10 Light — Reflection and Refraction

MULTIPLE CHOICE QUESTIONS

1. Magnifying power of a concave lens is always

(a) > 1 (b) < 1

(c) = 1 (d) > 2

2. An object is placed at a distance of 10 cm from convex mirror of focal length 10 cm. The image will form

(a) at infinity

(b) at focus

(c) at the pole

(d) behind the mirror between P and F

3. When the power of a lens is - 2D, what is its focal length?

(a) + 50 cm (b) - 100 cm

(c) – 50 cm (d) + 100 cm

4. When the magnification produced by a lens has a negative value, the image will be

(a) virtual and inverted

(b) virtual and erect

(c) real and erect

(d) real and inverted

Answers. 1. (b) 2. (d) 3. (c) 4. (d)

ASSERTION-REASON TYPE QUESTIONS

For a given question below, two statements are given - one labelled assertion(A) and the other labelled reason (R). Select the correct answer to this question from the codes (i), (ii), (iii) and (iv) as given below

(i) Both A and R are true and R is the correct explanation of the assertion.

(ii) Both A and R are true but R is not the correct explanation of the assertion.

(iii) A is true but R is false.

(iv) A is false but R is true.

Assertion: A ray of light that travels obliquely from one transparent medium into another will change its direction in the second medium.

Reason: Light travels with different speeds in different media.

Ans. (i)

TABLE BASED QUESTIONS

Analyse the following observation in the 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	+ 125

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

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

Ans. (*a*) The focal length of the convex lens is f = 20 cm.

Reason: At S. No. 3, object distance u = – 40 cm, image distance v = + 40 cm

Thus, object is at 2F.

Therefore, $2f$ = 40 cm $\Rightarrow f$ = 20 cm

(*b*) Observation at S.No. 6 is not correct.

The value, u = – 15 cm, indicates that the object is in between the optical centre and the focus (i.e., less than the focal length) of the lens and hence, the image should be on the same side as the object. Accordingly, the image distance should be negative and cannot be positive (+ 125 cm) as shown in table.

VERY SHORT ANSWER QUESTIONS

1. What will be the angle of reflection when a ray falls normally on the surface of a plane mirror?

Ans. When a ray falls normally on the surface of a plane mirror, then the **angle of incidence** is **zero**. Thus, from **laws of reflection,** the **angle of reflection** is also **zero**.

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

Ans. Given, radius of curvature, R = 20 cm

We know that, focal length, $f = \frac{R}{2} = \frac{20\text{ cm}}{2} =$ 10 cm

Thus, focal length of the spherical mirror is 10 cm.

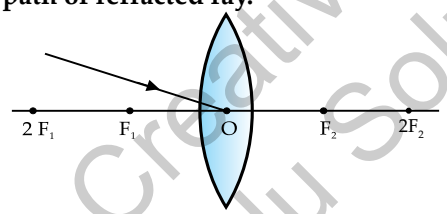
3. Name a mirror that can give an erect and enlarged image of an object.

Ans. Concave mirror

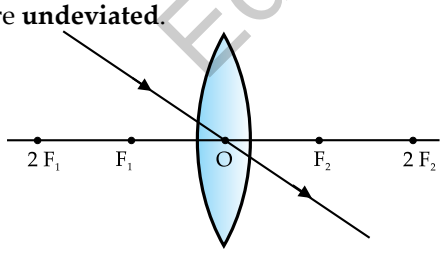
4. Which lens is used in making spectacles to correct the hypermetropia?

Ans. Convex lens

5. Redraw the given diagram to show the path of refracted ray.



Ans. A ray of light will pass through the optical centre **undeviated**.



6. Write two different uses of convex mirror.

Ans. (i) Convex mirror is used as a **rear view mirror** in vehicles like cars, bikes, buses, trucks, etc.,

(ii) In **street lights,** convex mirror is used to diverge light over an extended area.

SHORT ANSWER QUESTIONS

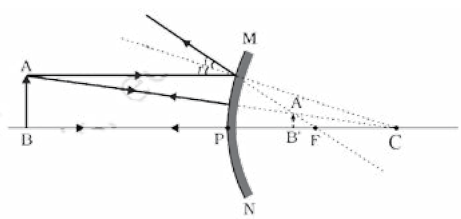
1. Differentiate between real and virtual image.

Ans.

S. No.	Real image	Virtual image
1.	The image of an object formed by the **actual intersection of light rays** after reflection is known as **real image**.	When the rays of light **do not meet actually** after reflection but **appear to meet,** then the image so formed is known as **virtual image**.
2.	It is always inverted.	It is always erect.
3.	It **can** be **taken on a screen.**	It **cannot** be **obtained on a screen**.
	For example, image produced by a projector	For example, image formed by a plane mirror

2. If the image formed by a mirror for all positions of the object placed in front of it is always diminished, erect and virtual. State the type of the mirror and also draw a ray diagram to justify your answer.

Ans. Convex mirror



3. The refractive indices of glass and water with respect to vacuum are 3/2 and 4/3

respectively. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (a) vacuum; (b) water.

