CHAPTER 9

Light : Reflection & Refraction

Level - 1

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (B) is correct.

Explanation: When a ray passes through the centre of curvature of a concave mirror, it strikes the mirror perpendicularly (normally) to the surface. The normal to the mirror at the point of incidence is along the same line as the ray itself, meaning the angle of incidence is zero. Since the ray is incident along the radius (normal), it reflects back along the same path.

Thus, for a ray passing through the centre of curvature, the angle of incidence is zero.

2. Option (C) is correct.

Explanation: Consider using a magnifying glass to project an image onto a screen. To ensure the image on the screen is the same size as the real object, position it at the appropriate distance from the lens. The item must be twice the distance from the lens's focus point to use a magnifying glass with a curved lens. This ensures that the image remains consistent with the original size.

3. Option (A) is correct.

Explanation: Absolute refractive index of glass and water is $\frac{3}{2}$ and $\frac{4}{3}$ respectively.

As we know that,

Speed of light in medium (v)

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

As speed of light is constant.

$\therefore$ Speed of light in medium (v) $\times$ refractive index (m) = constant

$$v_g \times \mu_g = v_w \times \mu_w$$

$$v_w = \frac{v_g \times \mu_g}{\mu_w} = \frac{2\times 10^8 \times \frac{3}{2}}{\frac{4}{3}}$$

$$v_w = \frac{9}{4}\times 10^8 \text{ m/s}$$

4. Option (A) is correct.

Explanation: Refractive index of glass is maximum for violet colour and minimum for red colour as refractive index of a medium is inversely proportional to the wavelength of light passing through it.

5. Option (D) is correct.

Explanation: Focal length, f = –50 ($\because$ it is a concave mirror)

Magnification = –1

Since,

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

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

$$\Rightarrow \quad -u = -v \Rightarrow u = v$$

Using mirror formula

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

$$\frac{1}{-50} = \frac{1}{u} + \frac{1}{u} \qquad (\because v = u)$$

$$\frac{1}{-50} = \frac{2}{u}$$

$$u = -100 \text{ cm}$$

Distance between object and image = $v - u$

$$\Rightarrow \quad -100 - (-100) = 0 \text{ cm}$$

6. Option (D) is correct.

Explanation: When an object is placed at infinity in front of a convex mirror, the rays coming from the object will be parallel to the principal axis after reflection. In this scenario:

1. For a convex mirror, the focal point lies behind the mirror. According to the New Cartesian sign convention, distances measured behind the mirror are positive. Thus, the focal length (f) of a convex mirror is positive (+).
2. When an object is placed at infinity, the image formed by a convex mirror is virtual, erect and

highly diminished. It is formed at the focus, which is behind the mirror. According to the New Cartesian sign convention, distances behind the mirror, where virtual images are formed are positive. Therefore, the image distance is also positive (+).

7. Option (A) is correct.

Explanation: To form an erect image, the object should be placed inside the focal point of the concave mirror, which means object distance u must be less than the focal length f.

For f = 10 cm, the object should be placed at a distance less than 10 cm from the mirror.

8. Option (B) is correct.

Explanation: A concave mirror forms a virtual, enlarged image when the object is placed between the pole (P) and the principal focus (F). In this case, the image will appear on the same side as the object and it will be virtual, upright and magnified.

If the object is placed between the pole and the principal focus (closer to the mirror), the image formed will be virtual, upright and enlarged.

At other positions like at the focus or beyond it, the nature of the image changes (real and inverted, or smaller in size).

9. Option (B) is correct.

Explanation: Refractive index of a medium,

$$n_m = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}}$$

Speed of light in vacuum, $c = 3 \times 10^8 \text{ms}^{-1}$

Speed of light in the glass,

$$v = \frac{\text{Speed of light in vacuum}}{\text{Refraction index of glass}}$$

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

$$v = \frac{3\times10^8}{1.50} = 2\times10^8 \text{ ms}^{-1}$$

Therefore, speed of light in the glass, $v = 2 \times 10^8$ m/s

10. Option (D) is correct.

Explanation: A convex mirror always forms a virtual, erect and diminished image. The focal length (f) of a convex mirror is positive because the focus is behind the mirror. The image distance (v) is also positive because the virtual image is formed behind the mirror. The height of the image (h_i) is positive because the image is erect. The correct representation according to the New Cartesian Sign Convention is:

v = +5 cm; f = +10 cm; h_i = +7.5 cm

11. Option (B) is correct.

Explanation: The characteristic of a spherical mirror that is given by the ratio of the size of the image to the size of the object is magnification.

Magnification (M) is defined as the ratio of the height (or size) of the image to the height (or size) of the object. It is given by the formula:

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

12. Option (A) is correct.

Explanation: The power of a lens (P) is related to its focal length (f) by the formula:

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

where,

P is the power of the lens (in diopters, D),

f is the focal length of the lens (in metres).

A negative power indicates a concave lens (diverging lens), where the focus is on the same side of the lens as the object.

