pole and centre of curvature of a spherical mirror.

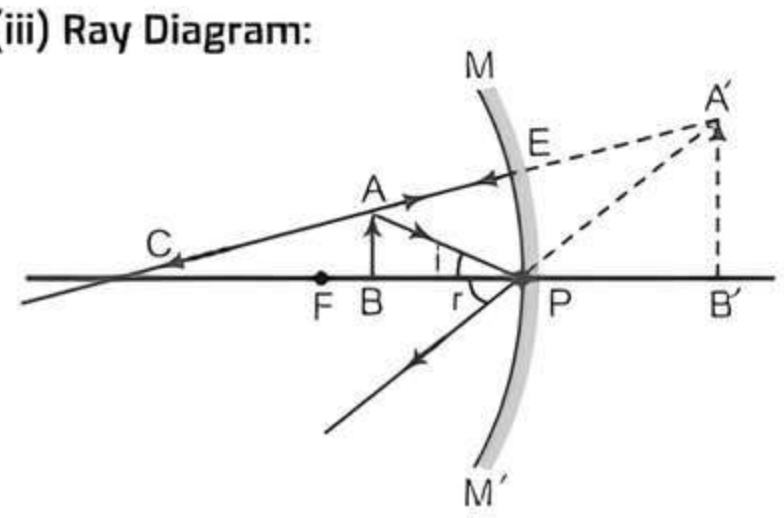
(ii) (a) Principal focus of concave mirror:



(b) Principal focus of convex mirror:



(iii) Ray Diagram:



Q 3. A 10 cm long pencil is placed 5 cm in front of a concave mirror having a radius of curvature of 40 cm.

(i) Determine the position of the image formed by this mirror.

(ii) What is the size of the image?

(iii) Draw a ray diagram to show the formation of the image as mentioned in the part (i).

(CBSE SQP 2023-24)

Sol. (i) Given, $h_o = +10$ cm, $u = -5$ cm, $R = 40$ cm

$$f = \frac{-40}{2} \text{ cm (concave mirror)} = -20 \text{ cm}$$

Using mirror formula,

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

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-20)} - \frac{1}{(-5)}$$

$$= \frac{-1}{20} + \frac{1}{5} = \frac{-1+4}{20} = \frac{3}{20}$$

$$\Rightarrow \quad v = \frac{20}{3} = 6.67 \text{ cm}$$

The image is formed 6.67 cm behind the mirror.

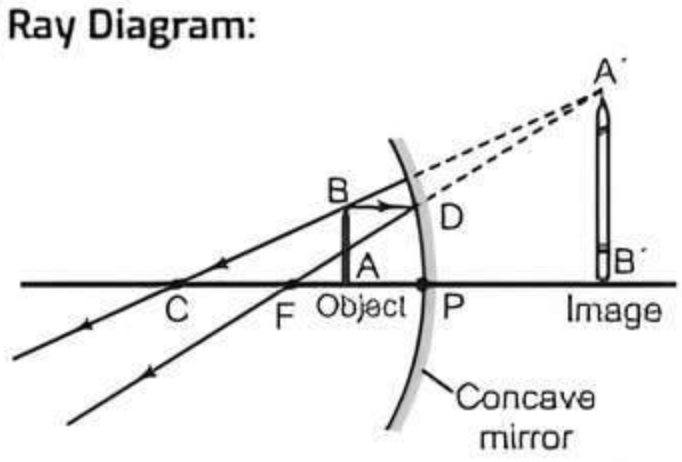
(ii) We know that, $m = \frac{-v}{u} = \frac{h_i}{h_o}$

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

$$= \frac{-6.67}{-5} \times 10$$

$$= 13.34 \text{ cm}$$

(iii) Ray Diagram:



Q 4. Suppose you have three concave mirrors, A, B and C of focal lengths 10 cm, 15 cm and 20 cm. For each concave mirror, you perform the experiment of image formation for three values of object distances of 10 cm, 20 cm and 30 cm. Giving reason, answer the following:

(i) For the three object distances, identify the mirror/mirrors which will form an image of magnification –1.

