

Light—Reflection and Refraction

TOPIC COVERED

Reflection of Light



Multiple Choice Questions

1 Mark



- The things visible to us due to the presence of**
(a) object (b) light (c) dark (d) none of these
- Which of the following phenomenon is not associated with light?**
(a) Image formation by mirror
(b) Twinkling of stars
(c) Formation of rainbow
(d) Magnetic field lines
- Which of the following is incorrect about the properties of light?**
(a) Straight-line propagation of light
(b) Light is a form of energy
(c) Light needs a medium to propagate
(d) It has a finite speed
- The light incident on a highly polished surface rebound into the same medium in same or different direction, is called**
(a) reflection of light (b) refraction of light
(c) scattering of light (d) none of these
- Image formed by the plane mirror is**
(a) virtual, diminished and behind the mirror
(b) virtual, erect, same size and behind the mirror
(c) real, same size, formed on the same side of the object.
(d) virtual, erect, enlarged and behind the mirror

6. Which type of mirror is used to get a virtual, erect, laterally inverted and same size image as that of object?

- (a) Convex mirror (b) Concave mirror
(c) Plane mirror (d) All of these

7. In reflection of light, the angle of reflection is _____ the angle of incidence.

- (a) equal to (b) greater than
(c) less than (d) cannot say

8. The angle between the incident ray and reflected ray is 60° , the angle of incidence is

- (a) 60° (b) 45°
(c) 30° (d) 90°

9. A ray of light is incident on a plane reflecting surface at angle of incidence of 30° . Then the reflected ray is deviated by an angle equal to

- (a) 30° (b) 150°
(c) 60° (d) 120°

10. The angle of incidence for a ray of light having zero reflection angle is

- (a) 90° (b) 45° (c) 30° (d) 0°

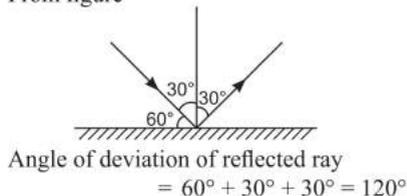
Answers

1. (b) 2. (d)
3. (c) Light is an electromagnetic wave in nature which do not require any medium for its propagation.
4. (a) 5. (b) 6. (c) 7. (a)

8. (c) $\angle i + \angle r = 60^\circ$, but $\angle i = \angle r$

$$\therefore \angle i = 30^\circ$$

9. (d) From figure



10. (d)



**Very Short Answer
Type Questions 2 Marks**



11. State the two laws of reflection of light.

Ans. Laws of reflection of light

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

12. List four characteristics of the images formed by plane mirrors. [Delhi 2015; Foreign 2013]

Ans. Characteristics of image formed by a plane mirror

- (i) It is always virtual and erect.
(ii) The size of image is equal to that of the object.
(iii) The image is formed at the same distance behind the mirror as the object is in front of the mirror.
(iv) The image is laterally inverted.

PRACTICE QUESTIONS

1. The law of reflection holds good for:

- (a) plane mirror only.
(b) spherical mirror only.
(c) parabolic mirror only.
(d) any highly polished surface irrespective of their shape.

2. Straight line propagation of light is due to

- (a) large velocity
(b) small wavelength
(c) its unabsorption by surroundings
(d) its reflection by surroundings

3. Choose the incorrect statement from the following:

- (a) For a smooth surface, reflected light rays travel in the same direction.
(b) For a rough surface, reflected light rays travel in the same direction.
(c) For a rough surface, reflected light rays scatter in all directions.
(d) Flat, still water surface acts as a reflective surface.

4. (a) State the difference between ray and beam of light.

- (b) What is the angle of reflection when a ray of light falls normally on a smooth reflecting surface?

TOPIC COVERED

Spherical Mirrors



Multiple Choice Questions

1 Mark



- The surface of the spoon curved inwards can be approximated to
 - convex mirror
 - concave mirror
 - plane mirror
 - concavo convex mirror
- The centre of the reflecting surface of a spherical mirror is a point called
 - centre of curvature
 - focus
 - pole
 - none of the above
- Centre of curvature of a convex mirror lies
 - behind the mirror
 - infront of the mirror
 - at the surface of the mirror any where
 - at infinity
- Principal axis of a spherical mirror is always normal to the mirror at its
 - focus
 - pole
 - centre of curvature
 - both (a) and (c)
- Diameter of the reflecting surface of spherical mirror is called
 - radius of curvature
 - focal length
 - aperture
 - both (a) and (b)
- A concave mirror of radius 30 cm is placed in water. It's focal length in air and water differ by
 - 15
 - 20
 - 30
 - 0
- A real image is formed by the light rays after reflection or refraction when they:
 - actually meet or intersect with each other.
 - actually converge at a point.
 - appear to meet when they are produced in the backward direction.
 - appear to diverge from a point.

Which of the above statements are correct?

- (A) and (D)
- (B) and (D)
- (A) and (B)
- (B) and (C)

[CBSE 2020]

Answers

- (b)
- (c)
- (a)
- (b)
- (c)
- (d) The focal length of spherical mirror does not depends on the surrounding medium.
- (c) (A) and (B)



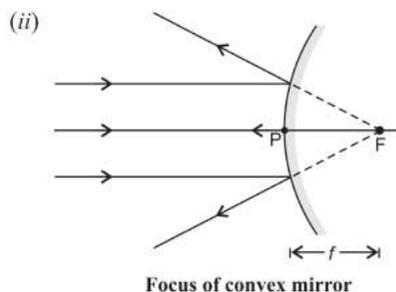
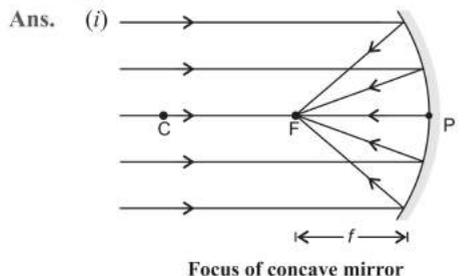
Very Short Answer Type Questions 2 Marks



- Explain why a ray of light passing through the centre of curvature of a concave mirror, gets reflected along the same path.
 - State the type of mirror that can make a parallel beam of light when light from a point source is incident on it. At what location on the principal axis, this point source is placed?

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

- Draw ray diagrams to show the principal focus of a
 - concave mirror
 - convex mirror



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

[AI 2017]

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

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

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

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

SA Short Answer Type Questions 3 Marks

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

- (i) Pole
- (ii) Centre of curvature
- (iii) Principal axis
- (iv) Principal focus

Ans. (i) **Pole:** The central point of the reflecting spherical surface is called the pole (P). It lies on the surface of the mirror.
 (ii) **Centre of Curvature:** The centre of the hollow sphere of which the spherical mirror is a part, is called the centre of curvature (C).

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

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

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

Ans. **Difference between real image and virtual image**

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

PRACTICE QUESTIONS

- Centre of curvature of a spherical mirror is
 - (a) not a part of the mirror
 - (b) lies outside its reflecting surface
 - (c) both (a) and (b)
 - (d) neither (a) nor (b)
- A student obtained a bright and sharp image of a sun by using a concave mirror and exposed to it sunlight for some time, it catches fire because
 - (a) reflected ray has more energy
 - (b) the heat produced due to the concentration of sunlight at the focus of a concave mirror ignites the paper.
 - (c) high temperature of atmosphere able to burn the paper itself and sun rays have no role.
 - (d) none of these
- The relation $R = 2f$ is valid:
 - (a) For concave mirrors but not for convex mirrors
 - (b) For convex mirrors but not for concave mirrors
 - (c) Neither for concave mirrors nor for convex mirrors
 - (d) For both concave and convex mirrors
- (a) Where the principal focus of a spherical mirror lies exactly?
 - (b) If the radius of curvature of a concave mirror is twice that of convex mirror, what is the ratio of their focal length?
- (a) Define focal length of spherical mirror.
 - (b) How we can we find an approximate focal length of a concave mirror? Give reason.

TOPIC COVERED

Image Formation by Concave Mirror

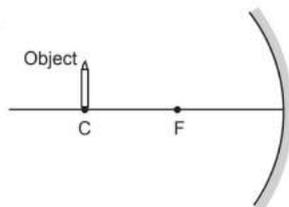


Multiple Choice Questions

1 Mark



1.



Which of the following statements is not true in reference to the diagram shown above? [CBSE 2021]

- Image formed is real.
 - Image formed is enlarged.
 - Image is formed at a distance equal to double the focal length.
 - Image formed is inverted.
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]
- real
 - inverted
 - virtual and inverted
 - virtual and erect
3. For a real object, which of the following can produce a real image?
- Plane mirror
 - Concave mirror
 - Concave lens
 - Convex mirror
4. The nature of the image formed by concave mirror when the object is placed between the focus (F) and centre of curvature (C) of the mirror observed by us is
- real, inverted and diminished
 - virtual, erect and smaller in size
 - real, inverted and enlarged
 - virtual, upright and enlarged
5. 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]
- Infinity
 - 30 cm
 - Between 15 cm and 30 cm
 - Between 0 cm and 15 cm

6. An object at a distance of 30 cm from a concave mirror gets its image at the same point. The focal length of the mirror is

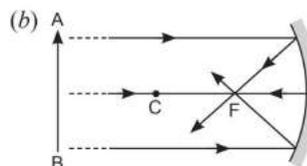
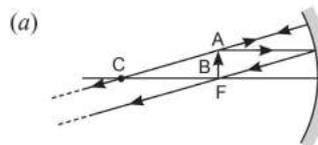
- 30 cm
- 30 cm
- 15 cm
- +15 cm

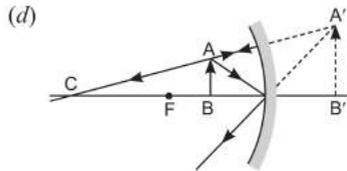
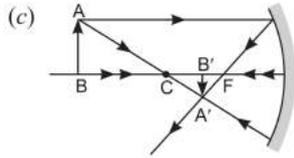
Questions 7, 8, 9 and 10 are based on the following passage.

The image below shows a student demonstrating that sun-rays concentrated to a point using a spherical mirror can burn a paper as a science project. [CFPQ, CBSE]



7. What is the term used for the distance between the mirror and the paper?
- radius of curvature
 - principal focus
 - principal axis
 - focal length
8. What kind of image would be formed on the paper?
- Real and diminished
 - Real and enlarged
 - Virtual and diminished
 - Virtual and enlarged
9. The student wants to depict the above experiment as a ray diagram. Which of the following diagram should he draw?





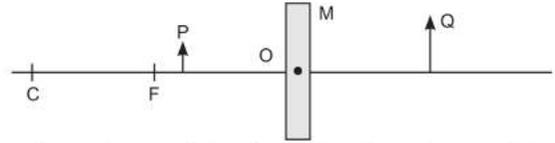
10. If the student wishes to point the mirror to another object so as to obtain a virtual enlarged image, what should be the position of object with respect to the mirror?
- At principal focus
 - At centre of curvature
 - Between pole and principal focus
 - Between centre of curvature and principal focus

Answers

- (b)
- (d) virtual and erect
- (b) Only concave mirror can produce a real image for any position of object between its focus and infinity.
- (c) When object lies between C and F, the real, inverted and enlarged image is formed beyond C.
- (d)
- (c) When object is placed at $2F$, the image formed by concave mirror is also at $2F$. So $2f = -30$ or $f = -15$ cm.
- (d) focal length
- (a) Real and inverted because rays actually intersect after reflection and image can be taken on the screen.
- (b)
- (c)

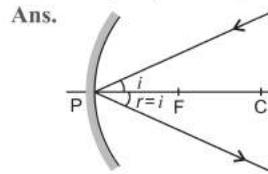
VSA Very Short Answer Type Questions 2 Marks

11. List four properties of the image formed by a concave mirror, when object is placed between focus and pole of the mirror.
- Ans. (i) Behind the mirror
(ii) Enlarged, i.e. magnified
(iii) Virtual
(iv) Erect
12. Consider the following diagram in which M is a mirror and P is an object and Q is its magnified image formed by the mirror.



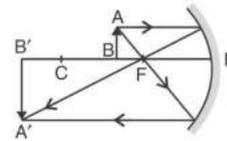
State the type of the mirror M and one characteristic property of the image Q. [Delhi 2016]

- Ans. The given mirror M is a concave spherical mirror. When the object lies between the pole and the focus of the concave mirror, an erect, virtual and enlarged image is formed. So one characteristic property of the image Q formed in the given figure is that it is virtual.
13. For a concave mirror draw a ray diagram to show the reflected ray when the ray of light incident obliquely on the pole of mirror.



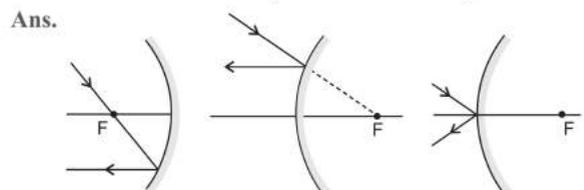
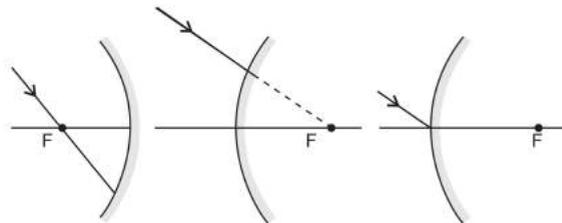
14. What is the minimum number of rays required for locating the image formed by a concave mirror for an object? Draw a ray diagram to show the formation of a virtual image by a concave mirror.

Ans. Two rays are required.



SA Short Answer Type Questions 3 Marks

15. Draw the following diagram in which a ray of light is incident on a concave/convex mirror on your answer sheet. Show the path of this ray, after reflection, in each case. [Delhi 2016]



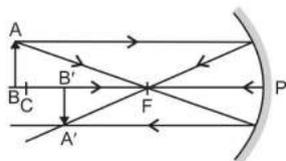
16. For the given data showing the focal lengths of three concave mirrors A, B and C, and the respective distances of different objects from these mirrors.

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

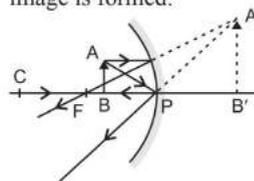
Answer the following questions:

- (a) In the given position of object from the mirrors, which mirror will form a diminished image of the object. Draw a ray diagram for image formation by this mirror.
- (b) Which mirror can be conveniently used as a make-up mirror? Draw a ray diagram to illustrate this function.