13. Option (B) is correct.

Explanation: A lens with a positive power (e.g., 4D) is a converging lens and can form a real image. A lens with a negative power (e.g., –3D) is a diverging lens and cannot form a real image; it forms only virtual images.

14. Option (C) is correct.

Explanation: The speed of light in a vacuum is approximately 3.00×10^8 m/s. The absolute refractive index of a medium can be calculated using the formula:

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

In this case, the speed of light in the medium is given as 2.25×10^8 m/s.

Substituting the values:

$$n = \frac{3.00\times10^8 \text{ m/s}}{2.25\times10^8 \text{m/s}}$$

This simplifies to $\frac{4}{3}$

15. Option (A) is correct.

Explanation: When an object is set beyond the centre of curvature, then a parallel light ray to the principal axis, moves through the focus F. Simultaneously, the other ray passes through the optical centre C and goes undeviating. In this way, a diminished, real and inverted image is formed on the other side of the lens between the focus F and centre of curvature 2F.

Assertion-Reason Questions (1 Mark)

1. Option (B) is correct.

Explanation: A convex mirror always forms a virtual, erect, and diminished image behind the mirror, regardless of the position of the object. This happens because the reflected rays diverge, and the image appears to form at a point where the extensions of these diverging rays meet behind the mirror. The reason is also true as according to the sign convention, the focal length of a convex mirror is considered positive. Thus, both assertion and reason are true but reason is not the correct explanation of assertion.

2. Option (A) is correct.

Explanation: The centre of a circle which passes through a curve at a given point and has the same tangent and curvature at that point is called the centre of curvature of a mirror. It is the same as the centre of the sphere that constitutes the reflecting surface of the spherical mirror.

3. Option (A) is correct.

Explanation: When a light ray passes through the centre of curvature of a concave mirror, it strikes the mirror along the normal of the mirror, i.e., when the incident ray strikes normal to the surface of mirror then angle of incidence = 0°. So, according to the law of reflection: angle of incidence = angle of reflection = 0°. Thus, the ray of light retraces its path.

4. Option (A) is correct.

Explanation: The incident ray will refract while entering the second medium. While leaving the second medium, it again enters the first medium. Here also, the ray will suffer refraction. The angle of refraction depends upon the refractive indices of the media. And since the medium will remain the same, the angle of incidence will be equal to the angle of emergence. Hence, the emergent ray will be parallel to the incident ray.

As mentioned, the extent of bending depends upon the refractive index of the medium. As the medium is the same, the bending of the ray of light will be equal. The light ray bends towards normal when it enters a denser medium. If the incident ray is entering from rarer to a denser medium, then the emergent ray will be entering denser to rare medium. Hence, the bending will be the opposite. This is the reason why the emergent ray is parallel to the direction of the incident ray.

Level - 2

CASE-BASED QUESTIONS (4 Marks)

1. (i) Real Image (the final image is formed due to the lens at the eye-piece)

(ii) Concave Mirror

(iii) (a) A converging lens is used at the eyepiece to collect the rays from the plane mirror and help the viewer to see a real erect image of the star.

OR

(b) The plane mirror laterally inverts the image formed by the curved mirror and its position helps to direct the rays towards the eye-piece.

2. (i) In Case 1, where mirror A has a focal length of 20 cm and an object distance of 45 cm, the mirror will form a diminished image of the object. This is because the object distance (u) is greater than twice the focal length ($2f$). According to the formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, when $u > 2f$, the image formed is diminished.

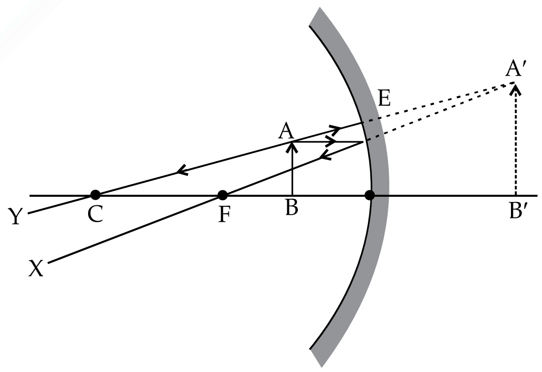
(ii) The image in Case 2 (Mirror B with a focal length of 15 cm and an object distance of 30 cm) shows two properties:

1. The image is formed beyond $2f$ (twice the focal length).

2. The image is real.

(iii) (a) Nature of the Image: The image formed will be virtual and erect.

Size of the Image: The image formed by mirror C will be magnified.



OR

(b) To determine the position of the image created by a concave mirror, use the mirror formula:

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

- Given, $f = -12$ cm (negative because it's a concave mirror), $u = -18$ cm (negative because the object is placed in front of the mirror).

Substitute the values into the formula:

$$\frac{1}{-12} = \frac{1}{v} + \frac{1}{-18}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{-12} - \frac{1}{-18}$$

$$\Rightarrow \quad -\frac{3}{36} + \frac{2}{36} = \frac{-1}{36}$$

$$v = -36$$

The image is formed in front of the mirror at a distance of 36 cm from the pole of the mirror.