(ii) Out of the three mirrors, identify the mirror which would be preferred to be used for shaving purposes/make up.

(iii) For the mirror B, draw ray diagram for image formation for object distances 10 cm and 20 cm.

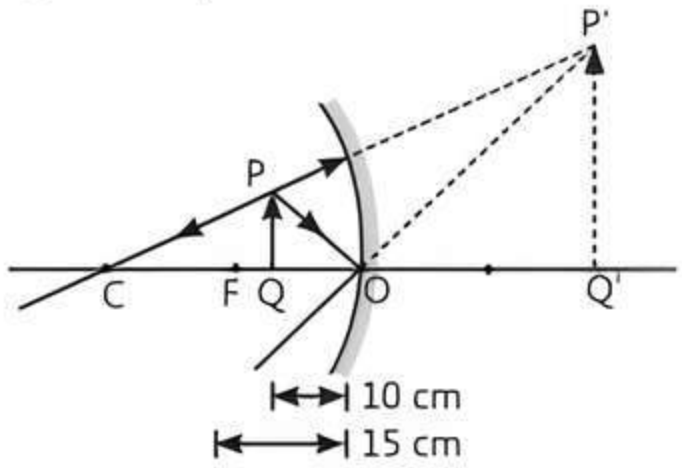
(CBSE 2016)

Ans. (i) A real, inverted and same size image of the object is formed by the concave mirror of magnification –1. It is possible when the object is placed at C (R = 2f). Therefore, for the object distances of 20 cm and 30 cm, the concave mirrors 'A' and 'B' will produce the real, inverted and same size image of the object. So, the concave mirrors 'A' and 'B' will form an image of magnification –1.

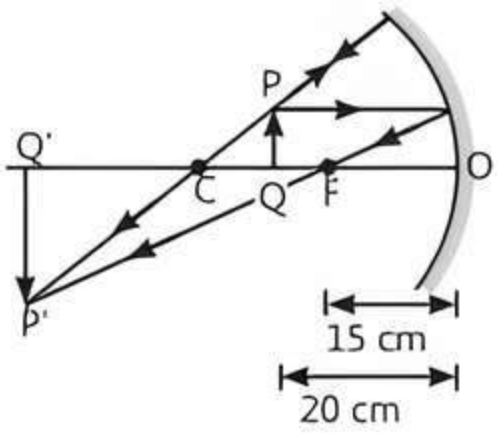
(ii) The concave mirror 'C' of focal length 20 cm must be preferably used for shaving purposes. The reason is, when we bring our face within its focal length, it forms a virtual, erect and enlarged image of our face.

(iii) Ray diagram for image formation by mirror B:

(a) For object distance 10 cm.



(b) For object distance 20 cm.



Q 5. (i) A security mirror used in a big showroom has radius of curvature 5 m. If a customer is standing at a distance of 20 m from the cash counter, find the position, nature and size of the image formed in the security mirror.

(ii) Neha visited a dentist in his clinic. She observed that the dentist was holding an instrument fitted with a mirror. State the nature of this mirror and reason for its use in the instrument used by dentist.

Ans.

TiP

The given mirror is convex because convex mirrors are used as security mirrors in big showrooms.

(i) $R = 5$ m

$f = \frac{+5}{2}$m (Convex mirror) $u = -20$ m

According to mirror formula.

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

$$\frac{1}{v} + \frac{1}{-20} = \frac{1}{5/2}$$

$$\frac{1}{v} - \frac{1}{20} = \frac{2}{5}$$

$$\frac{1}{v} = \frac{2}{5} + \frac{1}{20} = \frac{8+1}{20} = \frac{9}{20}$$

$$v = \frac{20}{9} = 2.2\text{m}$$

Let h_1 be x

$$m = \frac{-v}{u} = \frac{h_2}{x}$$

$$\Rightarrow \quad \frac{-20}{9x - 20} = \frac{h_2}{x}$$

$$\frac{1}{9} = \frac{h_2}{x}$$

$$h_2 = \frac{x}{9}$$

Virtual and erect image is formed.