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



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



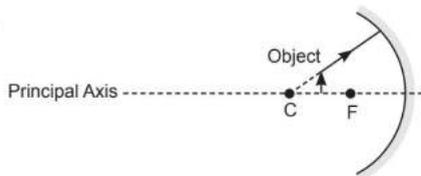
17. "A concave mirror of focal length 15 cm can form a magnified erect as well as inverted image of an object placed in front of it." Justify this statement stating the position of the object with respect to the pole of the mirror in both cases for obtaining the images. [AI 2014, 13]

Ans. (i) When the object is placed between P (pole) and F (focus) of the concave mirror, we get a magnified and erect image.

(ii) When the object is placed between C (centre of curvature) and F (focus), we get a magnified and inverted image.

PRACTICE QUESTIONS

- Under which of the following condition(s) a concave mirror can form an enlarged image?
 - At C
 - At F
 - Between C and F
 - Beyond C
- The image formed by concave mirror is real for the position of object
 - at infinity
 - at centre of curvature
 - at its focus
 - all of these
-



While looking at the above diagram, Nalini concluded the following-

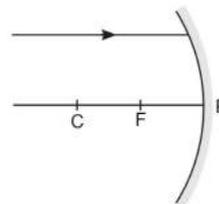
- the image of the object will be a virtual one.
- the reflected ray will travel along the same path as the incident ray but in opposite direction.
- the image of the object will be inverted.

- (iv) this is a concave mirror and hence the focal length will be negative.

Which one of the above statements are correct?

[CBSE Sample Paper 2022]

- (i) and (ii)
 - (i) and (iii)
 - (ii), (iii) and (iv)
 - (i), (ii), (iii) and (iv)
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.



5. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object with respect to the mirror? Draw ray diagram to justify your answer.

TOPIC COVERED

Image Formation by Convex Mirror



Multiple Choice Questions

1 Mark

- The nature of image formed by a convex mirror when the object distance from the mirror is less than the distance between pole and focal point (F) of the mirror would be
 - real, inverted and diminished in size
 - real, inverted and enlarged in size
 - virtual, upright and diminished in size
 - virtual, upright and enlarged in size
- An object at a distance of +15 cm is slowly moved towards the pole of a convex mirror. The image will get
 - shortened and real
 - enlarged and real
 - enlarge and virtual
 - diminished and virtual
- On moving the object from infinity towards the pole of the convex mirror, the image moves from
 - focus towards pole
 - focus towards centre of curvature
 - pole to infinity on the same side of object
 - focus to infinity behind the mirror
- If the object moves away from the pole of a convex mirror, then, the size of image gradually changes from
 - highly enlarged to enlarged
 - diminished to point size
 - highly diminished to diminished
 - highly diminished to same size of object

Answers

- (c) Convex mirror always forms a virtual, erect diminished image irrespective of the position of object in front of it.
- (d) Convex mirror always formed virtual and diminished image.
- (a)
- (b)



Very Short Answer Type Questions 2 Marks

- List four specific characteristics of the images of the object formed by convex mirrors. [Delhi 2015, 12]

Ans. Properties of image formed by a convex mirror:

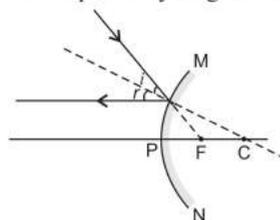
- It always formed behind the mirror, between the pole and its focus.
- The image is always virtual and erect.
- The size of image is always smaller than the object.
- Magnification is always positive.

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

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

- Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed towards the principal focus of a convex mirror. Mark on it the angle of incidence and the angle of reflection. [Delhi 2014]

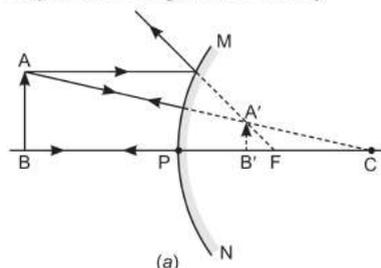
Ans. The required ray diagram is as follows:



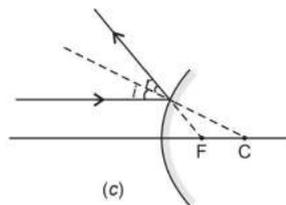
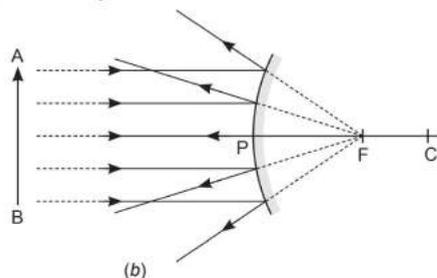
- If the image formed by a spherical mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it? Draw a labelled ray diagram to support your answer. [CBSE 2018, AI 2015, Foreign 2016]

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

- Object between pole and infinity



(ii) At infinity



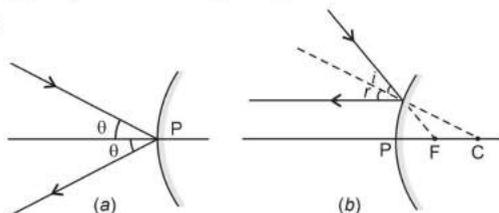
S **A** Short Answer Type Questions

3 Marks

9. Draw a ray diagram to show the path of the reflected ray in each of the following cases. A ray of light incident on a convex mirror. [Foreign 2015]

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

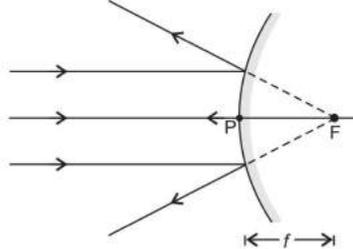
Ans.



10. 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]

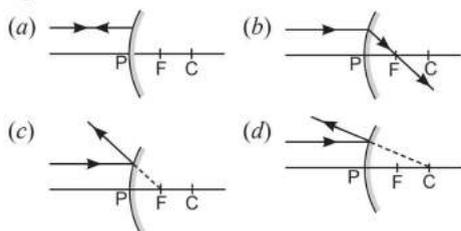
- Ans. (i) The point 'F' on the principal axis, where the incident light rays parallel to the principal axis appear to diverge or come from after reflection, is called its principal focus (F) of a diverging mirror. In case of a diverging mirror, principal focus lies on the opposite side of the reflecting surface.
- (ii) The distance between the pole and the focus of the mirror is called the focal length of the mirror. For a diverging mirror, focal length is always positive.



Focus of convex mirror

PRACTICE QUESTIONS

1. Which of the following ray diagram is correct for the ray of light incident on a convex mirror as shown in figure?



- 2. Give reason (s): We cannot obtain an image formed by a convex mirror on a screen.
- 3. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray of light parallel to the principal axis of a convex mirror and show the angle of incidence and the angle of reflection on it.

4. 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.

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

6. The focal length of a convex mirror is 15 cm. A object is placed at a distance equal to its radius of curvature in front of it. Draw a ray diagram to show the image formation in this case. What kind of image is formed?

TOPIC COVERED

Sign Convention for Reflection by Spherical Mirror



Multiple Choice Questions

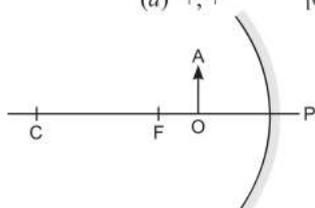
1 Mark



1. 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 image distance in this case are respectively:

(a) +, - (b) -, +
(c) -, - (d) +, + [CBSE 2023]

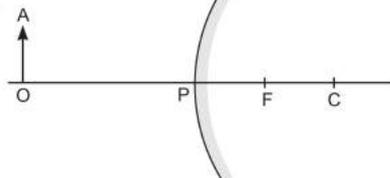
2.



For the diagram shown, according to the New Cartesian Sign convention the magnification of the image formed will have the following specifications: [CBSE 2021]

- (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

3.



For the diagram shown, according to new Cartesian sign convention, the object distance (u) and focal length (f) of the mirror will have the following specifications:

- (a) u – negative, f – positive
(b) u – negative, f – negative
(c) u – positive, f – negative
(d) u – positive, f – positive

Answers

1. (d) Both lies on +ve x -axis.
2. (b)
3. (a)



Short Answer Type Question

3 Marks



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

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

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

PRACTICE QUESTIONS

1. According to the Cartesian Sign convention, the sign assigned to image distance (v) and height of the image (h_i) formed by convex mirror:
- (a) both will have negative in sign
(b) both will have positive in sign
(c) negative sign for image distance and positive sign for image height
(d) positive sign for image distance and negative sign for image height.
2. What is the sign convention for the image distance formed by concave mirror?
3. What are the sign convention for the height of (a) real image (b) virtual image formed by spherical mirrors? Give reason.

TOPICS COVERED

Mirror Formula and Magnification



Multiple Choice Questions

1 Mark

- A concave mirror of focal length 20 cm forms an image having twice the size of object. For the virtual position of image, the position of object will be at
(a) 25 cm (b) 40 cm
(c) 10 cm (d) At infinity
- If a man's face is 25 cm in front of concave shaving mirror producing erect image 1.5 times the size of face, focal length of the mirror would be
(a) 75 cm (b) 25 cm
(c) 15 cm (d) 60 cm
- What is the position of the object placed on the side of reflecting surface of a concave mirror of focal length 15 cm if the image is formed at the distance of 30 cm from the mirror?
(a) 15 cm (b) 30 cm
(c) 25 cm (d) 40 cm
- An object of height 4 cm is kept at a distance of 30 cm from the pole of a diverging mirror. If the focal length of the mirror is 10 cm, the height of the image formed is [CBSE 2021]
(a) +3.0 cm (b) +2.5 cm
(c) +1.0 cm (d) +0.75 cm

Answers

- (c) For virtual image,

$$m = -\frac{v}{u} = +2 \Rightarrow v = -2u$$
 As $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

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

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

$$\Rightarrow u = -10 \text{ cm}$$
- (a) In concave shaving mirror, virtual erect and large size image, behind the mirror is obtained, using

$$m = -\frac{v}{u} \Rightarrow 1.5 = -\frac{v}{-25}$$

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

Now, from mirror formula,

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

$$= \frac{1}{75/2} + \frac{1}{-25} = -\frac{1}{75}$$

$$\therefore f = -75 \text{ cm}$$

Hence, focal length of concave mirror is 75 cm.

- (b) When an object is placed at the centre of curvature in front of a concave mirror, image is also formed at the centre of curvature, so $u = -2f = v = 30 \text{ cm}$.
- (c) Mirror formula, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$ gives
 $v = +7.5 \text{ cm}$ and
 Magnification, $m = \frac{h_i}{h_o} = -\frac{v}{u}$
 $\Rightarrow h_i = +1.0 \text{ cm}$



Very Short Answer

Type Question 2 Marks

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

Ans. Concave mirror as it forms a real image.

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

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

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

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

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

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

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

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



Short Answer Type Questions

3 Marks



6. An object 4 cm in height, is placed at 15 cm in front of a concave mirror of focal length 10 cm. At what distance from the mirror should a screen be placed to obtain a sharp image of the object. Calculate the height of the image. [Delhi 2017]

Ans. Given: $h_1 = +4$ cm, $f = -10$ cm, $u = -15$ cm, $v = ?$ and $h_2 = ?$

Using spherical mirror formula, we get

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} + \frac{1}{u} \\ \Rightarrow \frac{1}{-10} &= \frac{1}{v} - \frac{1}{15} \\ \frac{1}{v} &= \frac{1}{-10} + \frac{1}{15} = \frac{-3+2}{30} = -\frac{1}{30} \\ \therefore v &= -30 \text{ cm} \end{aligned}$$

Thus, screen should be placed at a distance of 30 cm on the same side of the object to obtain its sharp image.

Now, $\frac{h_2}{h_1} = \frac{v}{u}$

$$\begin{aligned} \therefore h_2 &= \frac{v}{u} \times h_1 = \frac{-30}{-15} \times 4 \text{ cm} \\ &= 8 \text{ cm} \end{aligned}$$

The height of real and inverted image is 8 cm.

7. An object is placed at a distance of 30 cm from a convex mirror, the magnification produced is $1/2$. Where should the object be placed to get the magnification of $1/3$? [HOTS]

Ans. Given: $u = -30$ cm, $m = 1/2$

Using the formula,

$$m = -\frac{v}{u} \quad (\text{For a convex spherical mirror})$$

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

Using mirror formula,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} + \frac{1}{u} \\ \Rightarrow \frac{1}{f} &= \frac{1}{15} + \frac{1}{-30} = \frac{1}{30} \\ \therefore f &= +30 \text{ cm} \end{aligned}$$

Again, $m' = -\frac{v'}{u'}$

$$\frac{1}{3} = -\frac{v'}{u'} \Rightarrow v' = -\frac{u'}{3}$$

Using again, $\frac{1}{f} = \frac{1}{v'} + \frac{1}{u'}$

$$\begin{aligned} \therefore \frac{1}{30} &= -\frac{3}{u'} + \frac{1}{u'} = -\frac{2}{u'} \\ \Rightarrow u' &= -60 \text{ cm} \end{aligned}$$

Hence the object should be placed at a distance of 60 cm in front of a convex mirror to get the magnification of $1/3$.

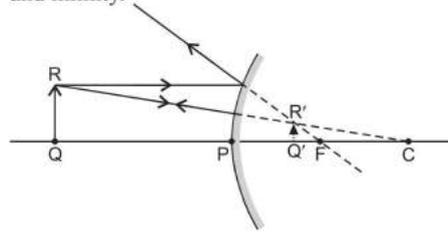
8. "The linear magnification produced by a spherical mirror is $+1/3$. Analysing this value state the (a) type of mirror and (b) position of the object with respect to the pole of the mirror. Draw ray diagram to justify your answer. [Foreign 2014]

Ans. (a) Since the magnification is $+1/3$, the image is virtual. It is a convex mirror.

(b) $m = \frac{\text{Image distance}}{\text{Object distance}}$

$$= \frac{\text{height of image}}{\text{height of object}} = \frac{h_i}{h_o} = +\frac{1}{3}$$

The Image formed is of smaller size than the size of object placed in front of the mirror while the object is placed anywhere between the pole (P) of the mirror and infinity.



9. Draw a diagram and apply Cartesian sign conventions for calculating the focal length and nature of a spherical mirror which forms a $1/3$ times magnified virtual image of an object placed 18 cm in front of it.