3. (i) The principal axis of a concave mirror is the straight line that passes through the center of curvature (C) and the pole (P) of a concave mirror. It is perpendicular to the mirror's surface at the pole.

(ii) A ray of light incident parallel to the principal axis on a concave mirror will pass through the focus after reflection. According to the question, this reflected ray passes through a point on the principal axis, 10 cm from the pole. Hence, the focal length (*f*) of the concave mirror is 10 cm.

The radius of curvature (R) is related to the focal length by the formula:

$$R = 2f$$

Substituting the value of

$$R = 2 \times 10 = 20 \text{ cm}$$

Thus, the radius of curvature of the mirror is 20 cm.

(iii)(a) For a convex mirror, the mirror formula is:

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

where,

f = focal length = 15 cm (positive for convex mirror)

u = object distance = –10 cm (negative as the object is on the left side of the mirror)

v = image distance (to be found)

Substituting the known values into the formula:

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

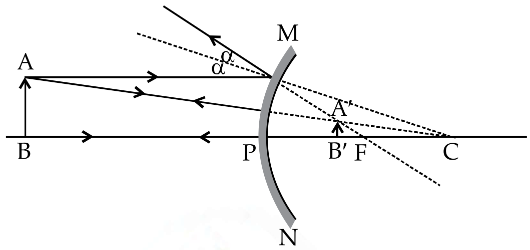
$$\frac{1}{v} = \frac{1}{15} + \frac{1}{10} = \frac{2}{30} + \frac{3}{30} = \frac{5}{30}$$

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

Thus, the position of the image is 6 cm behind the convex mirror.

OR

(b) The mirror that forms a virtual, erect, and diminished image is a convex mirror. This type of image is always formed irrespective of the position of the object in front of the convex mirror.

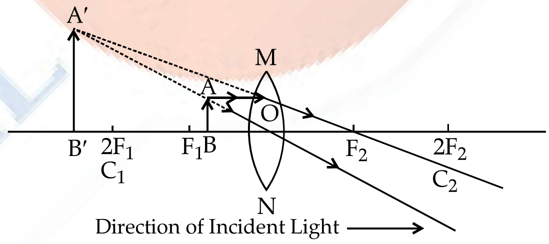


4. (i) For a real, inverted, and magnified image formed by a convex lens, the object distance (u) must be greater than the focal length (f) but less than twice the focal length ($2f$).

Therefore, $f < u < 2f$. Given f = 2 cm, the range of object is more than 2 cm and less than 4 cm from the optical centre.

(ii) For a virtual, erect, and magnified image formed by a convex lens, the object distance (u) must be less than the focal length (f). Therefore, $u < f$. Given f = 6 cm, the range of object is less than 6 cm from the optical centre.

(iii)(a)



OB = 12 cm

OF = 18 cm

A′B′ : Image

OR

(b) To determine the focal length of the convex lens, we can use the lens formula:

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

where,

f is the focal length of the lens,
v is the image distance (distance from the lens to the image),
u is the object distance (distance from the lens to the object).
Since the image is the same size, the object distance (u) equals the image distance (v). Therefore,

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

Substituting the values:

$$\frac{1}{f} = \frac{1}{30}+\frac{1}{30}=\frac{2}{30}=\frac{1}{15}$$

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

5. (i) (1) Vehicle headlights

(2) Shaving mirrors

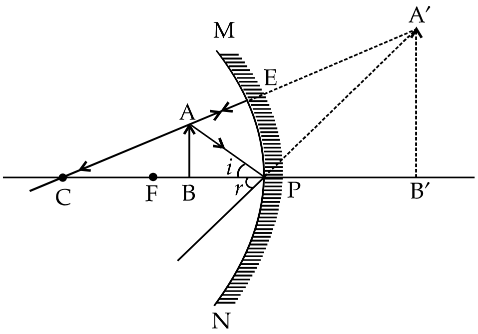
(ii) The radius of curvature (R) of a mirror is related to the focal length (f) by the formula:

$$R = 2f$$

Given, $f = 15$ cm

$$R = 2 \times 15 = 30 \text{ cm}$$

(iii) (a)



OR

(b) (1) Given,

Object distance (u) = –100 cm

Image distance (v) = –100 cm

Focal length (f) = ?

[f in case of a concave mirror is negative.]

Using formula,

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

We get,

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

$$\frac{1}{f} = \frac{2}{-100}=\frac{1}{-50}$$

So, $f = -50$ cm

Hence, focal length = –50 cm.

(2) Size of object (h_o) = 10 cm

Magnification = ?

From formula,

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

Substituting we get,

$$m = -\frac{-100}{-100} = -1$$

Hence, magnification of the object = –1 i.e., inverted image is formed of same size as object.

6. (i) Refractive index of diamond,

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

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

$$2.42 = \frac{3\times10^8}{\text{Speed of light in diamond}}$$

$$\text{Speed of light in diamond} = \frac{3\times10^8}{2.42}$$

$$= 1.23 \times 10^8 \text{ m/s}$$

(ii) $\angle r_{\text{carbon disulphide}} < \angle r_{\text{glass}} < \angle r_{\text{water}}$

(iii) (a) (1) Since the speed of light is lesser in glass than the speed of light in water, glass is optically denser than water. This demonstrates that glass presents a greater barrier to light transmission than water.