Size: Image would be $\frac{1}{9}$th of the original size of the customer *i.e.*, diminished image.

(ii) This mirror will be concave mirror because it forms virtual, erect and enlarged image of the object (when object is placed between pole and focus of this mirror). It helps the doctor to see an enlarged image of tooth.

Q 6. (i) 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.

(ii) 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 (a) $n_1 > n_2$ (b) $n_1 = n_2$ (c) $n_1 < n_2$.

Ans. (i) We know that,

Refractive index of a medium (μ) = Velocity of light in vacuum / Velocity of light in the medium.

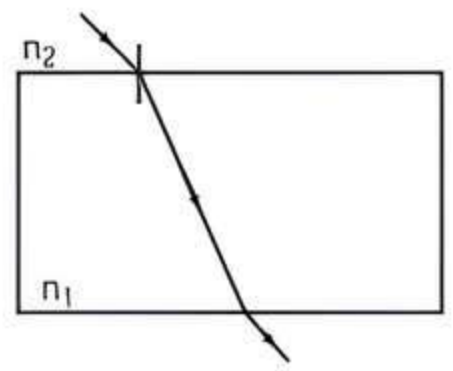
Let the velocity of light in vacuum be v_1 and velocity of light in the medium be v_2.

Hence, $\mu = v_1/v_2$

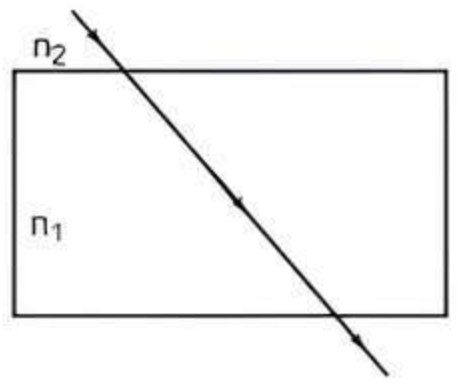
$= v_1/(v_1/2)$ [Given that, $v_2 = v_1/2$]

$= 2$

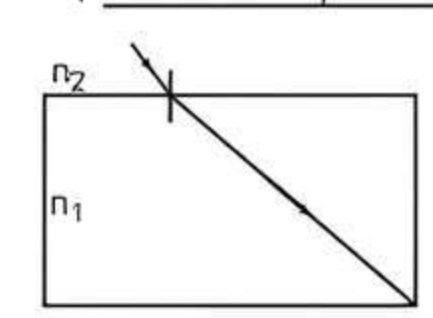
(ii) (a) The ray moves towards the normal.



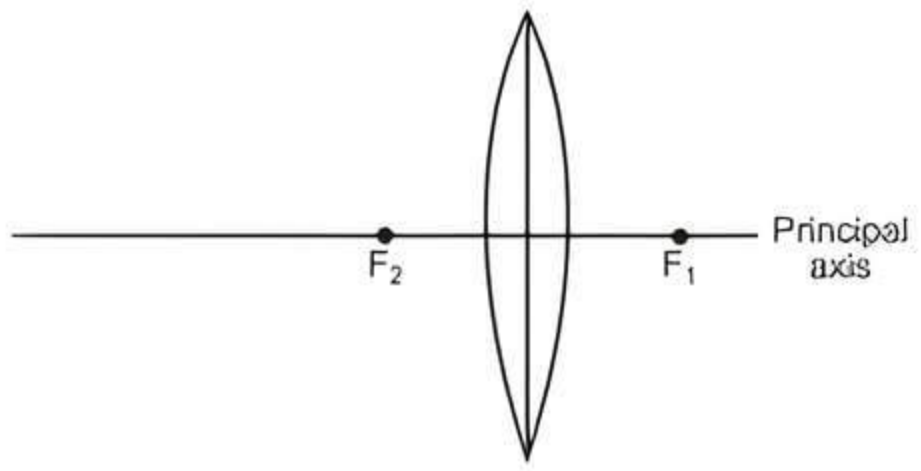
(b) The ray moves undeviated.