Ans. According to question, for a virtual image

$$m = +\frac{1}{3}, u = -18 \text{ cm}$$

But, $m = -\frac{v}{u} = +\frac{1}{3}$

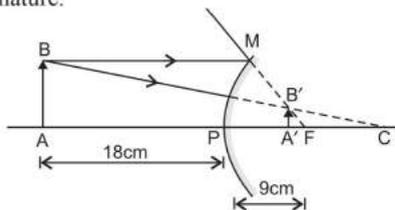
$$\Rightarrow v = -\frac{u}{3} = -\frac{-18}{3} = +6 \text{ cm}$$

Using mirror formula,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} + \frac{1}{u} = \frac{1}{6} + \frac{1}{-18} \\ &= \frac{1}{6} - \frac{1}{18} = \frac{3-1}{18} = \frac{2}{18} = \frac{1}{9} \end{aligned}$$

$$\therefore f = +9 \text{ cm}$$

So, the focal length of the given spherical mirror is 9 cm. The positive sign shows the given mirror is convex in nature.



A Long Answer
Type Questions 5 Marks

10. A student has focussed the image of a candle flame on a white screen using a concave mirror. The situation is as given below:

Length of the flame = 1.5 cm

Focal length of the mirror = 12 cm

Distance of flame from the mirror = 18 cm

If the flame is perpendicular to the principal axis of the mirror, then calculate the following:

- (a) Distance of the image from the mirror
(b) Length of the image.

If the distance between the mirror and the flame is reduced to 10 cm, then what would be observed on the screen? Draw ray diagram to justify your answer for this situation. [Foreign 2015]

Ans. Given: $h_o = +1.5$ cm, $f = -12$ cm, $u = -18$ cm

(a) For a concave mirror, using mirror formula

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

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-12} - \frac{1}{-18}$$

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

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

or $v = -36$ cm

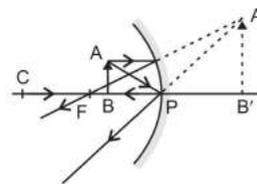
So, the distance of the image from the mirror is 36 cm, the negative sign indicates that the image is formed on the same side of the object.

(b) Using the formula $m = \frac{h_i}{h_o} = -\frac{v}{u}$

or $h_i = -\frac{v}{u} \times h_o = -\frac{-36}{-18} \times 1.5$
 $= -3.0$ cm

So, the length of the image is 3.0 cm.

If the distance between the mirror and the flame is reduced to 10 cm, no image is formed on the screen as the object lies between the focus and the pole of the mirror. So, a virtual image behind the mirror is obtained as shown in the figure given below.



11. An object 4.0 cm in size, is placed 25.0 cm in front of a concave mirror of focal length 15.0 cm.

- (a) At what distance from the mirror should a screen be placed in order to obtain a sharp image?
(b) Find the size of the image.
(c) Draw a ray diagram to show the formation of image in this case. [CBSE 2020]

Ans. (a) Given: For concave mirror, Object distance (u) = -25 cm; Focal length (f) = -15 cm; Height of object (h_o) = 4.0 cm

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

Substituting u and f , we get

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

$$= \frac{1}{-15} - \frac{1}{-25} = \frac{-2}{75}$$

$v = -37.5$ cm

Therefore, the screen should be placed in front of the mirror *i.e.* on same side of the object at a distance of 37.5 cm from the mirror in order to obtain the sharp image of the object on it.

(b) Magnification of the mirror is given by

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

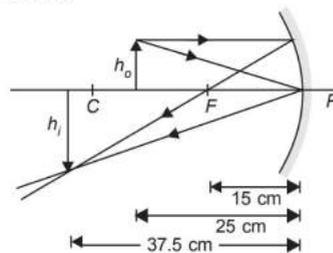
$$h_i = -h_o \times \frac{v}{u}$$

$$= -4 \times \frac{-37.5}{-25} = -6$$

Therefore, size of image is 6 cm.

Since $h_i > h_o$, the image is enlarged and negative sign of v shows that image is real and inverted.

(c) Ray diagram to show the formation of image in the case.



PRACTICE QUESTIONS

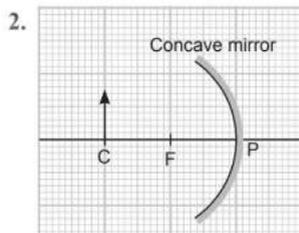
1. Consider the situation where:

- An object is 3 cm (height).
- Mirror is concave with 6 cm focal length.
- Object is placed at the centre of curvature.

Which of the following options are correct?

[CBSE Sample Paper 2021]

- (a) The mirror will produce an image of magnification +1.5.
- (b) The mirror will produce an image of magnification -1.
- (c) The mirror will produce an image of magnification +1.
- (d) The mirror will produce an image of magnification -1.5.



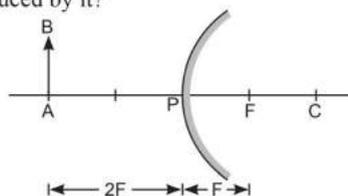
Examine the above figure and state which of the following option is correct? [One small box in the figure is equal to 1 cm] [CBSE Sample Paper 2022]

- (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.

3. The linear magnification produced by a spherical mirror is $-1/5$. 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. [Foreign 2014]

4. An object is kept in front of a concave mirror of focal length 20 cm. The image is three times the size of the object. Calculate two possible distances of the object from the mirror.

5. An object is kept in front of a convex mirror as shown in figure. What will be the value of magnification produced by it?



6. An object is kept at a certain distance in front of a concave mirror with a focal length of 12 cm. The real image is formed at a point that is 10 cm away from the object. Calculate the magnification of the image formed by mirror.

7. An object 2 cm in size is placed 30 cm in front of a concave mirror of focal length 15 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? What will be the nature and the size of the image formed? Draw a ray diagram to show the formation of the image in this case.

8. 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 following:

- (i) Distance of the image from the mirror
- (ii) Height of the image

[CBSE 2023]

TOPIC COVERED

Uses of Spherical Mirrors



Multiple Choice Questions

1 Mark

1. In which of the following is a concave mirror used?

[CBSE 2021]

- (a) A solar cooker.
- (b) A rear view mirror in vehicles.

(c) A safety mirror in shopping malls.

(d) In viewing full size image of distant tall buildings.

2. Which of the following mirror is used by a dentist to examine a small cavity?

(a) Convex mirror

(b) Plane mirror

(c) Concave mirror

(d) Combination of convex and concave mirror

3. **Magnification produced by the rear-view mirror fitted in vehicles**

- (a) is equal to one
- (b) is greater than one
- (c) is less than one
- (d) depends on distance and height of the vehicle behind the driver's vehicles.

4. **A full length image of the Taj Mahal can definitely be seen by using**

- (a) a plane mirror
- (b) a concave mirror
- (c) a convex mirror
- (d) all of these

Answers

- 1. (a)
- 2. (c) Concave mirror forms erect and enlarged image when held close to the cavity.
- 3. (c) A rear-view mirror fitted in vehicles is convex in nature. Convex mirror always forms virtual, erect and diminished image irrespective of the object distance, i.e. $v < u$. So, magnification produced by it is always less than 1.
- 4. (c)

VSA Very Short Answer Type Questions 2 Marks

5. **What should be the position of the object, when a concave mirror is used:** [DoE]

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

- Ans. (a) Object should be placed between pole and focus.
(b) Object should be placed at focus.

6. **“Vehicles in this mirror are closer than they appear”. Why is this warning printed on the side view mirror of most vehicles?** [DoE]

Ans. The phrase “vehicles in this mirror are closer than they appear” is a safety warning printed on the side view mirror of most vehicles. It is present because the side view mirror is a convex mirror and it gives a virtual image of wide field behind the vehicle and appears the objects smaller and farther away than they actually are, and the angular size of the virtual image is also smaller than the angular size of the object. During the lane change, a driver assumes that an adjacent

vehicle is at a safe distance behind, when in fact it is quite a bit closer. The warning serves as a reminder to the driver of this potential problem.

SA Short Answer Type Questions 3 Marks

7. **Name the type of mirror used**

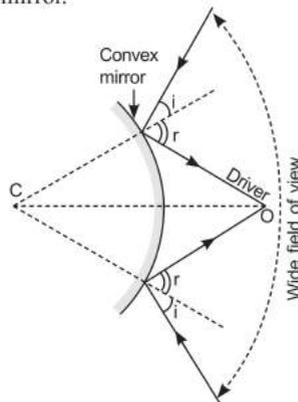
- (a) by dentist and (b) in vehicles headlights
- Give reason why such mirrors are used in each case.**

- Ans. (a) Dentists use a concave mirror because it converges the light and when the object lies between its pole and principal focus, it forms a virtual, erect and enlarged image behind it. Hence they use the concave mirror so that they could see the cavity or plaque clearly, which is inside the teeth.
- (b) Concave mirror is used in the vehicle headlights. The light bulb is placed at its focus. The light rays emitted from the bulb, after reflection from the mirror becomes parallel to the principal axis. This powerful parallel beam of light enabling the driver to see the road ahead clearly.

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

- Ans. Convex mirror is used because
- (i) it always produces a virtual and erect image between its pole and focus.
 - (ii) the size of image formed is smaller than the object irrespective of position of object.

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



PRACTICE QUESTIONS

1. In torches, search light and vehicles head lights the source of light is placed
- (a) between the focus and centre of curvature of the reflector.

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

2. If you look into the mirror and find that the image of your face is larger than your face, then the type of mirror is
- (a) concave mirror
(b) convex mirror

- (c) plane mirror
(d) combination of plane and concave mirror
3. Name the type of the mirrors used in design of solar furnaces. Explain how high temperature is achieved by this device.

TOPIC COVERED

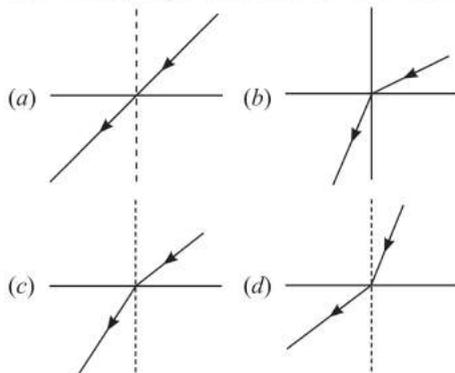
Refraction of Light



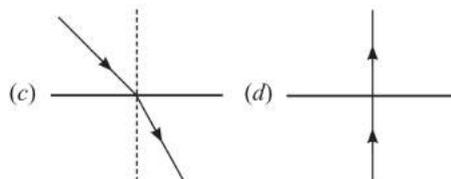
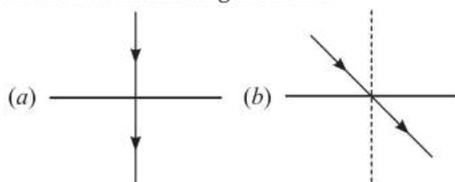
Multiple Choice Questions

1 Mark

1. The phenomenon of light exhibit in the case of apparent displacement of a pencil, partly immersed in water is
- (a) refraction (b) reflection
(c) dispersion (d) scattering
2. As light travels from optically rarer medium to an optically denser medium, it will have
- (a) increase in velocity
(b) decrease in velocity
(c) no change in velocity
(d) cannot say
3. Which of the following figures shows refraction of light while going from denser to rarer medium?



4. Which of the following figure shows no refraction of light when it is incident normally on a boundary of the two interfacing medium?



5. A real image is formed by the light rays after reflection or refraction when they:
- (A) actually meet or intersect with each other.
(B) actually converge at a point.
(C) appear to meet when they are produced in the backward direction.
(D) appear to diverge from a point.
- Which of the above statements are correct?

[CBSE 2020]

- (a) (A) and (D)
(b) (B) and (D)
(c) (A) and (B)
(d) (B) and (C)

Answers

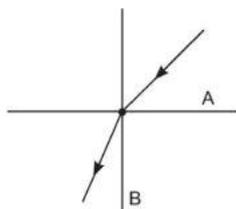
1. (a)
2. (b) When the optical density of the medium increases, its refractive index value also increases, and the speed of light in that medium decreases as both are inversely proportional to each other.
3. (d)
4. (a)
5. (c) (A) and (B)



Very Short Answer Type Questions 2 Marks

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

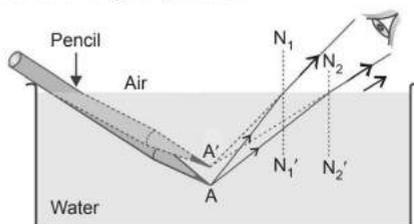
[DoE]



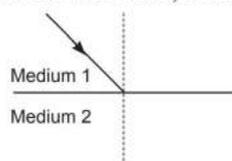
Ans. The given figure shows that the ray of light bends towards the normal after refraction, when it enters from medium A to medium B and $\angle i > \angle r$. This indicates that medium B is optically denser than A.

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

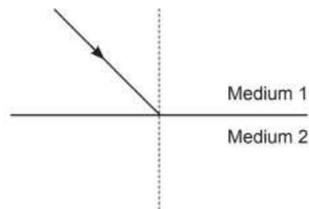
Ans. The light from different points on the pencil, immersed in water, refracts and appears to come from a point above the original position.



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



Case I: (medium 1 having higher refractive index)



Case II: (medium 2 having higher refractive index)

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

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

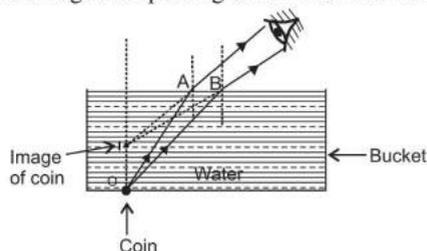
Case II: bend towards the normal in medium 2 after refraction.

SA Short Answer Type Question

3 Marks

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

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



PRACTICE QUESTIONS

- A lemon is kept in water in a glass tumbler, when viewed from the side appears to be
 - bigger than its actual size
 - smaller than its actual size
 - same size as the as the actual size
 - dark
- Choose the incorrect statement from the following:
 - Letters appear to be raised, when seen through a glass slab placed over it.
 - Light does not travel in the same direction in all media.

- Speed of light in different media is same.
- All of the above

- For the same angle of incidence 45° , the angle of refraction in two transparent medium I and II are 20° and 30° respectively. Out of I and II, which medium is optically denser and why?
- A ray of light travelling in air enters obliquely into water. Does the light ray bend towards or away from the normal? Why? Draw a ray diagram to show the refraction of light in this situation.

TOPIC COVERED

Refraction Through a Rectangular Glass Slab



Multiple Choice Questions

1 Mark

1. A light ray incident on a rectangular glass slab, after emerging from the opposite parallel faces, it is found that the

(a) $\angle i > \angle e$ (b) $\angle i < \angle e$
 (c) $\angle i = \angle e$ (d) $\angle i \neq \angle e$

where $\angle i$ = angle of incidence
 $\angle e$ = angle of emergence

2. Choose the correct statement for a rectangular glass slab.

(a) The emergent ray is not shifted sideways slightly
 (b) The emergent ray is perpendicular to the incident ray.
 (c) The ray emerges parallel to the incident ray.
 (d) The incident and emergent rays are inclined towards each other.