(2) Light will enter from water to glass without bending i.e. undeviated because in this case

$\angle i = 0$; $\angle r = 0$

OR

(b) $\eta_{\text{glass}} = \frac{3}{2}$

$\eta_{\text{water}} = \frac{4}{3}$

$V_{\text{glass}} = 2 \times 10^8$ m/s

(1) Speed of light in vacuum

$$\therefore \quad \eta_g = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in glass } (V_g)}$$

$$c = \eta_g \times V_g$$

$$= \frac{3}{2}\times 2\times10^8 \text{ m/s}$$

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

(2) Speed of light in water

$$V_w = \frac{c}{\eta_w}$$

$$= \frac{3\times10^8}{\frac{4}{3}}$$

$$= \frac{9}{4}\times10^8$$

$$= 2.25 \times 10^8 \text{ m/s}$$

7. (i) The absolute refractive index is defined as the ratio of the speed of light in a vacuum to the speed of light in the given medium. It is always greater than 1.

Absolute refractive index of a medium

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

(ii) (1) The speed of light is more in water.

(2) The ray of light will bend away from the normal when entering water from glass.

(iii) (a) Given,

Refractive index of glass, $\eta_g = \frac{3}{2}$

Refractive index of water, $\eta_w = \frac{4}{3}$

Speed of light in glass, $V_g = 2 \times 10^8$ m/s.

Refractive index of medium

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

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

$$c = 3 \times 10^8 \text{ m/s}$$

(1) Speed of light in water

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

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

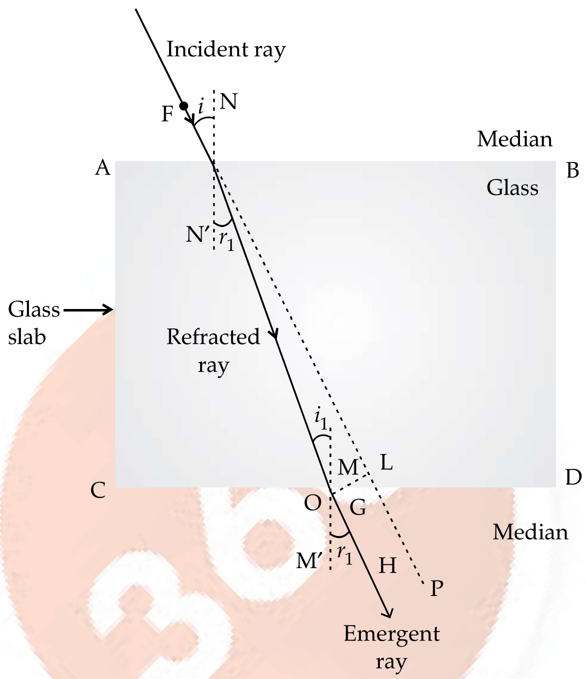
$$= \frac{9}{4} \times 10^8 \text{ m/s}$$

$$= 2.25 \times 10^8 \text{ m/s}$$

(2) Speed of light in vacuum $= 3 \times 10^8$ m/s

OR

(b)



EF is the incident ray and GH is the emergent ray, which is parallel to the incident ray.

Level - 3

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. (i) The lens is a convex lens.

(ii) The image is virtual.

(iii) Magnification for lens $= \frac{v}{u} = \frac{h_i}{h_o} = 2$

$$\frac{-30 \text{ cm}}{u} = 2$$

Hence $u = -15$ cm.

2. According to the mirror formula.

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

The focal length of a convex mirror, $f = 15$ cm.

Object distance, $u = -10$ cm

Image distance (v) = ?

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

$$\frac{1}{v} = \frac{1}{15} - \frac{1}{-10}$$

$$\frac{1}{v} = \frac{1}{15} + \frac{1}{10}$$

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

$$\frac{1}{v} = \frac{5}{30}$$

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

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

Image is formed behind the mirror.

3. (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 the 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 medium.

$$\frac{\sin i}{\sin r} = \text{constant}$$

4. Absolute refractive index of a medium is the ratio of speed of light in air/vacuum to the speed of light in the given in medium.

Given:

$$c = 3 \times 10^8 \text{ m/s}; n_m = 1.5; v_m = ?$$

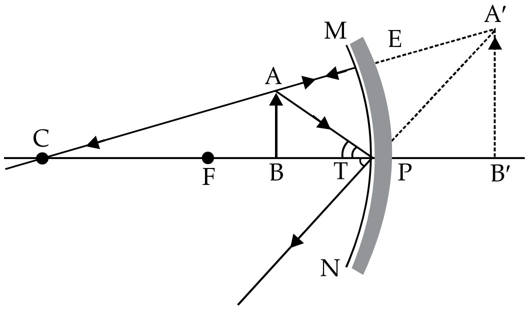
Absolute refractive index of a medium

$$n_m = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$$

$$1.5 = \frac{3 \times 10^8}{v_m}$$

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

5.