(c) The ray moves away from the normal.



Q 7.



The above image shows a thin lens of focal length 5 m.

(i) What is the kind of lens shown in the above figure?

(ii) If a real inverted image is to be formed by this lens at a distance of 7 m from the pole, then show with calculation where should the object be placed?

(iii) Draw a neatly labelled diagram of the image formation mentioned in (ii). *(CBSE SQP 2023-24)*

Ans. (i) Convex lens

(ii) Given, $f = +5$ m (convex lens)

$v = +7$ m (real image)

Using lens formula,

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

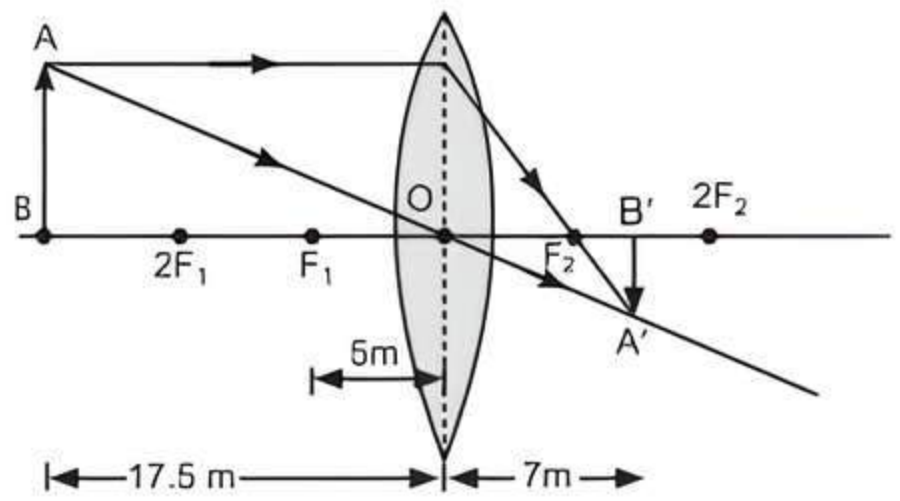
$$\Rightarrow \quad \frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{1}{7}-\frac{1}{5}$$

$$=\frac{5-7}{35}=\frac{-2}{35}$$

$$\Rightarrow \quad u=\frac{-35}{2}=-17.5 \text{ cm}$$

Thus, the object should be placed at a distance of 17.5 m in front of the convex lens. The minus sign shows that the object is on the left side of the lens.

(iii) **Ray Diagram:**



Q 8. Rishi went to a palmist to show his plan. The palmist used a special lens for this purpose.

(i) State the nature of the lens and reason for its use.

(ii) Where should the palmist place/hold the lens so as to have a real and magnified image of an object?

(iii) If the focal length of this lens is 10 cm and the lens is held at a distance of 5 cm from the palm, use lens formula to find the position and size of the image. *(CBSE 2020)*

Ans. (i) The lens is convex because it forms virtual, erect and magnified image of his palm.

(ii) Real and magnified image is obtained when the object is placed between f and $2f$ of the lens.

(iii) Given : $f = +10$ cm

$u = -5$ m

$v = ?$

According to lens formula,

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

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

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

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

$$\frac{1}{v}=\frac{1-2}{10}=\frac{-1}{10}$$

$$v = -10 \text{ cm}$$

Image will be formed at a distance of 10 cm on the left hand side of lens.

$$m=\frac{h_2}{h_1}=\frac{v}{u}$$

Let h_1 be x.

$$\therefore \quad \frac{h_2}{x}=\frac{-10}{-5}$$

$$h_2 = 2x$$

So, the size of the image will be twice of the object.