3. A ray of light falling on a glass slab at 90° . The angle of incidence is

(a) 90° (b) zero
 (c) $< 90^\circ \neq 0$ (d) greater than 90°

4. Mohit took a thick glass slab whose one opposite parallel face is silvered. He observed that it formed multiple images. This happened on account of

(a) refraction of light (b) reflection of light
 (c) dispersion of light (d) both (a) and (b)

5. A student suggested the following 'guidelines' to his friend for doing the experiment on tracing the path of a ray of light passing through a rectangular glass slab for three different angles of incidence:

[Delhi 2008]

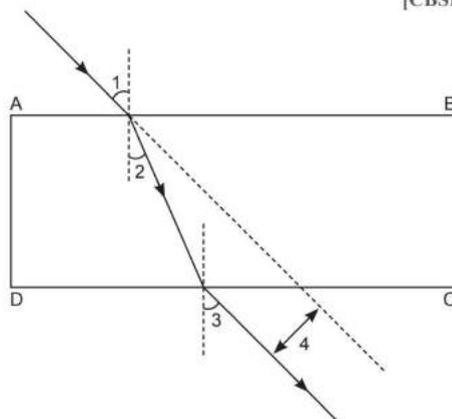
- Draw the 'outline' of the glass slab at three positions on the drawing sheet.
- Draw 'normals' on the top side of these 'outlines' near their left end.
- Draw the incident rays on the three 'outlines' in directions making angles of 30° , 45° , 60° with the normals drawn.
- Fix two pins vertically on each of these incident rays at two points nearly 1 cm apart.
- Look for the images of the 'heads' of these pins while fixing two pins from the other side, to get the refracted rays.

When he showed these 'guidelines' to his teacher, the teacher corrected and modified the 'guidelines' labelled as

(a) B, C, E (b) B, D, E
 (c) B, C, D (d) C, D, E

6. A student has traced the path of ray of light through a glass slab as follows. If you are asked to label 1, 2, 3 and 4, the correct sequence of labelling $\angle i$, $\angle e$, $\angle r$ and lateral displacement respectively is

[CBSE 2016]



(a) 2, 1, 3, 4
 (b) 1, 2, 3, 4
 (c) 1, 3, 2, 4
 (d) 1, 3, 4, 2

7. Select the correct statement(s) from the following regarding refraction of light when light is incident from the optically denser medium A on a optically rarer medium B.

- Light will bend towards the normal in medium B.
- Speed of light will be more in medium B as compared to medium A.
- Angle of refraction will be more than angle of incidence.
- Angle of refraction will be less than angle of incidence.

(a) Both I and II
 (b) Both II and III
 (c) Both II and IV
 (d) Only I, II and IV

Answers

- (c)
- (c)
- (b) When light rays incident along the normal, then by definition the angle of incidence is zero.
- (d) Silvered face acts as a smooth reflecting surface.
- (b) The normals are not generally at the ends.
While fixing pins, the foot has to be taken as reference. The pins should be far off from each other.
- (c)
- (b)

VSA Very Short Answer Type Question 2 Marks

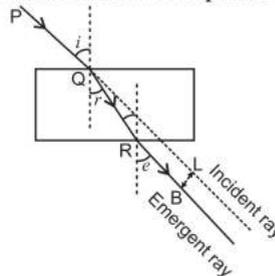
- Why does the emergent ray in a glass slab is parallel to the incident ray?
 - Why does the emergent ray shift sideways?
- Ans. (a) We know that, in case of refraction, when incident ray travels from air to glass, it bends towards normal and bends away from the normal when it travels through glass to air. Thus, the extent of bending of the ray of light at the opposite parallel faces i.e. air-glass and glass-air interface of rectangular glass slab are equal and opposite. Hence, the emergent ray is parallel to the incident ray in case of refraction through rectangular glass slab.
- The emergent ray shift sideways slightly because of
 - angle of incidence, and
 - thickness of glass slab

SA Short Answer Type Questions 3 Marks

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

Ans.

 - When a ray of light passes through the glass slab, it bends twice.
 - First time, at air-glass interface, it bends towards normal at denser medium i.e., inside glass slab. It is due to decrease in the speed of refracted light ray.
 - Second time, at glass-air interface, the speed of light of refracted ray in rarer medium increases and the ray bends away from the normal.
- What is understood by lateral displacement of light? Illustrate it with the help of a diagram. List any two factors on which the lateral displacement of a particular substance depends.

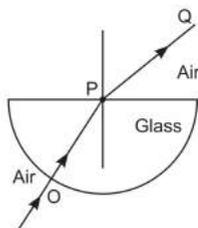


- Ans. Lateral displacement is the perpendicular distance between the incident ray produced and emergent ray. The lateral displacement in the given diagram is BL. The lateral displacement depends on the thickness of the slab, the incident angle and the refractive index of the material.

PRACTICE QUESTIONS

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

[CBSE Sample Paper 2022]



- 45°
 - 0°
 - 90°
 - 180°
- Why does a light ray incident on a rectangular glass slab immersed in any medium emerge parallel to itself? Explain using a diagram.

TOPIC COVERED

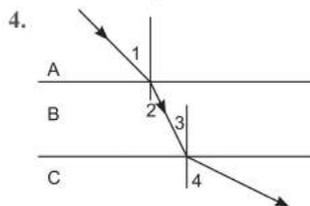
Refractive Index



Multiple Choice Questions

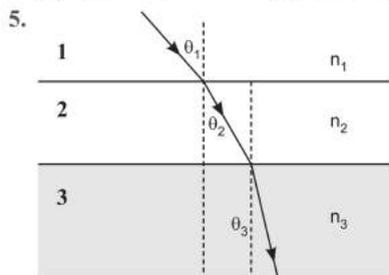
1 Mark

- Snell's law can be derived from which type of incidence of light ray?
 - Angle of refraction
 - Angle of incidence
 - Oblique incidence
 - Angle of reflection
- Which of the following represents correctly Snell's law of refraction?
 - $\frac{\sin r}{\sin i} = \frac{1}{n}$
 - $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$
 - $n_2 \sin i = \text{constant}$
 - All of these
- When an incident ray of light enters a medium from air, it bends towards the normal. Which of the following is TRUE about the refractive index of the medium (n_m) as compared to the refractive index of air (n_a)? [CFPQ, CBSE]
 - n_m is equal to n_a
 - n_m is less than n_a
 - n_m is more than n_a
 - The refractive indices cannot be compared based on the given information.



A ray of light is incident as shown. If A, B and C are three different transparent media, then which among the following options is true for the given diagram? [CBSE 2021]

- $\angle 1 > \angle 4$
- $\angle 1 < \angle 2$
- $\angle 3 = \angle 2$
- $\angle 3 > \angle 4$



In the diagram shown above 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]

- $n_1 = n_2$
 - $n_1 > n_2$
 - $n_2 > n_3$
 - $n_3 > n_1$
- 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]
 - 2×10^8 m/s and 1.33×10^8 m/s
 - 1.33×10^8 m/s and 2×10^8 m/s
 - 2.25×10^8 m/s and 2×10^8 m/s
 - 2×10^8 m/s and 2.25×10^8 m/s
 - You are given three media A, B and C of refractive index 1.33, 1.65 and 1.46. The medium in which the light will travel fastest is
 - A
 - B
 - C
 - equal in all three media

Answers

- (c)
- (b)
- (c) The bending of the ray of light towards the normal indicates that the second medium is an optically denser medium whose refractive index is higher than that of air.
- (c)
- (d) Bending of light ray in medium 3 is more than in medium 1, i.e. $\theta_3 < \theta_1$ so, $n_3 > n_1$.
- (d) Use $v = \frac{c}{n}$.
- (a) As, ${}_a n_m = \frac{v_a}{v_m}$ or $v_m = \frac{v_a}{{}_a n_m}$
So, the light will travel faster in a medium having lower refractive index.



Very Short Answer Type Questions 2 Marks

- A ray of light enters into benzene from air. If the refractive index of benzene is 1.50, by what percent does the speed of light reduce on entering the benzene?

Ans. The absolute refractive index of benzene is given by

$$n = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in benzene } (v)}$$

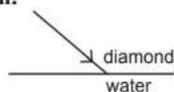
$$1.50 = \frac{3 \times 10^8}{v}$$

$$\Rightarrow v = 2 \times 10^8 \text{ ms}^{-1}$$

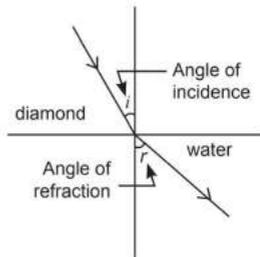
Therefore, percentage decrease in the speed of light on entering the benzene,

$$\begin{aligned} &= \frac{c-v}{v} \times 100\% \\ &= \frac{3 \times 10^8 - 2 \times 10^8}{3 \times 10^8} \times 100 \\ &= \frac{100}{3} \\ &= 33.33\% \end{aligned}$$

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



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



10. With respect to air, the refractive index of ice is 1.31 and that of rock salt is 1.54. Calculate the refractive index of rock salt with respect to ice.

Ans. Given: ${}_{\text{air}}n_{\text{ice}} = 1.31$, ${}_{\text{air}}n_{\text{rock}} = 1.54$

$${}_{\text{ice}}n_{\text{rock}} = \frac{{}_{\text{air}}n_{\text{rock}}}{{}_{\text{air}}n_{\text{ice}}} = \frac{1.54}{1.31} = 1.18$$

11. The refractive index of a medium 'x' with respect to 'y' is $\frac{2}{3}$ and the refractive index of medium 'y' with respect to 'z' is $\frac{4}{3}$. Calculate the refractive index of medium 'z' with respect of 'x'. If the speed of light medium 'x' is $3 \times 10^8 \text{ ms}^{-1}$, calculate the speed of light in medium 'y'. [CBSE 2020, HOTS]

Ans. Given: $n_{xy} = \frac{2}{3}$, $n_{yz} = \frac{4}{3}$, $n_{zx} = ?$

We know that,

$$n_{xy} \times n_{yz} \times n_{zx} = 1$$

$$\Rightarrow \frac{2}{3} \times \frac{4}{3} \times n_{zx} = 1$$

$$\Rightarrow n_{zx} = \frac{9}{8}$$

Speed of light in medium 'y': Let the speed of light in medium 'y' be v and speed of light in medium 'x' is c , then $n_{yx} = \frac{c}{v}$

$$\Rightarrow \frac{1}{n_{xy}} = \frac{c}{v} \Rightarrow \frac{1}{2/3} = \frac{3 \times 10^8}{v}$$

$$\Rightarrow v = 3 \times 10^8 \times \frac{2}{3} = 2 \times 10^8 \text{ ms}^{-1}$$

Hence, the speed of light in medium 'y' is $2 \times 10^8 \text{ ms}^{-1}$.

12. Light enters from air to water having refractive index $\frac{4}{3}$. Find the speed of light in water. The speed of light in vacuum is $3 \times 10^8 \text{ ms}^{-1}$.

Ans. Refractive index of water = $\frac{4}{3}$

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

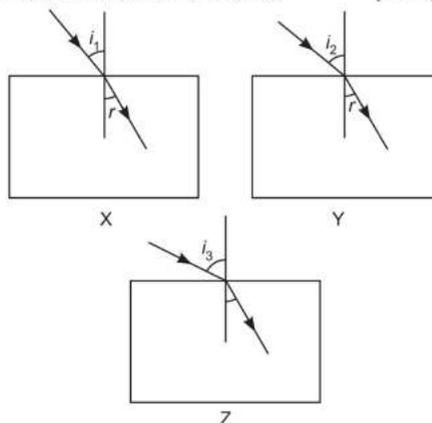
$$\text{Using, } n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in water}} = \frac{c}{v}$$

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

$$\Rightarrow v = \frac{9 \times 10^8}{4} = 2.25 \times 10^8 \text{ ms}^{-1}$$

$$\therefore \text{Speed of light in water} = 2.25 \times 10^8 \text{ ms}^{-1}$$

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



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

Ans. According to Snell's law

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

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

Combining (i) and (ii), we have

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

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

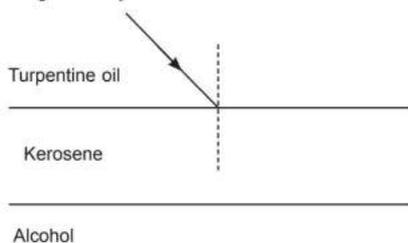
$$v_x > v_y > v_z \dots \text{for } i_3 > i_2 > i_1$$

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

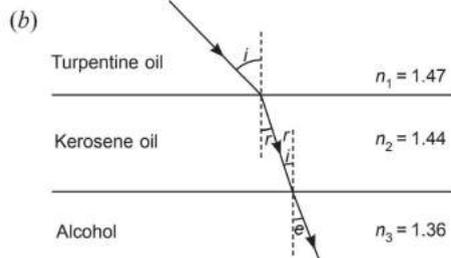
SA Short Answer Type Questions **3 Marks**

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

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



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



15. (a) For the same angle of incidence in media P, Q and R, the angles of refraction are 45° , 35° and 15° respectively. In which medium will the velocity of light be (i) minimum (ii) maximum? Give reason for your answer. [HOTS]

(b) When light enters from air to glass, the angles of incidence and refraction in air and glass are 45° and 30° respectively. Find the refractive index of glass. (Given that $\sin 45^\circ = \frac{1}{\sqrt{2}}$, $\sin 30^\circ = \frac{1}{2}$) [HOTS]

Ans. (a) From Snell's law, $n = \frac{\sin i}{\sin r}$

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

where c = velocity of light in vacuum /air

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

Since c and $\sin i$ are constant. Therefore, $\sin r \propto v$.

Since the value of $\sin r$ will be least for 15° and maximum for 45° among the three, the velocity of light will be (i) minimum in medium R. (ii) maximum in P.

(b) Using Snell's law,

$$n_{ga} = \frac{\sin i}{\sin r} = \frac{\sin 45^\circ}{\sin 30^\circ}$$

$$\Rightarrow n_{ga} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2} = 1.41$$

16. State the laws of refraction of light. Explain the term 'absolute refractive index of a medium' and write an expression to relate it with the speed of light in vacuum. [CBSE 2018]

Ans. Laws of refraction of light:

- (a) The incident ray, the normal at the point of incidence and the refracted ray, all lie in the same plane for the two given transparent media.
- (b) The ratio of sine of angle of incidence, i.e. $\sin i$ to the sine of angle of refraction, i.e. $\sin r$ is always constant, for the light of a given colour and for the given pair of media.