P : Pole; F : Principal focus; AB : Object; A′B′ : Image

6. (i) Clearly, the ray in medium B is moving towards normal when it enters from medium A. Hence, medium B is optically denser than medium A. This means that the refractive index of medium B with respect to refractive index of medium A will be greater than 1.

(ii) The refractive index (n) of medium B with respect to medium A can be calculated using the formula:

$$n = \frac{V_a}{V_b}$$

where, V_a is the speed of light in medium A and V_b is the speed of light in medium B.

So, if the speed of light in medium A is V_a and in medium B is V_b, the refractive index of medium B with respect to medium A can be calculated as:

$$n = \frac{V_a}{V_b}$$

7. Given : $u = -20$ cm $f = 15$ cm (Convex Mirror because f is positive)

According to mirror formula,

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

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

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

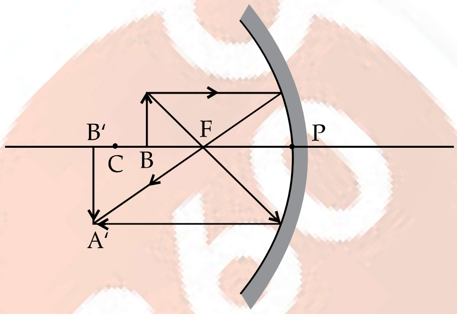
$$\frac{1}{v} = \frac{-4+3}{60} = -\frac{1}{60}$$

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

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

$$m = -\frac{-60}{-20} = -3$$

8.



9. (i) $n_P = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium P}}$

$$n_q = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium Q}}$$

$$\frac{n_P}{n_Q} = \frac{v_Q}{v_P}$$

$$= \frac{1.33}{2.52} = \frac{v_Q}{2 \times 10^8}$$

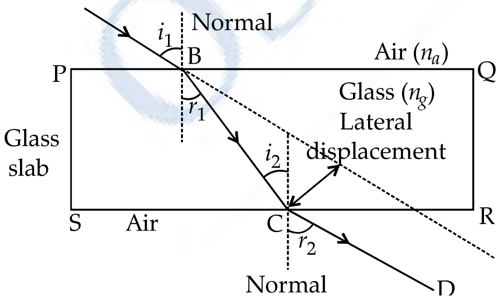
$$v_Q = \frac{1.33 \times 2 \times 10^8}{2.52}$$

$$= 1.056 \times 10^8 \text{ m/s}$$

(ii) The ray will travel undeviated through the medium Q.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1.



2. To determine the position of the image formed by a concave mirror, we use the mirror formula:

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

where,

f is the focal length of the mirror $f = -12$ cm (negative for concave mirrors),

u is the object distance, $u = -8$ cm (negative as the object is on the same side as the incoming light),

v is the image distance.

Substitute the known values into the mirror formula

$$\frac{1}{-12} = \frac{1}{-8} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{-12} - \frac{1}{-8}$$

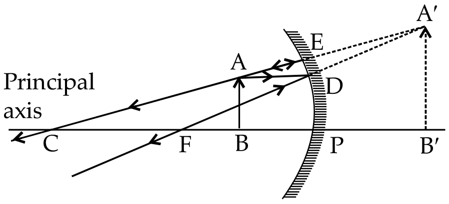
$$\frac{1}{v} = \frac{-1}{12} + \frac{1}{8}$$

$$\frac{1}{v} = \frac{-2}{24} + \frac{3}{24}$$

$$\frac{1}{v} = \frac{1}{24}$$

$$v = 24 \text{ cm}$$

The image is formed at 24 cm behind the mirror.



3. (i) Image of an object formed by a mirror is real, inverted indicates that the mirror is a concave mirror and that the image is formed on the same side as the object.

So, using magnification formula to find object distance

If an object

$m = -1, v = -30$ cm

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

$$-1 = -\left(\frac{-30}{u}\right),$$

$u = -30$ cm is the object distance.

The object is placed at 30 cm from the mirror.

(ii) If an object is moved 15 cm toward the mirror, the new object distance (u_{new}) is 15 cm less than original distance (u)

$$u_{new} = u - 15 \text{ cm}$$

$$u_{new} = 30 - 15 \text{ cm}$$

$$u_{new} = 15 \text{ cm}$$

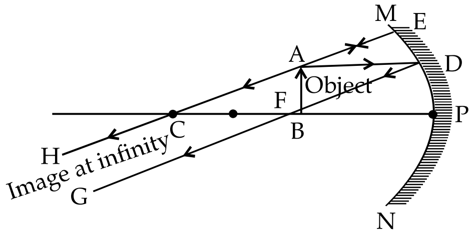
Now using mirror formula, new imaged distance will be:

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

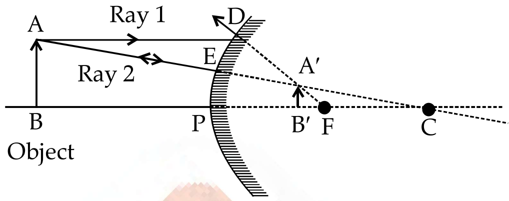
$$\frac{1}{f} = \frac{1}{-15} + \frac{1}{15}$$

$$v = \infty$$

The image is formed at infinity.