Q 9. 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

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

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

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

Ans. (i) From S.No. 3, we can say that the radius of curvature of the lens is 40 cm because when the object is placed at centre of curvature of a convex lens, its image is formed on the other side of the lens at the same distance from the lens.

$$\therefore \quad R = 40 \text{ cm}$$

$$\Rightarrow \quad f=\frac{R}{2}=\frac{40}{2}=20 \text{ cm}$$

(ii) S.No. 6 is not correct as the object is between focus and optical centre.

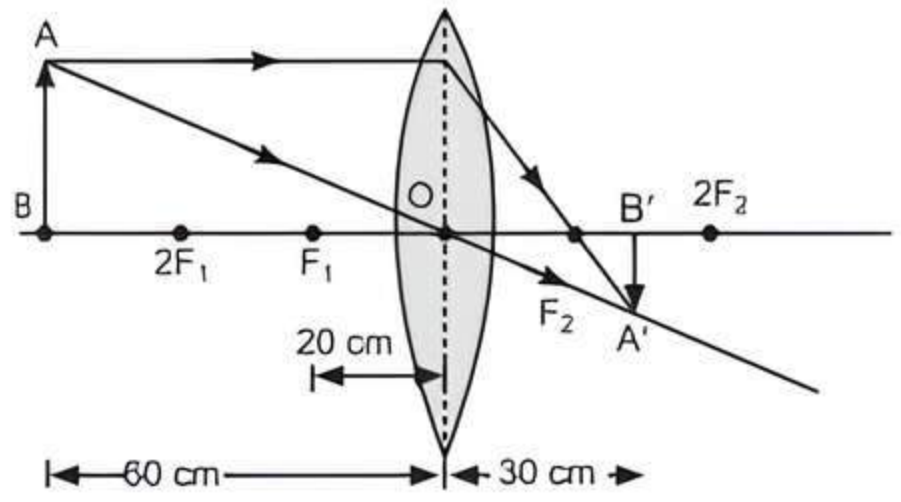
Thus, image formed will be on the same side of the lens as the object, *i.e.*, 'v' must be negative.

But in S.No. 6, v is positive so S.No.6 is incorrect.

TiP

Be clear with concepts of nature, position and size of the image formed by a convex lens. Also, practice image formation in lenses using ray diagrams.

(iii) **Ray Diagram for S.No. 2:**



Magnification, $m = \frac{v}{u} = \frac{+30}{-60} = -0.5$

COMMON ERROR

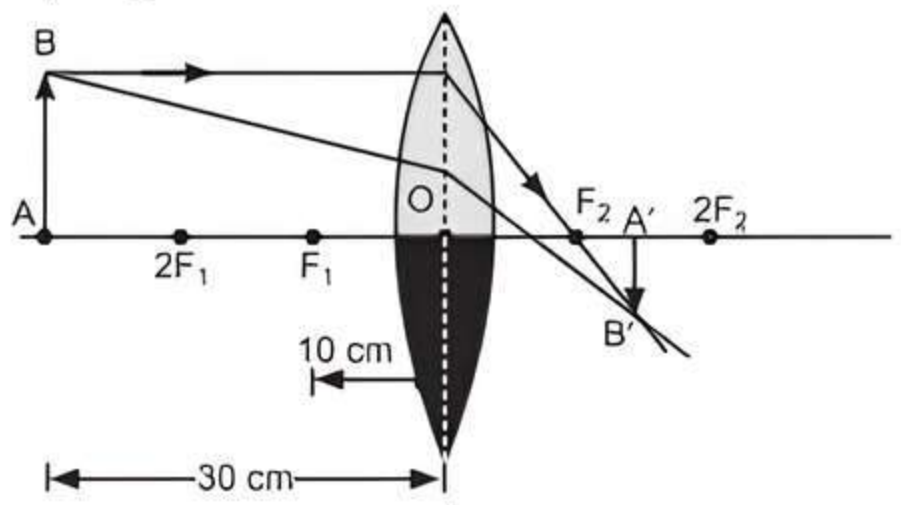
Generally students forget to find the value of magnification in this question.