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

The constant n_{21} is called the refractive index of the second medium with respect to the first medium.

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

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

17. (a) Find the absolute refractive index of a medium in which light travels with a speed of 1.4×10^8 m/s.

(b) How do we distinguish a medium to be rarer or denser? Give two reasons.

Ans. (a) Absolute refractive index of the medium is given by

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

i.e. $n_m = \frac{c}{v}$

Given: $c = 3 \times 10^8$ m/s, $v = 1.4 \times 10^8$ m/s

$$\therefore n_m = \frac{c}{v} = \frac{3 \times 10^8}{1.4 \times 10^8} = \frac{3}{1.4} = 2.14$$

- (b) (i) Based on the bending of light.
 (ii) Based on the velocity of light in the medium or by knowing its refractive index.

Long Answer Type Question 5 Marks

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

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

[CBSE Sample Paper 2020]

Ans. (a) Refractive Index of a medium (n)

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

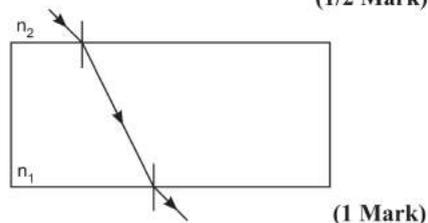
Let the velocity of light in vacuum be v_1 and velocity of light in the medium be v_2 .

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

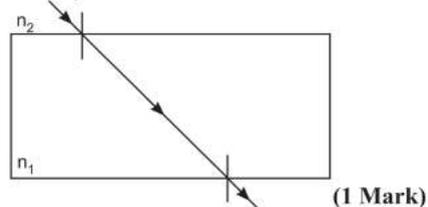
Hence $n = \frac{v_1}{v_2}$ (1/2 Mark)

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

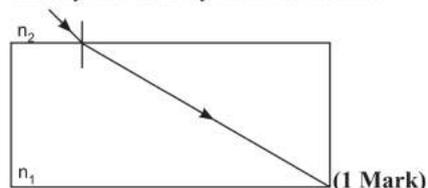
- (b) (i) The ray moves towards the normal. (1/2 Mark)



- (ii) The ray moves undeviated. (1 Mark)

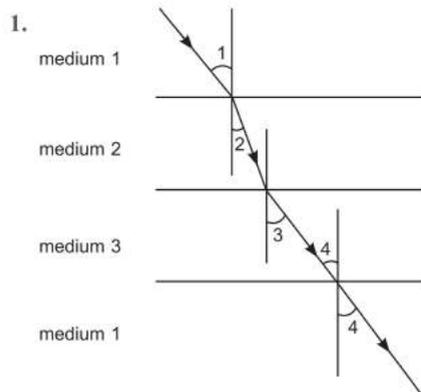


- (iii) The ray moves away from the normal. (1 Mark)



[CBSE Marking Scheme]

PRACTICE QUESTIONS



In the above diagram light is travelling through different media. It is noted by a scientist that $\angle 1 = \angle 3 = \angle 4$ but

$\angle 2 < \angle 1$. Which of the following statement would be correct? [CBSE Sample Paper 2022]

- (a) Medium 1 is the denser than medium 3 but its density is equal to medium 2.
 (b) Medium 2 is the rarest medium.
 (c) Medium 3 is denser than medium 1.
 (d) Medium 1 and 3 are essentially the same medium, but medium 2 is denser than 1 and 3.
2. 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.
- (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.
3. When light is incident on a glass slab, the incident ray, refracted ray and the emergent ray are in the three media A, B and C. If n_1 , n_2 and n_3 are the refractive indices of A, B and C respectively and the emergent ray is parallel to the incident ray, which of the following is true?
- (a) $n_1 < n_2 < n_3$ (b) $n_1 > n_2 > n_3$
 (c) $n_1 < n_2 = n_3$ (d) $n_1 = n_3 < n_2$
4. Prove that refraction will not take place at the boundary that separates two media of equal refractive indices. Draw ray diagram to justify this statement.
5. With respect to air, the refractive index of ice is 1.31 and that of rock salt is 1.54. Calculate the refractive index of rock salt with respect to ice.

TOPICS COVERED

Refraction by Spherical Lenses and Formation of Images

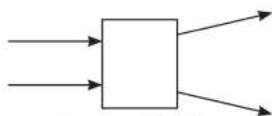


Multiple Choice Questions

1 Mark

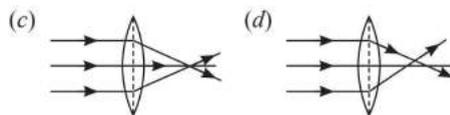
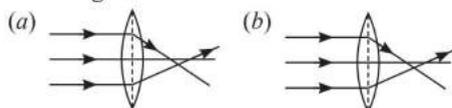


1. The following diagram shows the use of an optical device to perform an experiment of light. As per the arrangement shown, the optical device is likely to be a;



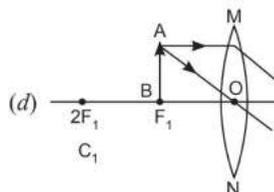
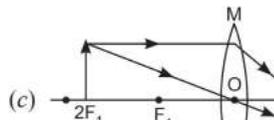
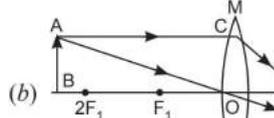
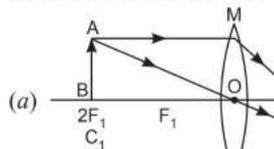
[CBSE 2021]

- (a) Concave mirror (b) Concave lens
 (c) Convex mirror (d) Convex lens
2. A divergent lens will produce
- (a) always real image
 (b) always virtual image
 (c) both real and virtual image
 (d) none of these
3. When object moves closer to convex lens, the image formed by it shift
- (a) away from the lens (b) towards the lens
 (c) first towards and then away from the lens
 (d) first away and then towards the lens
4. When object moves closer to a concave lens the image formed by it shifts
- (a) away from the lens on the same side of object
 (b) toward the lens
 (c) away from the lens on the other side of lens
 (d) first towards and then away from the lens
5. The distance between the optical centre and point of convergence is called focal length in which of the following cases?

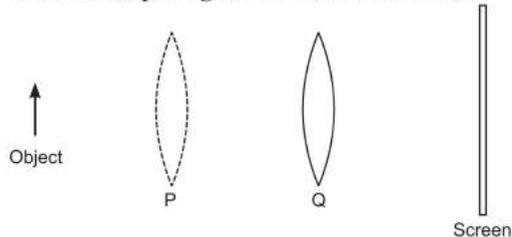


6. A student wants to obtain magnified image of an object AB as on a screen. Which one of the following arrangements shows the correct position of AB for him/her to be successful?

[CBSE 2021]

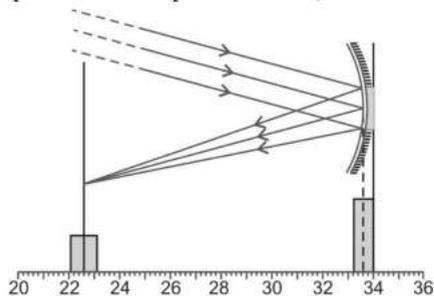


7. When a lens is placed at Q, a sharp image is formed on the screen. The image formed is real, inverted and diminished. When the lens is moved to P, another sharp image is formed on the screen.



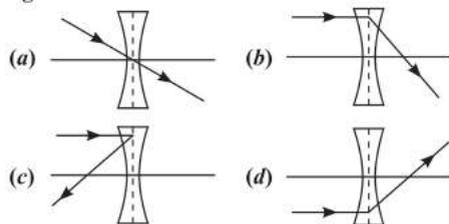
What is the nature of the image formed when the lens is at P? [CFPQ, CBSE]

- (a) Magnified and inverted
 (b) Magnified and upright
 (c) Diminished and upright
 (d) Diminished and inverted
8. When sun rays are focused with the help of a convex lens, a sharp bright spot is observed on a sheet of paper at its focus. What does this bright spot indicate?
- (a) Bright image of the sun
 (b) Virtual image of the sun
 (c) Real image of the sun
 (d) Magnified image of the sun
9. The focal length of the concave mirror in the experimental set up shown below, is :



- (a) 10.2 cm (b) 11.0 cm
 (c) 11.4 cm (d) 12.2 cm

10. Which of the following correctly shows refraction of light from a concave lens?



Answers

1. (b) Rays are refracted and diverse, so the optical device is concave lens.

2. (b) Diverging (concave) lens will always forms a virtual, erect and diminished image.
3. (a) As object moves from infinity towards optical centre of the convex lens image is shifted away from its focal point and moves towards infinity.
4. (b) When object is at infinity, image is formed at the focus of concave lens. When object is moved towards lens, the image is also moved towards lens from its focus and its size increases.
5. (c) Parallel rays after refracting meet at the focus of a convex lens.
6. (c)
7. (a) When the distance between the convex lens and an object is decreased, then the size of image is increased. The sharp image is continuously formed on the screen that is real and inverted. On decreasing the distance further in such a way that the object comes between the principal focus and optical centre of the lens, then virtual, upright and the magnified image is formed and this virtual image cannot be taken on the screen.
8. (c)
9. (b) $f = \text{separation between the screen and pole} = 33.6 - 22.6 = 11.0 \text{ cm.}$
10. (a)

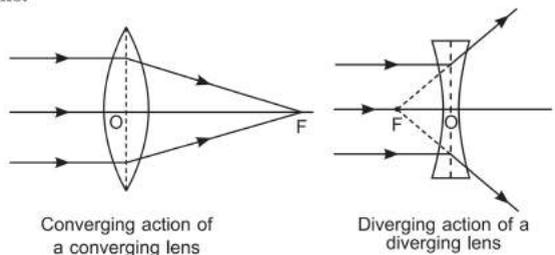
VSA Very Short Answer Type Questions 2 Marks

11. 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, inverted and will be formed at the centre of curvature of the given convex lens.

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

Ans.



13. (a) What is a lens?
 (b) Distinguish between a double convex lens and a double concave lens.

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

(b) Differences:

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

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

Ans. Focal length of spherical lens depends on the
 (i) refractive index of the glass, and
 (ii) radius of curvature of its two surfaces.

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

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

SA Short Answer Type Questions **3 Marks**

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

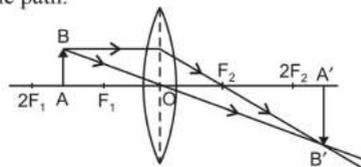
Ans. List of two light rays chosen for refraction
 (i) A ray of light parallel to the principal axis.
 (ii) A ray of light passing through the optical centre of a lens.

Path of these rays after refraction

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

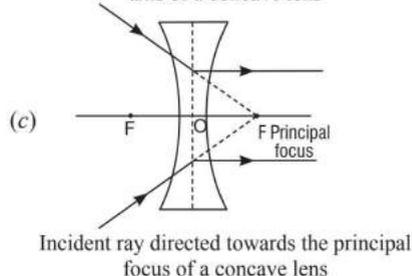
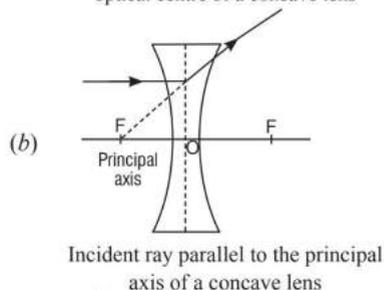
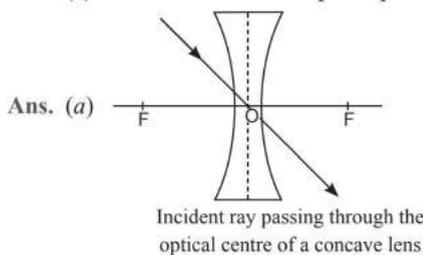
In case of a concave lens, the ray will appear to diverge or appear to come from the principal focus positioned on the same side of the object.

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



17. Draw a ray diagram to show the path of the refracted ray in each of the following cases:

A ray of light incident on a concave lens is
 (a) passing through its optical centre.
 (b) parallel to its principal axis.
 (c) directed towards its principal focus. [AI 2014]



18. We wish to obtain an equal sized inverted image of a candle flame on a screen kept at distance of 4 m from the candle flame.

(a) Name the type of lens that should be used.
 (b) What should be the focal length of the lens and at what distance from the candle flame the lens be placed.
 (c) Draw a labelled diagram to show the image formation in this case. [CBSE 2018C]

Ans. (a) Convex lens.

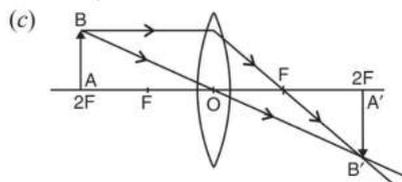
- (b) Candle should be placed at centre of curvature of convex lens i.e. $u = 2f$ to obtain equal size inverted image at $2F_2$ i.e. $v = 2f$ on the other side of the lens.

Here, $u + v = 4 \text{ m}$

$$\Rightarrow 2f + 2f = 4 \Rightarrow f = \frac{4}{4} = 1 \text{ m}$$

So, focal length of convex lens, $f = 1 \text{ m}$

Distance of candle flame from the lens, $u = 2f = 2 \times 1 = 2 \text{ m}$.



A Long Answer Type Question 5 Marks

19. A student wants to project the image of a candle flame on the walls of school laboratory by using a lens.

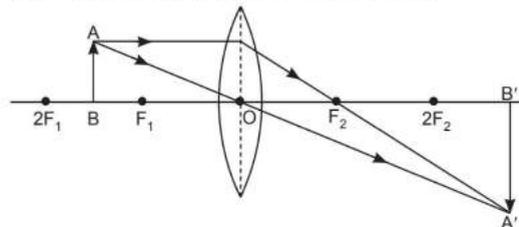
- (a) Which type of lens should he use and why?
 (b) At what distance in terms of focal length ' f ' of the lens should he place the candle flame so as to get (i) a magnified, and (ii) a diminished image respectively on the wall?

- (c) Draw ray diagram to show the formation of the image in each case. [Delhi 2014]

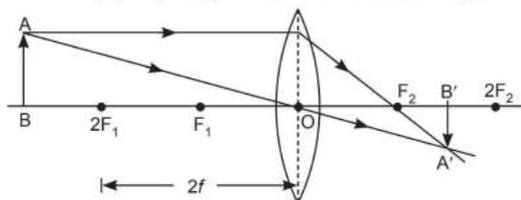
Ans. (a) He should use a convex lens as it forms a real image.