4. (i)



A′B′ is the image formed.

(ii) The image of object obtained in the convex mirror is erect and diminished. This is because a convex mirror always forms a virtual, erect and diminished image of an object.

The position of the image is behind the mirror, between P and F.

(iii) The image distance is positive. This is because the image formed is behind the mirror.

5. (i) Height of object, $h = 3$ cm

Distance of object from mirror, $u = -18$ cm (negative sign indicates that the object is placed on the left side of the mirror)

Focal length of mirror, $f = -12$ cm (negative sign indicates that the mirror is concave)

We can use the mirror formula to find the distance of the image from the mirror:

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

where, v is the distance of the image from the mirror.

Substituting the values of u and f, we get:

$$\frac{1}{-12} = \frac{1}{-18} + \frac{1}{v}$$

$$v = -36 \text{ cm}$$

(negative sign indicates that the image is formed on the left side of the mirror)

Therefore, the distance of the image from the mirror is 36 cm.

(ii) To find the height of the image, we can use the magnification formula:

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

where, m is the magnification of the image.

Substituting the values of v and u, we get:

$$m = -\frac{-36}{-18} = -2$$

Since the magnification is negative, the image is inverted and enlarged.

The height of the image can be found using the formula:

$$h' = m \times h$$

where h' is the height of the image and h is the height of the object.

Substituting the values of m and h, we get:

$$h' = -2 \times 3 = -6 \text{ cm}$$

Therefore, the height of the image is 6 cm.

6. The power of a lens is defined as the reciprocal of its focal length. Mathematically, it can be expressed as

$$\text{the Power of lens} = \frac{1}{\text{focal length}}$$

where the focal length is measured in meters and the power of the lens is measured in diopters (D).

In this case, the given focal length of the lens is –10 cm. We need to convert this to meters to calculate the power of the lens. So, we have:

Focal length = –10 cm = –0.1 m

The negative sign indicates that the lens is a concave lens, also known as a diverging lens.

The power of the lens is:

$$\text{Power of lens} = \frac{1}{-0.1 \text{ m}} = -10\text{D}$$

The negative sign indicates that the lens has a negative power, which means it is a diverging lens.

The magnification (m) is given by:

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

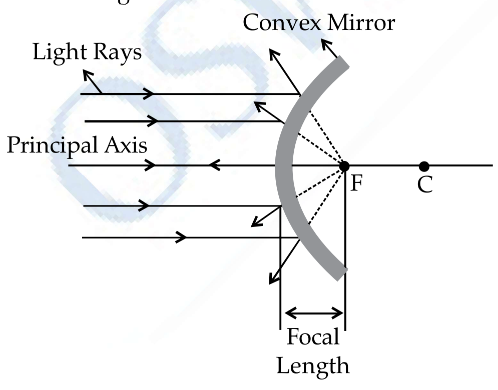
Here $u = -20$ cm

(negative as per New Cartesian convention)

Hence, the magnification will be positive.

7. (i) Principal focus: The principal focus of the diverging mirror is the point on the principal axis from where the rays parallel to principal axis appear to diverge after reflection.

(ii) Focal length: The distance between the pole and the principal focus of a spherical mirror is called the focal length.



8. Object height, O = +10 cm

Focal length, f = +15 cm

Object distance, u = –25 cm

Image distance, v = ?

Image height, I = ?

Using lens formula,

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

$$\frac{1}{15} = \frac{1}{v} - \frac{1}{(-25)}$$

Or, $$\frac{1}{v} = \frac{1}{15} - \frac{1}{25}$$

$$\frac{1}{v} = \frac{2}{75}$$

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

The image distance is 37.5 cm.

Also, $$-\frac{v}{u} = \frac{I}{O}$$

Hence, $$\frac{-\frac{75}{2}}{-25} = \frac{1}{10}$$

$$I = (-1.5) \times 10 = -15 \text{ cm}$$

Height of image is 15 cm, inverted.

9. (i) Height of the object = 5 cm

Object distance (u) = –20 cm

Focal length (f) = –18 cm

Using the lens formula, we can find the image distance (v) for the given object distance (u) and focal length (f):

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

$$= \frac{1}{-20} + \frac{1}{-18}$$

$$= -\left(\frac{18+20}{360}\right)$$

$$= \frac{-38}{360}$$

$$\Rightarrow \quad v = \frac{-360}{38} = -9.47 \text{ cm}$$

To find the magnification (m), we can use the formula:

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

Substituting the values, we get:

$$m = -\frac{-9.47}{20} = 0.47$$

(ii) When a concave lens forms a virtual image, the magnification is always less than 1 (i.e., the image is smaller than the object). This is because a concave lens always forms a virtual, erect, and diminished image of a real object.

On the other hand, when a convex lens forms a virtual image, the magnification can be greater than or less than 1, depending on the position of the object relative to the lens. If the object is closer to the lens than its focal length, the magnification is greater than 1 (i.e., the image is larger than the object). If the object is farther from the lens than its focal length, the magnification is less than 1 (i.e., the image is smaller than the object).