Q 10. One-half of a convex lens of focal length 10 cm is covered with a black paper. Can such a lens produce an image of a complete object placed at a distance of 30 cm from the lens? Draw a ray diagram to justify your answer.

A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. *(CBSE 2015)*

Ans. Yes, a complete image of an object will be produced with less intensity. This is because the light falling on the covered portion will not reach the image position.

Ray Diagram:



Given, for a convex lens, $h_o = +4$ cm.

$f = +20$ cm.

$u = -15$ cm

By using lens formula,

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

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

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{20} - \frac{1}{15} = \frac{3-4}{60} = -\frac{1}{60}$$

$$\Rightarrow \quad v = -60 \text{ cm}$$

Hence, the image is formed on the same side of the object at a distance of 60 cm from the optical centre of the lens. The negative sign indicates that image is virtual.

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

$$\Rightarrow \quad h_i = \frac{v}{u} \times h_o = \frac{-60}{-15} \times 4 = +16 \text{ cm}$$

Hence, the image is four times larger than the size of the object, *i.e.*, 16 cm. The positive sign indicates that image is erect.

Q 11. (i) Define optical centre of a spherical lens.

(ii) A divergent lens has a focal length of 20 cm. At what distance should an object of height 4 cm from the optical centre of the lens be placed so that its image is formed 10 cm away from the lens. Find the size of the image also.

(iii) Draw a ray diagram to show the formation of image in above situation. *(CBSE 2016)*

Ans. (i) **Optical Centre:** It is the central point 'O' on the principal axis of the lens, through which an incident ray of light passes (refracted) without suffering any deviation.

(ii) Given, $f = -20$ cm, $h_o = 4$ cm, $v = -10$ cm

By using lens formula,

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

$$\Rightarrow \quad \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{-10} - \frac{1}{-20}$$

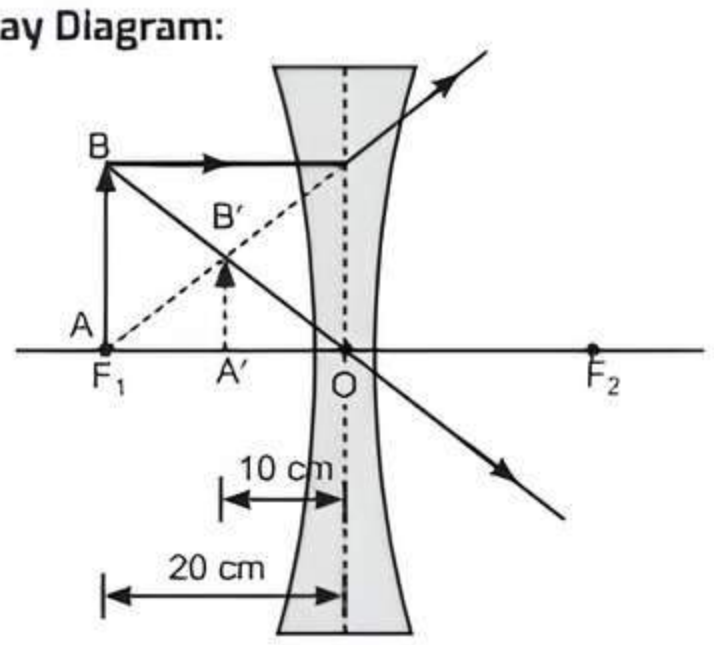
$$\Rightarrow \quad u = -20 \text{ cm}$$

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

$$\Rightarrow \quad h_i = \frac{v}{u} \times h_o = \frac{-10}{-20} \times 4 = +2$$

Hence, a diminished virtual image is formed and its size is 2 cm.