- (b) He should place the candle flame between F_1 and $2F_1$ (the focus and the centre of curvature of the lens) to get the magnified image on the wall, while the diminished image is obtained when the object is located at a distance greater than $2f$.

- (c) (i) Ray diagram for a magnified image

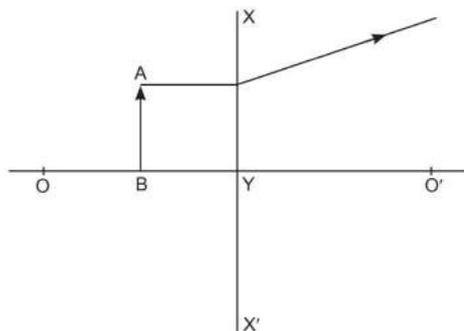


- (ii) Ray diagram for a diminished image



PRACTICE QUESTIONS

1. Study the diagram given below and identify the type of lens XX' and the position of the point on the principal axis OO' where the image of the object AB appear to be formed: [CBSE 2021]

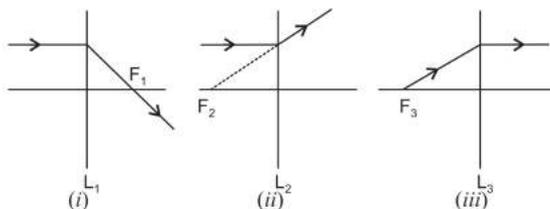


- (a) Concave; between O' and Y
 (b) Concave; between O and Y
 (c) Convex; between O' and Y
 (d) Convex; between O and Y

2. A student has focused on the screen a distant building using a convex lens. If he has selected a blue coloured building as object, select from the following options the one which gives the correct characteristics of the image formed on the screen. [CBSE 2015]

- (a) virtual, erect, diminished and in green shade
 (b) real, inverted, diminished and in violet shade
 (c) real, inverted, diminished and in blue shade
 (d) virtual, inverted, diminished and in blue shade
3. How does the focal length of a thick convex lens differ from that of a thin lens made of the same glass?
4. What is the difference between a convex lens and a biconvex lens?
5. Which lens bends more light, thick convex lens or thin convex lens made of the same material?
6. (a) On what factor does the size of image formed by a thin convex lens depends?
 (b) A ray of light is passing through the principal focus of a convex lens. How will it emerge after refraction through the lens?
 (c) Which law is obeyed by the light rays when refracted through a spherical lens?

7. (a) What is the focal length of the lens used in sunglasses?
 (b) The following figures show the path of light rays through three lenses marked L_1 , L_2 and L_3 and their focal points F_1 , F_2 and F_3 respectively. Identify the nature of lenses.



TOPICS COVERED

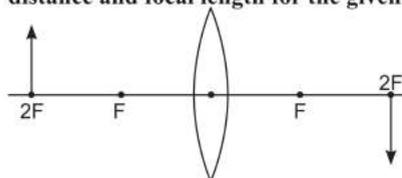
Sign Convention for Spherical Lenses, Lens Formula and Magnification



Multiple Choice Questions

1 Mark

1. For the diagram shown, according to New Cartesian Sign Convention, the sign of object distance, image distance and focal length for the given lens will be



- (a) $-, +, +$ (b) $-, -, +$
 (c) $-, -, -$ (d) $+, -, +$
2. If the magnification produced by lens has a negative value, the image will be
 (a) real and erect (b) virtual and erect
 (c) real and inverted (d) virtual and inverted
3. Linear magnification of a concave lens is always positive but less than one. This is because it forms
 (a) real image only
 (b) virtual and erect image on the other side of lens
 (c) virtual and diminished image on the same side of object irrespective of its position.
 (d) virtual, erect and enlarged image
4. A converging lens forms a three times magnified image of an object, which can be taken on a screen. If the focal length of the lens is 30 cm, then the distance of the object from the lens is [CBSE 2021]
 (a) -55 cm (b) -50 cm
 (c) -45 cm (d) -40 cm
5. The condition for which the spherical lens has equal focal length on either side of the lens is [CBSE 2021]
 (a) same medium on either side of lens
 (b) same radius of curvature of both curved surface
 (c) independent of medium on either side of lens.
 (d) both (a) and (b)

6. An object is placed at distance of 15 cm in front of a concave lens of focal length 15 cm. The position of image formed will be at a distance of
 (a) -15 cm (b) $+15$ cm
 (c) -7.5 cm (d) $+7.5$ cm
7. A teacher sets up the stand carrying a convex lens of focal length 21 cm placed at 42 cm mark on the optical bench. He asks four students A, B, C and D to suggest the position of screen on the optical bench so that a distinct image of a distance tree obtained on it. The correct position of the screen on the optical bench suggested by one of the student is
 (a) 63 cm (b) 32 cm (c) 21 cm (d) 84 cm

Answers

1. (a)
 2. (c)
 3. (c)
 4. (d) For real image, $m = -3 = \frac{v}{u} \Rightarrow v = -3u$
 By lens formula, we get $u = -40$ cm
 5. (d)
 6. (c) Substitute $u = -15$ cm, $f = -15$ cm in lens formula, we get, $v = -7.5$ cm.
 7. (a) The parallel rays coming from the distant tree are focused by the convex lens at its focal point. Therefore, the position of screen on optical bench is $42 + 21 = 63$ cm.



Very Short Answer Type Questions 2 Marks

8. An object is placed at a distance of 15 cm from a convex lens of focal length 20 cm. List four characteristics of the image formed by the lens.

[AI 2017]

Ans. Given: $u = -15$ cm, $f = +20$ cm
 As $|u| < |f|$

Therefore object is placed between 'F' and 'O' of the lens. Thus, the characteristics of the image is erect, virtual, enlarged and formed on the same side of the lens as object.

9. A real image $\frac{2}{3}$ rd of the size of the object is formed by a convex lens when the object is at a distance of 12 cm from it. Find the focal length of the lens.

[AI 2019]

Ans. Given: $h' = -\frac{2}{3}h$, $u = -12$ cm

• Magnification, $m = \frac{h'}{h} = \frac{v}{u}$

$$\Rightarrow v = \frac{h'}{h} \times u = \frac{-\frac{2}{3}h}{h} \times -12 = 8 \text{ cm}$$

• Using lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{8} - \frac{1}{-12} = \frac{1}{8} + \frac{1}{12} = \frac{5}{24}$$

$$\therefore f = +\frac{24}{5} = +4.8 \text{ cm}$$

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

[Foreign 2013]

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

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

where h_i is the height of the image and h_o is the height of the object.

If the image formed is virtual and erect, then the magnification is positive and if the image formed is real and inverted, then the magnification is negative.

SA Short Answer Type Questions **3 Marks**

11. An object of height 6 cm is placed perpendicular to the principal axis of a concave lens of focal length 5 cm. Use lens formula to determine the position, size and nature of the image if the distance of the object from the lens is 10 cm. [Delhi 2013]

Ans. Given: $h_o = 6$ cm, $f = -5$ cm, $u = -10$ cm

Using lens formula,

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

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

$$\text{or } \frac{1}{v} = \frac{1}{-5} - \frac{1}{-10} = \frac{-2-1}{10} = \frac{-3}{10}$$

$$v = -\frac{10}{3} \text{ cm}$$

Thus, the image is formed on the same side of the object at a distance of $\frac{10}{3}$ cm from the optical centre of the lens. The negative sign indicates that the image is virtual.

Using the formula,

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

$$\Rightarrow h_i = \frac{v}{u} \times h_o = \frac{-10}{3 \times (-10)} \times 6 = +2 \text{ cm}$$

The positive sign indicates that the image is erect.

12. An object placed on a metre scale at 8 cm mark was focussed on a white screen placed at 92 cm mark, using a converging lens placed on the scale at 50 cm mark.

- (a) Find the focal length of converging lens.
 (b) Find the position of the image formed if the object is shifted towards the lens at a position of 29.0 cm.
 (c) State the nature of the image formed if the object is further shifted towards the lens.

[AI 2013]

Ans. (a) $\therefore u = -(50 - 8) = -42$ cm,

$$v = 92 - 50 = 42 \text{ cm}$$

Focal length of converging lens (convex lens) is given by

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad (\text{lens formula})$$

$$\frac{1}{f} = \frac{1}{42} - \frac{1}{-42} = \frac{2}{42} = \frac{1}{21}$$

$$\therefore f = 21 \text{ cm}$$

- (b) Now, the object is shifted towards the lens at a position of 29.0 cm. Therefore, new object distance, $u' = -(50 - 29) = -21$ cm.

Again lens formula,

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

$$\frac{1}{21} = \frac{1}{v'} - \frac{1}{-21} = \frac{1}{v'} + \frac{1}{21}$$

$$\therefore \frac{1}{v'} = \frac{1}{21} - \frac{1}{21} = 0$$

$$\text{or } v' = \frac{1}{0} = \infty$$

So, the image will be formed at infinity.

(c) If the object is further shifted towards the lens, the object is now within the focus of a convex lens so the nature of image formed is

- virtual and erect, and
- enlarged or magnified, i.e. larger than the size of the object.

13. We wish to obtain an equal sized inverted image of a candle flame on a screen kept at distance of 4 m from the candle flame.

- (a) Name the type of lens that should be used.
 (b) What should be the focal length of the lens and at what distance from the candle flame the lens be placed.
 (c) Draw a labelled diagram to show the image formation in this case. [CBSE 2018C]

Ans. (a) Convex lens.

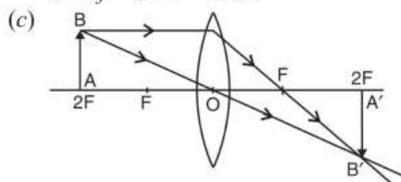
(b) Candle should be placed at centre of curvature of convex lens i.e. $u = 2f$ to obtain equal size inverted image at $2F_2$ i.e. $v = 2f$ on the other side of the lens.

Here, $u + v = 4$ m

$$\Rightarrow 2f + 2f = 4 \Rightarrow f = \frac{4}{4} = 1 \text{ m}$$

So, focal length of convex lens, $f = 1$ m

Distance of candle flame from the lens, $u = 2f = 2 \times 1 = 2$ m.



14. 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]

Ans. Given: For converging lens, object distance (u) = -25 cm;

Focal length (f) = 15 cm;

height of object (h_o) = 10 cm

$$\text{Lens formula: } \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Substituting u and f , we get

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \frac{1}{-25} = \frac{2}{75}$$

$$v = 37.5 \text{ cm}$$

Hence, image distance = 37.5 cm

Magnification of the lens is given by

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

$$h_i = h_o \times \frac{v}{u} = 10 \times \frac{37.5}{-25} = -15 \text{ cm}$$

The position of image is at distance 37.5 cm from the lens. The image is formed on the right side of the lens and it is real and inverted in nature.

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

(b) 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 reasons for this? [CBSE Sample Paper 2023]

Ans. (a) Given, image distance = $v = -25$ cm,
 focal length = $f = 5$ cm, magnification = $m = ?$
 From lens formula,

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

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

$$\text{Object distance} = u = \frac{-25}{6} \text{ cm}$$

$$\text{We know that, } m = \frac{v}{u} = \frac{-25 \times 6}{-25} = 6 \text{ (2 Marks)}$$

(b) This is because the least distance of distinct vision is 25 cm. (1 Mark) [CBSE Marking Scheme]

Long Answer Type Questions 5 Marks

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

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

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

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

(c) Select an appropriate scale and draw a ray diagram for the observation at S.No. 2. Also find the approximate value of magnification. [AI 2017]

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

Reason: Objects at S.No. 3 indicates that $u = -40$ cm, $v = +40$ cm

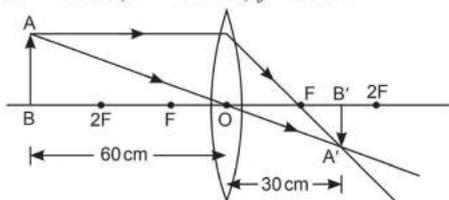
Thus, object is at $2F$.

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

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

The value, $u = -15$ cm, indicates that the object is in between the optical centre and the focus (i.e., less than the focal length) of the lens and hence, the image should be on the same side as the object. Accordingly, the image distance should be negative and cannot be positive (+120 cm) as shown in table.

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



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

17. (a) Define optical centre of a spherical lens.

(b) 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.

(c) Draw a ray diagram to show the formation of image in above situation. [AI 2016]

Ans. (a) **Optical centre:** The central point 'O' on the principal axis of the lens, through which an incident ray of light passes (refracted) without suffering any deviation, is called optical centre of the lens.

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

Using lens formula,

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

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

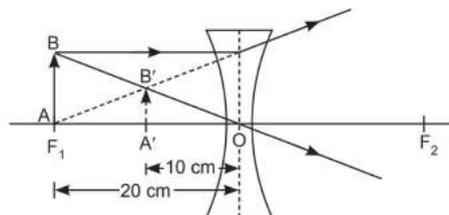
$$\Rightarrow u = -20 \text{ cm}$$

$$\therefore m = \frac{h_i}{h_o} = \frac{v}{u}$$

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

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

(c)



$AB = \text{Object height} = +4$ cm

$A'B' = \text{Image height} = +2$ cm

18. At what distance from a concave lens of focal length 20 cm, a 6 cm tall object be placed so as to obtain its image at 15 cm from the lens? Also calculate the size of the image formed. Draw a ray diagram to justify your answer for the above situation and label it. [Foreign 2016]

Ans. Given: $f = -20$ cm, $h_o = 6$ cm, $v = -15$ cm

Using lens formula,

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

$$\Rightarrow \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{-15} - \frac{1}{-20} = -\frac{1}{60}$$

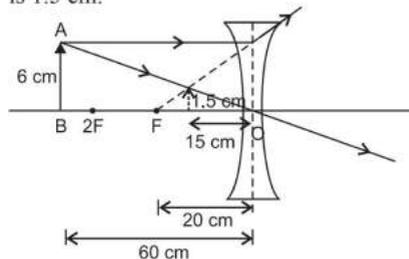
$$\Rightarrow u = -60 \text{ cm}$$

Using the formula,

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

$$\Rightarrow h_i = \frac{v}{u} \times h_o = \frac{-15}{-60} \times 6 = +1.5$$

Therefore, a diminished image is formed and its size is 1.5 cm.



19. 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 (nature, position, size, erect/inverted) formed by the lens in this case.