Thus, the magnification of the concave lens is always less than 1 and the magnification of the convex lens is greater than or less than 1, depending on the position of the object.

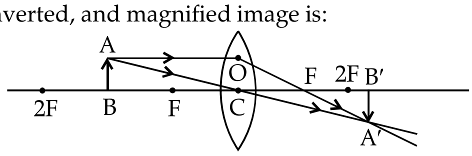
10. (i) For a real and inverted image to be magnified, the object must be placed between the focal point and twice the focal length (i.e., between f and $2f$).

Focal Length: $f = 10$ cm

Range of Object Distance:

The object distance u must be less than 20 cm (which is $2f$) and greater than 10 cm (which is f).

Therefore, the range of object distance for a real, inverted, and magnified image is:



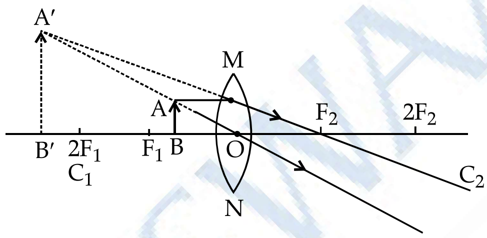
$$20 \text{ cm} > u > 10 \text{ cm}$$

(ii) For a virtual and erect image to be formed, the object must be placed within the focal length of the lens (i.e., less than f).

Range of Object Distance:

The object distance u must be less than 10 cm (which is f).

Therefore, the range of object distance for a virtual, erect, and magnified image is:



$$10 \text{ cm} > u > 0$$

11. (i) Object distance (u) = –18 cm (negative because the object is on the same side as the incoming light)

Image distance (v) = +36 cm (positive because the image is formed on the opposite side of the lens)

The magnification (m) of a lens is given by the formula:

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

Substituting the values:

$$m = -\frac{36}{18} = -2$$

This means the image is inverted and twice the size of the object.

(ii) The Lens Formula is given by:

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

$$\frac{1}{f} = \frac{1}{36} - \frac{1}{-18}$$

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

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

12. (i) Given that, an object is placed at a distance of 60 cm from a concave lens of focal length 30 cm.

So, we have

Distance of the object from concave lens, $u = -60$ cm

Focal length of a concave lens, $f = -30$ cm

We know, the distance of the object, distance of the image and focal length of concave lens are connected by the relationship

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

On substituting the values, we get

$$\frac{1}{-30} = \frac{1}{v} - \frac{1}{-60}$$

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

$$\frac{1}{-30} - \frac{1}{60} = \frac{1}{v}$$

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

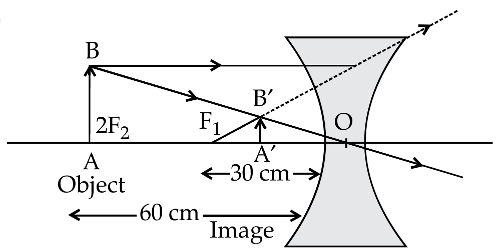
$$\frac{-3}{60} = \frac{1}{v}$$

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

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

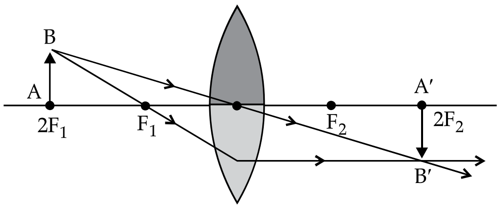
This means, the distance of the image from concave lens is 20 cm on the same side of lens.

(ii)



LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i)



The image formed will be real, inverted and located at $2F_2$ on the opposite side of the lens.

When the lens is uncovered:

The image position and size will remain the same.

However, the image will appear brighter because more light rays will pass through the lens.

When the lens is half covered:

The image position and size will remain the same.

Fewer rays are involved in forming the image, resulting in reduced brightness.

(ii) Object distance, $u = -15$ cm, $v = ?$

Focal length, $f = -15$ cm

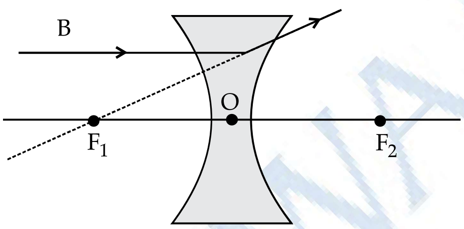
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

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

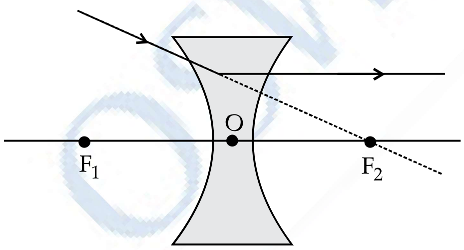
$$\frac{1}{-15} + \frac{1}{-30} = \frac{-3}{30} = \frac{-1}{10}$$

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

2. (i) (1)



(2)