(iii) **Ray Diagram:**



Q 12. An object is placed at a distance of 30 cm from a concave lens of focal length 30 cm.

(i) Use lens formula to determine the distance of the image from the lens.

(ii) List four characteristics of the image (nature, position, size, erect/inverted) in this case.

(iii) Draw a labelled diagram to justify your answer of part (ii). *(CBSE 2019)*

Sol. (I) Given: $u = -30$ cm, $f = -30$ cm

Using lens formula. $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

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

$= \frac{1}{(-30)} + \frac{1}{(-30)} = \frac{-1-1}{30}$

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

$v = -15$ cm

Now, $m = \frac{v}{u}$

$\Rightarrow$ $m = \frac{-15\text{ cm}}{-30\text{ cm}} = +\frac{1}{2}$

(II) Characteristics of the image:

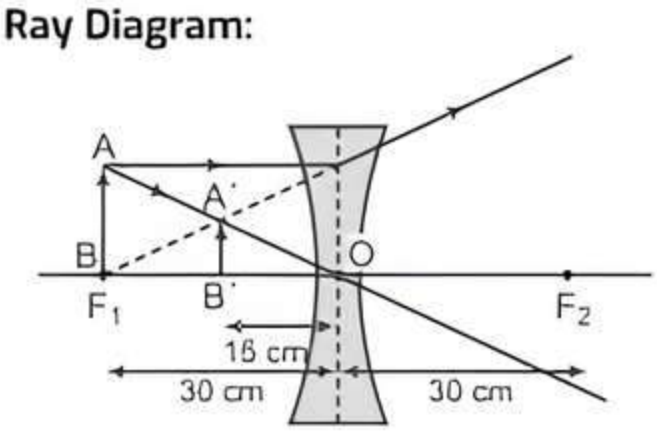
(a) Nature: Virtual

(b) Position: 15 cm from the lens on the same side as the object.

(c) Size of the image: Diminished

(d) Image formed: Erect

(iii) Ray Diagram:



Chapter Test

Multiple Choice Questions

Q 1. An object is placed 20 cm in front of a plane mirror. The mirror is moved 2 cm towards the object. The distance between the positions of the original and final images seen in the mirror is:

a. 2 cm b. 4 cm c. 10 cm d. 22 cm

Q 2. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be:

a. only plane b. only concave

c. only convex d. either plane or convex

Q 3. 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? *(NCERT EXEMPLAR)*

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

Q 4. The angle of incidence for a ray of light having zero reflection angle is:

a. 0° b. 30° c. 45° d. 90°

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): A convex mirror is used as a driver's mirror.

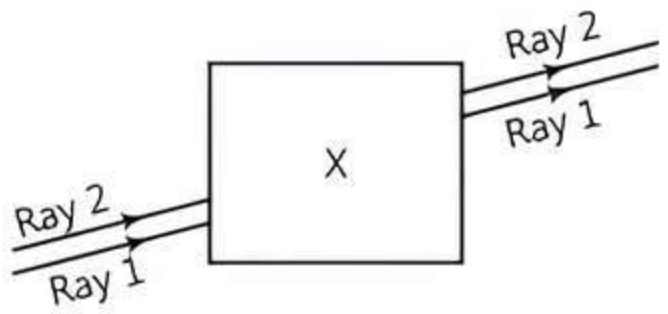
Reason (R): Because convex mirror's field of view is large and images formed are virtual, erect and diminished.

Q 6. Assertion (A): Property of converging a convergent lens does not remain same in all media.

Reason (R): Property of lens whether the ray is diverging or converging is independent of the surrounding medium.