(c) Draw ray diagram to justify your answer of part (b). [Delhi 2019]

Ans. Given for concave lens, $u = -60$ cm, $f = -30$ cm

(a) Using lens formula,

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

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

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

$$= -\frac{3}{60} = -\frac{1}{20}$$

$$\therefore v = -20 \text{ cm}$$

- (b) • Nature of image : Virtual
 • Position of image : Between optical centre and focus of concave lens.
 • Size of image: Smaller than the object using

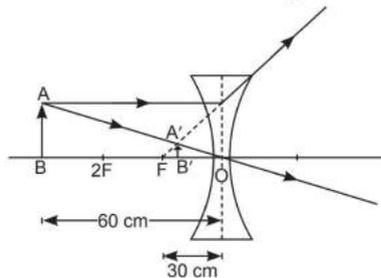
$$m = \frac{h_i}{h_o} = \frac{v}{u}$$

$$h_i = \frac{v}{u} \times h_o = \frac{-20}{-60} \times h_o = \frac{h_o}{3}$$

So size of image is one third of the object.

- Erect/inverted : Erect image

(c)



20. (a) Explain the following terms related to spherical lenses:

(i) Optical centre

(ii) Aperture

(iii) Focal length

- (b) A converging lens has focal length of 12 cm. Calculate at what distance should the object be placed from the lens so that it forms an image at 48 cm on the other side of the lens.

Ans. (a) (i) **Optical centre:** The centre point of a lens is known as its optical centre. It always lies inside the lens. A light beam passing through the optical centre emerges out without any deviation after refraction.

(ii) **Aperture:** This is the length of the lens through which refraction takes place.

(iii) **Focal length:** The distance of the principal focus from the optical centre of the spherical lens is called the focal length (f) of the lens.

- (b) Focal length of the converging lens,

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

Image distance, $v = +48 \text{ cm}$ (+ve sign is taken because of sign convention)

Using lens formula,

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

$$\Rightarrow \frac{1}{+12} = \frac{1}{+48} - \frac{1}{u}$$

$$\therefore \frac{1}{u} = \frac{1}{+48} - \frac{1}{12} = \frac{-3}{48}$$

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

So, the distance of the object from the lens is 16 cm.

PRACTICE QUESTIONS

- If the real image of the 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 2021]

(a) -80 cm (b) -40 cm

(c) $-\frac{40}{3}$ cm (d) $-\frac{80}{3}$ cm
- A concave lens has focal length of 20 cm. At what distance from the lens a 5 cm tall object be placed so that it forms an image at 15 cm from the lens? Also calculate the size of the image formed.
- An object of height 4.0 cm is placed at 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 approximate ratio of size of image to the size of the object. [CBSE 2018]
- (a) The image of an object formed by a lens is of same size but inverted. If the object distance is 30 cm, calculate

(i) The distance between the object and its image.

(ii) Focal length of the lens.

(b) Draw a ray diagram to show the image formed in above case. [CBSE 2023]

TOPICS COVERED

Combination, Power and Uses of Spherical Lens



Multiple Choice Questions

1 Mark

- If the power of lens is $-4.0D$, then it means that the lens is a [CBSE Sample Paper 2022]
 - concave lens of focal length -50 m
 - convex lens of focal length $+50$ cm
 - concave lens of focal length -25 cm
 - convex lens of focal length -25 cm
- In which of the following devices, convex lens is not used?
 - Magnifying glass
 - Microscope
 - Flashlights
 - Telescope
- Two convex lens P and Q have focal length 0.50 m and 0.40 m respectively. Which of the following is TRUE about the combined power of the two lenses? [CFPQ, CBSE]
 - P is equal to 4.5 D.
 - P is less than 4.5 D.
 - P is more than 4.5 D.
 - P cannot be determined from the information given.
- The combination of spherical lens of power $+3D$ and $-3D$ acts as a
 - bifocal lens of power $6D$
 - plane glass sheet/slab
 - convex lens having no power
 - concave lens of power $-6D$
- The focal length of four convex lens P, Q, R and S are 20 cm, 15 cm, 5 cm and 10 cm respectively. The lens having lowest power is
 - P
 - Q
 - R
 - S

Answers

- (c) $P = -4D$, therefore $P = \frac{100}{f(\text{cm})} \Rightarrow f = -25$ cm
Negative focal length means concave lens.
- (c) Concave lens is used in flashlights to widen the beam produced by the bulb.
- (a)
$$P = P_1 + P_2 = \frac{1}{f_1(\text{m})} + \frac{1}{f_2(\text{m})}$$

$$= \frac{1}{0.5} + \frac{1}{0.4} = 2 + 2.5 = 4.5D$$

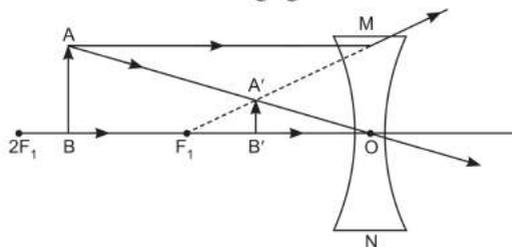
- (b) $P = P_1 + P_2 = +3D - 3D = 0D$
 \therefore The combination will behave as a plane glass sheet/slab.
- (a) $P \propto \frac{1}{f}$



Short Answer Type Questions

3 Marks

- (a) The power of a combination of two lenses XY is $5D$ if the focal length of lens X is 15 cm. State the nature and focal length of lens Y. [DoE]
 - When object is placed between infinity and the pole of the convex mirror, where is the image formed?
- Ans. (a) Power of a combination of two lenses X and Y = $5D$
- $$\therefore P = P_X + P_Y$$
- $$\therefore 5 = \frac{100}{15} + \frac{1}{f_Y} \quad (\because f_X = 15 \text{ cm})$$
- $$\Rightarrow \frac{1}{f_Y} = 5 - \frac{100}{15} = -\frac{25}{15}$$
- $$\therefore f_Y = -\frac{15}{25} = -0.6 \text{ m} = -60 \text{ cm}$$
- Therefore, the focal length of given lens Y is 60 cm and it is a concave lens.
- Between P and F, behind the mirror.
- 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? [AI 2017]
- Ans. It is a concave or diverging lens.



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

$$P = -10D,$$

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

8. An object is kept at a distance of 18 cm, 20 cm, 22 cm and 30 cm respectively from a lens of power +5D.

- (a) In which case or cases would you get a magnified image?
 (b) Which of the magnified image can be got on a screen? [HOTS]

Ans. \therefore Power of lens = +5 D

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

- (a) We would get a magnified image only when the object is kept at a distance of 18 cm, 22 cm and 30 cm respectively.
 (b) The object at the positions of 22 cm and 30 cm will produce a magnified, real image on a screen.

Reason:

- (i) A magnified virtual image is formed by a convex lens when the object lies between the focus and the optical centre of the lens.
 (ii) A magnified real image is formed by a convex lens when the object lies between F and 2F.

9. 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.

Ans. \therefore Power of lens = +4D

$$\therefore f = \frac{1}{P} = \frac{1}{+4} = +0.25 \text{ m} = 25 \text{ cm}$$

Since, f is positive hence the lens is converging lens.

Given that $u = -50 \text{ cm}$

Using lens formula, we have

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

$$\frac{1}{25} = \frac{1}{v} - \frac{1}{(-50)}$$

$$\Rightarrow \frac{1}{25} - \frac{1}{50} = \frac{1}{v}$$

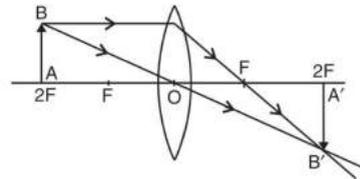
$$\Rightarrow \frac{1}{50} = \frac{1}{v} \Rightarrow v = 50 \text{ cm}$$

\therefore Magnification

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

$$\therefore m = \frac{50}{-50} = -1$$

The position of image is at distance 50 cm from the lens. The image is formed on the right side of lens and it is real and inverted in nature. The size of the image is same as size of the object.



10. 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. • **Power of a Lens:** The ability of a lens to converge or diverge the ray of light after refraction, is called power (P) of the lens. It is defined as the reciprocal of the focal length, i.e. $P = \frac{1}{f}$.

- Focal length of lens is -10 cm. Therefore, nature of lens = concave

$$\text{Power of lens, } P = \frac{100}{f(\text{cm})}$$

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

- Magnification produced by concave lens is always positive as it forms only virtual and erect image on the same side of the object.

PRACTICE QUESTIONS

- A lens of power +2D and lens of power -1D are placed in close contact with each other. The combination will behave like
 - a convergent lens of focal length 50 cm
 - a convergent lens of focal length 100 cm
 - a convergent lens of focal length 150 cm
 - a divergent lens of focal length 100 cm
- If a lens can converge the sun rays at a point 20 cm away from its optical centre, the power of the lens is
 - +2D
 - 2D
 - +5D
 - 5D
- A convex lens of focal length 25 cm and a concave lens of focal length 20 cm are placed in close contact with one another.

- (a) What is the power of the combination?
 (b) Is this combination converging or diverging?
4. A concave lens of power $-2D$ is in contact with the convex lens of power $+4D$. Now a parallel beam of light is allowed to incident on this combination. At

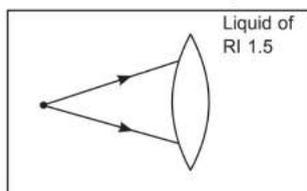
what distance from the combination will the beam get focused? State the nature of image formed.

5. State three uses of (a) convex lens (b) concave lens in our daily life.



INTEGRATED (MIXED) QUESTIONS

1. Distinguish between a convex and a concave mirror. **(2 Marks)**
2. Why does a ray falling normally on a plane mirror, retrace its path? **(2 Marks)**
3. A lens made of material with refractive index 1.5 is immersed in a liquid with refractive index 1.5. The diagram below shows two rays incident on the lens when it is immersed in the liquid. **(2 Marks)**



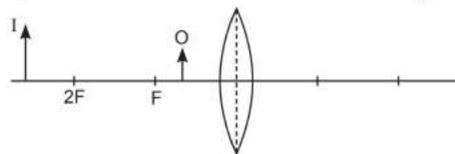
Copy the diagram and draw the light rays after they pass through the lens. Justify your diagram.

[CFPO, CBSE]

4. (a) Differentiate between reflection and refraction.
 (b) A lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides. Explain why it so appears. **[HOTS] (3 Marks)**
5. (a) "A convex lens of focal length ' f ' can form a magnified erect as well as inverted image." Justify this statement stating the position of the object with respect to the lens in each case for obtaining these images. **[AI 2013]**
 (b) 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. **(3 Marks)**
6. An object is kept at a distance of 18 cm, 20 cm, 22 cm and 30 cm respectively from a lens of power $+5D$. **(3 Marks)**
 (a) In which case or cases would you get a magnified image?
 (b) Which of the magnified image can be got on a screen? **[HOTS]**
7. (a) How can we differentiate between convex and concave lenses without touching them? **[DoE]**

- (b) Two thin lenses of power $+3.5 D$ and $-2.5 D$ are placed in contact. Find the power and focal length of the lens combination. **[DoE] (3 Marks)**

8. The diagram given below shows an object O and image I. **(3 Marks)**



Without actually drawing the ray diagram, state the following:

- (a) Type of lens (Converging/Diverging)
 (b) Name two optical instruments where such an image is obtained.
 (c) List three characteristics of the image formed if this lens is replaced by concave mirror of focal length ' f ' and an object is placed at a distance ' $f/2$ ' in front of the mirror **[CBSE AI 2020]**
9. Rohit wants to have an erect image of an object using a converging mirror of focal length 40 cm. **(3 Marks)**
 (a) Specify the range of distance where the object can be placed in front of the mirror. Justify.
 (b) Draw a ray diagram to show image formation in this case.
 (c) State one use of the mirror based on the above kind of image formation. **[CBSE Sample Paper 2023]**
10. 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: **(5 Marks)**
 (a) For the three object distances, identify the mirror/mirrors which will form an image of magnification -1 .
 (b) Out of the three mirrors identify the mirror which would be preferred to be used for shaving purposes/make-up.
 (c) For the mirror B draw ray diagram for image formation for object distances 10 cm and 20 cm. **[Foreign 2016]**

11. (a) Draw a ray diagram for showing the convergence of a parallel beam of light by a concave mirror and mark the positions of pole and the centre of curvature in it.
 (b) An object 4 cm in size is placed at 25 cm in front of a concave mirror of focal length 15 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and size of the image.
 (c) List any two uses of a concave mirror.
 [CBSE 2023] (5 Marks)
12. Draw a ray diagram in each of the following cases to show the formation of image, when the object is placed: (5 Marks)
 (a) between optical centre and principal focus of a convex lens.
 (b) anywhere in front of a concave lens.
 (c) at 2F of a convex lens.
 State the signs and values of magnifications in the above mentioned cases (a) and (b). [CBSE 2020]
13. (a) Draw a ray diagram to show the formation of image by a concave lens when the object is placed in front of it. (5 Marks)
 (b) In the above diagram mark the object distance (u) and the image distance (v) with their proper signs (+ve or -ve as per New Cartesian Sign convention) and state how these distances are related to the focal length (f) of the concave lens in this case.
 (c) Find the nature and power of the lens which forms a real and inverted image of magnification -1 at a distance of 40 cm from its optical centre.
 [CBSE 2016]



ASSERTION AND REASON QUESTIONS

Direction: The questions given below consist of an assertion and the reason. Use the following key to choose the appropriate answer.

- (a) Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.
 (b) The Assertion and the Reason are correct but the Reason is not the correct explanation of the Assertion.
 (c) Assertion is true but the Reason is false.
 (d) The statement of the Assertion is false but the Reason is true.
1. **Assertion:** Incident light is reflected in only one direction from a smooth surface.
Reason: Since the angle of incidence and the angle of reflection are same, a beam of parallel rays of light falling on a smooth surface is reflected as a beam of parallel light rays in one direction only.
2. **Assertion:** The word AMBULANCE on the hospital vans is written in the form of its mirror as ƆMƆA.LU8MA .
Reason: The image formed in a plane mirror is same size of the object.
3. **Assertion:** Concave mirrors are used as reflectors in torches, vehicle head-lights and in search lights.
Reason: When an object is placed beyond the centre of curvature of a concave mirror, the image formed is real and inverted.
4. **Assertion:** The light emerges from a parallel sided glass slab in a direction perpendicular to that in which it enters into the glass slab.
Reason: The perpendicular distance between the original path of incident ray and emergent ray coming out of glass slab is called lateral displacement of the emergent ray of light.
5. **Assertion:** When a pencil is partly immersed in water and held obliquely to the surface, the pencil appears to bend at the water surface.
Reason: The apparent bending of the pencil is due to the refraction of light when it passes from water to air.
6. **Assertion:** 1.33 is the absolute refractive index of water.
Reason: Air is optically denser than water. [KVS]
7. **Assertion:** The value of f in a concave mirror is taken as -ve and in a convex mirror, it is taken as +ve.
Reason: All distances measured to the right of the origin are taken as +ve and those measured along the left of the origin are taken as -ve. [KVS]
8. **Assertion:** A concave lens of very short focal length causes higher divergence than one with longer focal length.
Reason: The power of lens is directly proportional to its focal length. [CBSE 2021C]
9. **Assertion:** The SI unit of power of lens is 'diopter'.
Reason: The power of concave lens is positive and that of convex lens is negative. [CBSE 2021C]
10. **Assertion:** Higher the refractive index of the medium, lesser will be the velocity of light in that media.
Reason: Refractive index is inversely proportional to the velocity of light in the medium.