(ii) Given, $u = -16$ cm, $f = +24$ cm, $h = 4$ cm

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

$$\therefore \quad \frac{1}{v} - \frac{1}{(-16)} = \frac{1}{+24}$$

$$\frac{1}{v} = \frac{1}{24} - \frac{1}{16}$$

$$\frac{1}{v} = \frac{-1}{48}$$

$$v = -48 \text{ cm}$$

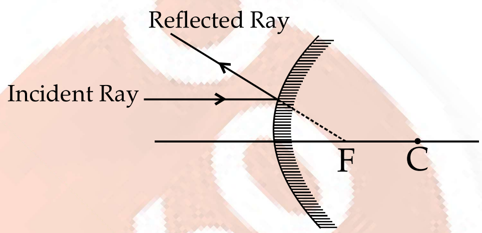
Image is formed on the same side as the object

$$m = \frac{h'}{h} = \frac{v}{u}$$

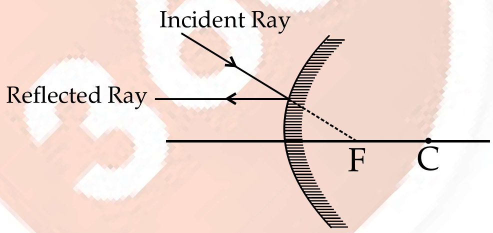
$$\frac{h'}{4} = \frac{-48}{-16}$$

$$h = 12 \text{ cm}$$

3. (i) (1)



(2)



(ii) Here $f = -12$ cm, $u = -18$ cm, $v = ?$, $h = 1.5$ cm, $h' = ?$

Mirror formula $\quad \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

$$= \frac{1}{-12 \text{ cm}} - \frac{1}{-18 \text{ cm}}$$

$$= \frac{-1}{36}$$

$$\therefore \quad v = -36 \text{ cm}$$

$$m = \frac{h'}{h} = -\frac{v}{u}$$

$$\frac{h'}{1.5} = -\frac{(-36)}{(-18)}$$

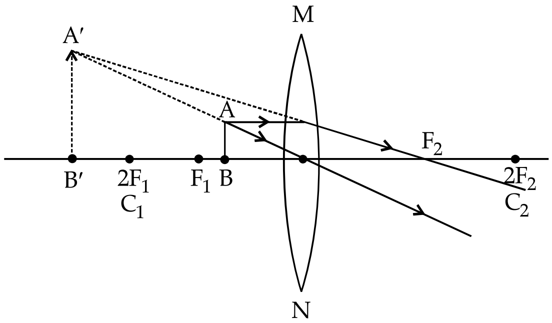
$$h' = -3.0 \text{ cm}$$

4. (i) At S. No. 3, $2f = 50$cm; $f = 25$ cm

Object distance (u) and image distance (v) are same. So it implies that object is placed at 2F.

(ii) S. No. 6 is not correct.

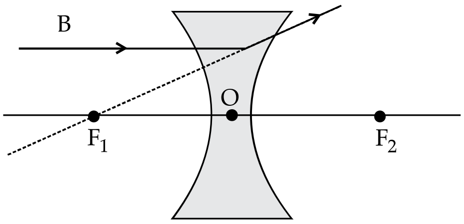
Reason: For $u = -15$ cm, sign of v must be negative. (as the image is formed on the same side of the lens as the object.



(iii) Magnification: $m = \frac{v}{u}$

$$= \frac{+150 \text{ cm}}{-30 \text{ cm}} = -5$$

5. (i) Principal axis: It is an imaginary line passing through the two centres of curvatures of a lens.



(ii) $f = -20$ cm; $h = 5$ cm; $v = -15$ cm

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

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

$$= \frac{1}{(-15)} - \frac{1}{(-20)}$$

$$= \frac{-1}{60 \text{ cm}}$$

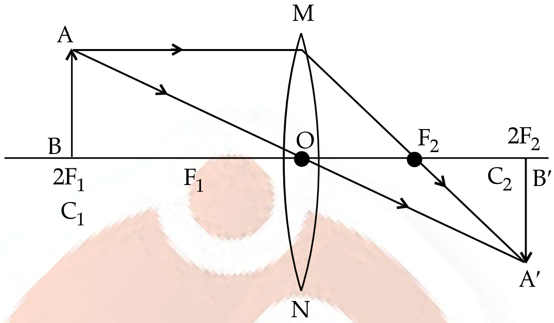
or $u = -60$ cm

The object is at a distance of 60 cm from the lens.

Size of the image (magnification): $m = \frac{h'}{h} = \frac{v}{u}$

$$h' = \frac{v}{u} \times h = \frac{(-15)}{(-60)} \times 5 = 1.25 \text{ m}$$

6. (i)



Magnification will be –1

(ii) (1) We use the lens formula:

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

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

$$\Rightarrow \frac{1}{v} = \frac{1}{-16} + \frac{1}{12}$$

$$= \frac{1}{48}$$

$$v = +48 \text{ cm}$$

(2) $$h_i = \frac{v}{u} \times h_0$$

$$= \frac{+48}{-16} \times 2 = -6 \text{ cm}$$

∴ Length of the image is 6 cm.