Ans. Given, refractive index of glass w.r.t. vacuum, $n_{gv} = \frac{3}{2}$ ... (i)

Refractive index of water w.r.t vacuum, $n_{wv} = \frac{4}{3}$ ... (ii)

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

(a) Speed of light in vacuum, v = ?

Refractive index,

$$n_{gv} = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in glass}} = \frac{3}{2}$$

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

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

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

Thus, speed of light in vacuum is 3×10^8 m/s.

(b) Speed of light in water, v_w = ?

Refractive index

$$n_{wv} = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in water}} = \frac{4}{3}$$

$$\Rightarrow \frac{v}{v_w} = \frac{4}{3}$$

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

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

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

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

Thus, speed of light in water is 2.25×10^8 m/s.

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

(a) What should be the range of distance of an object placed in front of the mirror?

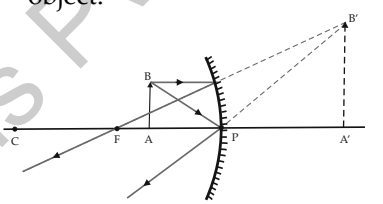
(b) Will the image be smaller or larger than the object? Draw ray diagram to show the formation of image in this case.

(c) Where will the image of the object be, if it is placed 24 cm in front of the mirror? Draw ray diagram for this situation also to justify your answer. Show the positions of pole, principal focus and the centre of curvature in the above ray diagrams.

Ans. (a) Given, focal length, $f = -12$ cm,

Thus, range of distance of object to obtain erect image should be less than 12 cm.

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



(c) Given, focal length, $f = -12$ cm,

Object distance, u = – 24 cm

Image distance, v = ?

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

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-12)} - \frac{1}{(-24)}$$

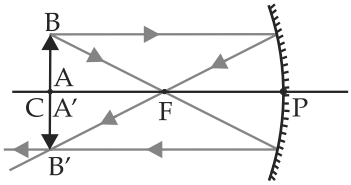
$$\frac{1}{v} = \frac{1}{-12} + \frac{1}{24}$$

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

$$\frac{1}{v} = -\frac{1}{24} \text{ cm}$$

$$\Rightarrow \quad v = -24 \text{ cm}$$

The image of the object will be formed at a distance of 24 cm. Since, the object distance is equal to the image distance therefore, the object and image must be at the centre of curvature.



5. An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm.

(a) Use lens formula to find the distance of the image from the lens.

(b) List four characteristics of the image formed by the lens in this case.

(c) Draw ray diagram to justify your answer of part (b).

Ans. Given, object distance, $u = -60$ cm;

Focal length, $f = -30$ cm

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

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

$$\therefore \quad \frac{1}{v} = -\frac{1}{30} - \frac{1}{60} = \frac{3}{60} = -\frac{1}{20}$$

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

(b) (i) This image formed is **virtual**.

(ii) The position of the image will be in between **optical centre** and **focus** of concave lens.

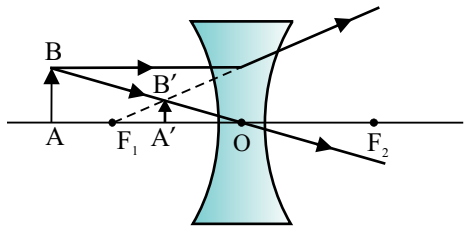
(iii) As magnification, $m = \frac{h_2}{h_1} = \frac{v}{u}$

$$\Rightarrow \quad h_2 = \frac{v}{u} \times h_1 = \frac{-20 \times h_1}{-60} = \frac{h_1}{3}$$

Thus, the size of image is one-third of the object.

(iv) The image formed is erect.

(c)



6. The image of a candle flame placed at a distance of 30 cm from a spherical lens is formed on a screen placed on the other side of the lens at a distance of 60 cm from the optical centre of the lens. Identify the type of lens and calculate its focal length. If the height of the flame is 3 cm, find the height of its image.

Ans. Given, object distance $u = -30$ cm;

Image distance, $v = +60$ cm;

Height of the object, $h_1 = +3$ cm

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

$$\Rightarrow \frac{1}{f} = \frac{1}{60} - \frac{1}{(-30)} = \frac{1}{60} + \frac{1}{30} = \frac{3}{60} = \frac{1}{20}$$

$$\therefore \quad f = +20 \text{ cm}$$

Thus, the positive sign of the focal length indicates that the given lens is convex in nature whose focal length is 20 cm.

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

$$\Rightarrow \qquad h_2 = \frac{v}{u} \times h_1 = \frac{(+60)}{(-30)} \times 3 = -6 \text{ cm}$$

So, the height of image is 6 cm. The negative sign indicates that the image is formed below the principal axis and is real and inverted.

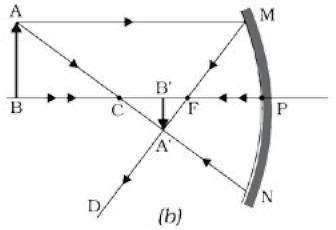
7. State two positions in which a concave mirror produces a magnified image of a given object. List the difference between the two images.

(b) Focal length of a concave mirror is 20 cm. What is the nature of image if an object is place at 60 cm?