Case Study Based Question

Q 7. Noor, a young student, was trying to demonstrate some properties of light in her science project work. She kept 'X' inside the box (as shown in the figure) and with the help of a laser pointer made light rays pass through the holes on one side of the box. She had a small butter-paper screen to see the spots of light being cast as they emerged.



Read the above passage carefully and give the answer of the following questions:

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

a. a converging lens

b. a parallel-sided glass block

c. a plane mirror

d. a triangular prism

(ii) She measured the angles of incidence for both the 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?
(Use the value sin 48.6° ≈ 0.75)

a. 45° b. 40° c. 30° d. 60°

(iii) Her friend noted the following observations from this demonstration:

I. Glass is optically rarer than air.

II. Air and glass allow light to pass through them with the same velocity.

III. Air is optically rarer than glass.

IV. Speed of light through a denser medium is faster than that of a rarer medium.

V. The ratio: sin of angle of incidence in the first medium to the ratio of sin of angle of refraction in the second medium, gives the refractive index of the second material with respect to the first one.

Which one of the combination of the above statements given below is correct?

a. (II). (IV) and (V) are correct.

b. (III) and (IV) are correct.

c. (I). (IV) and (V) are correct.

d. (III) and (V) are correct.

(iv) If the object inside the box was made of a material with a refractive index less than 1.5 then the:

a. lateral shift of the rays would have been less.

b. lateral shift of the rays would have been more.

c. lateral shift of the rays would remain the same as before.

d. there is not enough information to comment on any of the above statements.

Very Short Answer Type Questions

Q 8. What is the nature of the mirror having focal length −15 cm?

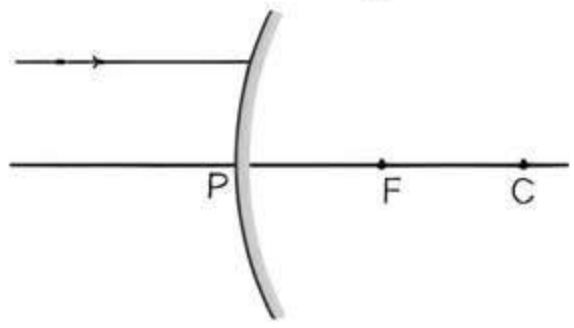
Q 9. What is the name given to the change in path of light with the change of medium?

Short Answer Type-I Questions

Q 10. The linear magnification produced by a spherical is $-\frac{1}{5}$. Analysing this value, state the (i) type of spherical mirror and (ii) the position of the object with respect to the pole of the mirror. Draw ray diagram to justify your answer.

Q 11. A concave mirror of focal length f can form a magnified erect as well as an inverted image of an object placed in front of it. Justify this statement stating the position of the object with respect to the mirror in each case for obtaining these image.

Q 12. A ray of light is incident on a convex mirror as shown. Redraw the diagram and complete the path of this ray after reflection from the mirror. Make angle of incidence and angle of reflection on it.



Short Answer Type-II Questions

Q 13. A convex lens made of a material of refractive index n_2 is kept in a medium of refractive index n_1. A parallel beam of light in incident on the lens. Draw the path of rays of light emerging from the convex lens, if:

(i) $n_1 < n_2$ (ii) $n_1 = n_2$

(iii) $n_1 > n_2$

Q 14. Define the following:

(i) focal length (ii) Principal focus

(iii) 1 dioptre

Q 15. 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?

Long Answer Type Questions

Q 16. A concave mirror and a convex mirror are placed co-axially, their reflecting surfaces facing each other. Their focal lengths are 15 cm and 12 cm respectively. An object placed between them is 20 cm from the concave mirror. The image formed by it is at the object itself. Calculate the distance of the convex mirror from the object.

Q 17. A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it. Draw ray diagram to justify this statement stating the position of the object with respect to the lens in each case. An object of height 4 cm is placed at a distance of 20 cm from a concave lens of focal length 10 cm. Use lens formula to determine the position of the image formed.