Ans. (a) The two positions in which a concave mirror produces a magnified image of the given object, are when the object is placed between (i) focus (F) and centre of curvature (C) (ii) focus (F) and pole (P)

The difference between the two images is that the image formed in case (i) is real and inverted, whereas in case (ii) it is virtual and erect.

(b) Since the object is placed beyond 2F,. Image will be real, inverted and smaller.



(b)

8. A convex lens of focal length 25 cm and a concave lens of focal length 10 cm are placed in close contact with each other. Calculate the lens power of this combination.

Ans. Given, f_1 = 25 cm (convex lens), f_2 = – 10 (concave lens)

We haven't discussed combination of power of a lens in DHT.

$$P = \frac{1}{f\,(\text{in metre})}$$

$$P_1 = \frac{1}{25\text{ cm}} = \frac{1}{\frac{25}{100}\text{ m}} = \frac{100}{25} = 4D$$

$$P_2 = \frac{1}{-10\text{ cm}} = \frac{1}{\frac{-10}{100}\text{ m}} = \frac{-100}{10} = -10D$$

Power of the combination = $P = P_1 + P_2$

$4D + (-10D) = 4D - 10D$

$= -6D$

The lens power of this combination is – 6D

LONG ANSWER QUESTIONS

1. State the type of mirror used (a) in headlights of a car; (b) as shaving mirrors; (c) by dentists and (d) in solar furnace. Support your answer with reason.

Ans. (a) **Concave mirrors** are used in the headlights of a car as reflector. In these **equipment**, bulb is placed at the **focus** of the concave mirror. Therefore, the light rays become parallel after being reflected from the concave mirror. These parallel rays of light thus help us to see things clearly upto a considerable distance at night.

(b) **Concave mirror** is used as shaving mirror because it produces enlarged and erect image of the face.

(c) **Concave mirror** is used by dentists to see the large image of the teeth of patients. This is because it converges the light at a certain point and when the object is placed very close to the mirror, i.e., between principle focus and pole of the mirror, a virtual, erect and enlarged image of the patient's teeth is produced, enabling the dentist to examine the problems in the patient's teeth.

(d) **Concave mirror** is used in solar furnace. This is because concave mirror has property to converge the sunlight along with heat radiation at its focus. As a result, the temperature at its focus increases and the substance placed at the focus gets heated to a high temperature.

2. (*a*) If the image formed by a lens is diminished in size and erect, for all positions of the object, what type of lens is it?

(*b*) Name the point on the lens through which a ray of light passes undeviated.

(*c*) An 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 30 cm. Find

(*i*) the position (*ii*) the magnification and (*iii*) the nature of the image formed.

Ans. (*a*) Concave lens.

(*b*) Optical centre.

(*c*) Given: $u = -30$ cm, $f = +20$ cm (convex lens), $v = ?$

(*i*) Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}, \text{ we get}$$

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

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

$\Rightarrow$ $v = 60$ cm

The image is formed at a distance of 60 cm from the lens on the right side.

(*ii*) Since, $m = \frac{v}{u} = \frac{60}{-30} = -2$

So, the image is inverted and double the size of the object.

(*iii*) The image is **real, inverted** and **enlarged**.

3. (*a*) To construct a ray diagram, we use two rays that are so chosen that it is easy to know their directions after reflection from the mirror. List two such rays and state the path of these rays after reflection in case of concave mirrors. Use these two rays and draw a ray diagram to locate the image of an object placed between pole and focus of a concave mirror.

(*b*) A concave mirror produces three times magnified image on a screen. If the object is placed 20 cm in front of the mirror, how far is the screen from the object?

Ans. (*a*) Rays which are chosen to construct a ray diagram for reflection are:

(*i*) A **ray parallel to the principal axis** and

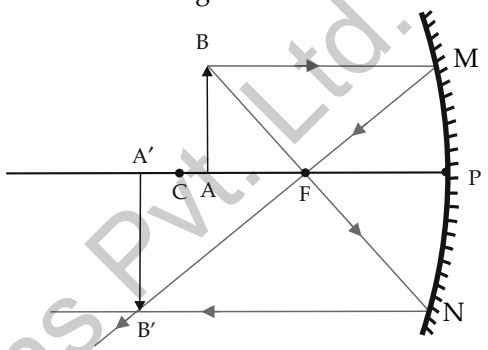
(*ii*) A **ray passing through the centre of curvature** of a concave mirror.

Path of these light rays after reflection:

(*i*) It will pass through the **principal focus** of a concave mirror

(*ii*) It gets reflected back along the same path.

When an object is placed between the **pole** and the **principal focus** of a concave mirror, a **virtual, erect and enlarged** image is formed behind the concave mirror as shown in the figure.



(*b*) Given: $u = -20$ cm and $m = -3$ (real image)

Magnification, m, is given by

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

$$v = -m \times u$$

$$v = -(-3) \times (-20 \text{ cm}) = -60 \text{ cm}$$

Distance between the object and the screen is $= -60$ cm $-(-20$ cm$)$

$= -60$ cm $+ 20$ cm

$= -40$ cm.

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