CASE-BASED QUESTIONS

The following questions are source-based/case-based questions. Read the case carefully and answer the questions that follow.

1. 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	-90	+18
2	-60	+20
3	-30	+30
4	-20	+60
5	-18	+90
6	-10	+100

- (a) State the lens formula.
(b) Write the serial number of that observation which is not correct. How did you arrive at this conclusion?
(c) Take an appropriate scale to draw ray diagram for the observation at S. No. 2.

Or

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

2.



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

To show her students the images of insects that she investigated in the lab, Mrs. Iyer brought a slide

projector. Her slide projector produced a 500 times enlarged and inverted image of a slide on a screen 10 m away. [CBSE Sample Paper 2023]

- (a) Based on the text and data given in the above paragraph, what kind of lens must the slide projector have?
(b) If v is the symbol used for image distance and u for object distance then with one reason state what will be the sign for $\frac{v}{u}$ in the given case?
(c) A slide projector has a convex lens with a focal length of 20 cm. The slide is placed upside down 21 cm from the lens. How far away should the screen be placed from the slide projector's lens so that the slide is in focus?

Or

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

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

- (a) What are the advantages and disadvantages of using a convex mirror for seeing traffic at the rear?
(b) Name the mirror that can give an erect and enlarged image of the object.
(c) An object is placed at the distance of 10 cm, 20 cm, 30 cm and 40 cm respectively from a concave mirror of focal length 15 cm. Which position of the object will produce (i) virtual image and (ii) an image of same size?

Or

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

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

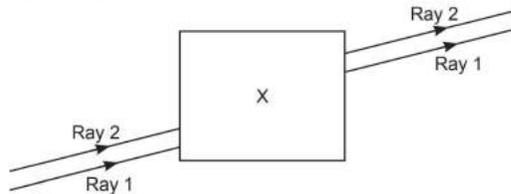
Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31		
Water	1.33	Rock salt	1.54
Alcohol	1.36		
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown glass	1.52	Diamond	2.42

- (a) Name the medium which have lowest and highest optical density.
 (b) You are given water, kerosene, benzene and dense flint glass. In which of these media a ray of light incident obliquely at same angle would bend the most?
 (c) How the absolute refractive index related to speed of light?

Or

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

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



- (a) What could be the X that she placed inside the box to make the rays behave as shown?
 (b) She measured the angle of incidence for both rays on the left side of the box to be 48.6° . She knew the refractive index of the material 'X' inside the box was 1.5. What will be the approximate value of angle of refraction? (Given: $\sin 48.6^\circ = 0.75$)
 (c) What would she observe in the lateral shift of the emergent ray if the object inside the box was made of a material with a refractive index less than 1.5?

Or

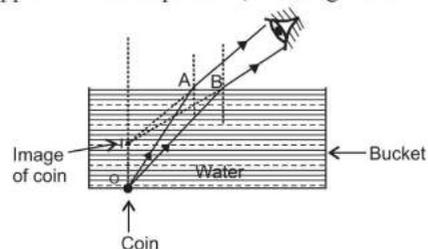
- (c) Draw the label diagram for the path of refracted ray through the material 'X' inside the box for the incident ray 1.
 6. A compound microscope is an instrument which consists of two lenses L_1 and L_2 . The lens L_1 called objective, forms a real, inverted and magnified image of the given object. This serves as the object for the second lens L_2 ; the eye piece. The eye piece functions like a simple microscope or magnifier. It produces the final image, which is inverted with respect to the original object, enlarged and virtual.

- (a) What types of lenses must be L_1 and L_2 ?
 (b) What is the value and sign of magnification (according to the New Cartesian Sign convention) of the image formed by L_1 ?
 (c) If the power of the eye piece (L_2) is 5 D and it forms an image at a distance 80 cm from its optical centre, at what distance should the object be?

Or

- (c) If the power of lenses L_1 and L_2 are in the ratio of 4 : 1, what would be ratio of the focal length of L_1 and L_2 ? [CBSE 2022]

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

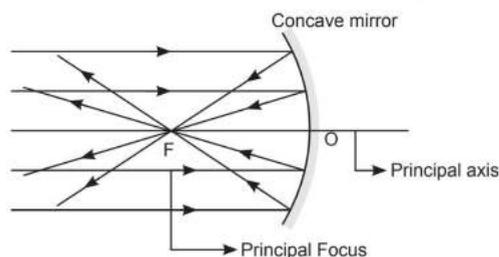


- (a) State the relationship between angle of incidence and angle of refraction formed by the ray at the point B of water-air interface.
 (b) Why does the coin appear raised when kept in water at the bottom of bucket?
 (c) The medium is changed from water (refractive index of water = 1.33) to a new medium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

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

Or

- (c) On what basis can we distinguish a medium as being optically rarer or optically denser?
8. Hold a concave mirror in your hand and direct its reflecting surface towards the sun. Direct the light reflected by the mirror on to a white card-board held close to the mirror. Move the card-board back and forth gradually until you find a bright, sharp spot of light on the board. This spot of light is the image of the sun on the sheet of paper; which is also termed as "Principal Focus" of the concave mirror. [CBSE 2023]



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

Or

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

(ii) magnification of the image formed with sign as per Cartesian Sign convention.

9. 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. [CBSE 2023]

- (a) Determine the speed of light in diamond if the refractive index of diamond with respect to vacuum is 2.42. Speed of light in vacuum is 3×10^8 m/s.
- (b) Refractive indices of glass, water and carbon disulphide are 1.5, 1.33 and 1.62 respectively. If a ray of light is incident in these media at the same angle (say θ), then write the increasing order of the angle of refraction in these media.
- (c) The speed of light in glass is 2×10^8 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

- (c) 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.



NCERT ZONE

NCERT INTEXT QUESTIONS

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1. Define the principal focus of a concave mirror.

Ans. The point on the principal axis, where all the incident rays, parallel to the principal axis, actually meet or converge after reflection from the concave mirror is called principal focus of a concave mirror.

2. The radius of curvature of a spherical mirror is 20 cm. What is its focal length? [DoE, KVS]

Ans. We know $f = \frac{R}{2} = \frac{20 \text{ cm}}{2} = 10 \text{ cm}$

where f and R are the focal length and radius of curvature respectively.

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

Ans. Concave mirror.

4. Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Ans. Convex mirror is used because:

- (i) it always produces a virtual and erect image.
 (ii) the size of image formed is smaller than the object.

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

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1. Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Ans. We know $f = \frac{R}{2} = \frac{32}{2} = 16$ cm

Hence, the focal length of convex mirror is 16 cm.

2. A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?

Ans. Given: $u = -10$ cm, $v = ?$ $m = -3$

(If image is real)

m is $-ve$.

\therefore Using the formula,

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

$$\therefore -3 = \frac{-v}{(-10)}$$

$$\therefore v = -30 \text{ cm}$$

\therefore The image is formed at a distance of 30 cm from the mirror on the same side of the object.

Page 150

1. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

Ans. A ray of light travelling in air enters obliquely into water, it will bend towards the normal. This is because the speed of light is lesser in a denser medium than the rarer medium. Water is optically denser than air.

2. Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is $3 \times 10^8 \text{ ms}^{-1}$. [DoE]

Ans. The refractive index of the medium,

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in medium (glass)}} = \frac{c}{v_g}$$

Therefore, speed of light in glass,

$$(v_g) = \frac{c}{n_m} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ ms}^{-1}$$

3. Find out, from Table 9.3, the medium having highest optical density. Also find the medium with lowest optical density.

Table 9.3 Absolute refractive index of some material media

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31		
Water	1.33	Rock salt	1.54
Alcohol	1.36		

Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown glass	1.52	Diamond	2.42

Ans. Highest optical density = Diamond

Lowest optical density = Air

When you compare the two media, you will find that the optically denser medium has the larger refractive index than the other. Therefore, from the table, we observe that diamond and air have the highest and lowest refractive indices, accordingly, the diamond has highest optical density and air has the lowest optical density.

4. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table 9.3.

Ans. The refractive index of the medium,

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

Therefore, speed of light in medium, $v_m = \frac{c}{n_m}$

From the above relation, it is clear that the speed of light is fastest in that medium whose refractive index is lowest. Water has the lowest refractive index among the three given media. Hence, the light will travel fastest in the water.

5. The refractive index of diamond is 2.42. What is the meaning of this statement?

Ans. This means that the ratio of speed of light in air to the speed of light in diamond is equal to 2.42.

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1. Define 1 dioptre of power of a lens.

Ans. 1 dioptre is the power of a lens whose focal length is 1 metre. $1D = 1 \text{ m}^{-1}$.

2. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.

Ans. The size of real and inverted image is equal to the size of the object. This is possible only when the object is placed at $2F_1$ of the convex lens. In this case, the image will also be formed at $2F_2$ on the other side of the lens. This means, $|u| = |v| = +50$ cm and $v = 2f$.

Therefore, focal length of the convex lens is

$$f = \frac{v}{2} = \frac{50}{2} = +25 \text{ cm} = +0.25 \text{ m}$$

[as $v = 2f = +50$ cm]

∴ Power of lens,

$$P = \frac{1}{f \text{ (in metres)}} = \frac{1}{+0.25} = +4\text{D}$$

Hence, the power of the given lens is +4D.

3. Find the power of a concave lens of focal length 2 m.

Ans. Focal length of concave lens, $f = -2 \text{ m} = -200 \text{ cm}$. Here, negative sign is due to diverging nature of the concave lens.

Power of the lens,

$$P = \frac{1}{f \text{ (in metres)}} = \frac{100}{f \text{ (in cm)}} = \frac{100}{-200} = -0.5 \text{ D}$$

Hence, the power of the given lens is -0.5 D

NCERT EXERCISES

1. Which one of the following materials cannot be used to make a lens?

(a) Water (b) Glass
(c) Plastic (d) Clay

Ans. (d) Clay cannot be used to make a lens because it cannot allow the light to pass through it while the other materials allow.

2. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(a) Between the principal focus and the centre of curvature
(b) At the centre of curvature
(c) Beyond the centre of curvature
(d) Between the pole of the mirror and its principal focus.

Ans. (d) The image formed by a concave mirror is observed to be virtual, erect and larger than the object only when the object is placed between the pole of the mirror and its principal focus.

3. Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(a) At the principal focus of the lens
(b) At twice the focal length
(c) At infinity
(d) Between the optical centre of the lens and its principal focus.

Ans. (b) When an object is placed at $2F_1$ of the convex lens, the image is formed at $2F_2$ on the other side of the lens. The image formed is real, inverted and of the same size as the object.

4. A spherical mirror and a thin spherical lens have each a focal length of -15 cm . The mirror and the lens are likely to be—

(a) both concave.
(b) both convex.
(c) the mirror is concave and the lens is convex.
(d) the mirror is convex, but the lens is concave.

Ans. (a) By sign convention, the negative sign of focal length indicates that it is the focal length of a concave mirror and a concave lens. Hence, both the spherical mirror and spherical lens are concave in nature.

5. 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) only either plane or convex.

Ans. (d) No matter whatever is the position of object, a convex mirror always forms a virtual, erect and diminished image of the object placed in front of it, whereas a plane mirror always forms a virtual, erect and of the same size image as that of the object placed in front of it. Therefore, the given mirror could be either plane or convex.

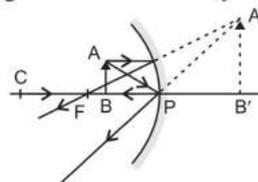
6. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(a) A convex lens of focal length 50 cm.
(b) A concave lens of focal length 50 cm.
(c) A convex lens of focal length 5 cm.
(d) A concave lens of focal length 5 cm.

Ans. (c) For reading small letters, we need a lens which forms a virtual, erect and magnified image. This condition is fulfilled by a convex lens. Also, the magnification is more for a short focal length of lens. Hence, for reading small letters, a convex lens of focal length 5 cm would prefer to use.

7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Ans. Focal length of concave mirror, $f = -15 \text{ cm}$.



Range of distance of the object from the mirror: For getting an erect image using a concave mirror, the object should be placed at a distance less than the focal length, i.e. 15 cm from the pole.

Nature of the image: Image will be virtual, erect and the image is larger than the object (magnified).

8. Name the type of mirror used in the following situations.

- Headlights of a car.
- Side/rear-view mirror of a vehicle.
- Solar furnace.

Support your answer with reason.

[Delhi 2013, 12, Foreign 2013, KVS]

Ans. Type of mirror used in

- Headlights of a car: Concave mirror

Concave mirror is used because light from the bulb placed at its focus gets reflected and a powerful parallel beam of light is obtained, which illuminates the road. This beam of light helps us to see things clearly upto a considerable distance at night.

- Side/rear-view mirror of a vehicle: Convex mirror

Convex mirror is used because

- it always produces a virtual and erect image between its pole and focus.
- the size of image formed is smaller than the object irrespective of position of object.

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

- Solar furnace: Concave mirror

Concave mirror has the 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 focal point gets heated to a high temperature.

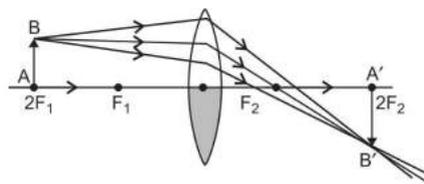
9. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

Ans. Yes, a complete image will be formed. When one-half of the lens (lower or upper) is covered; the other half part of the lens refracts light rays through it and contributes to the final image. The intensity of the image formed is reduced to half.

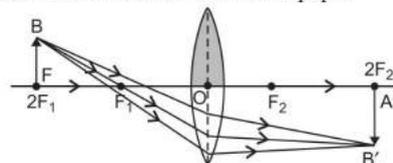
Experimental verification:

Take a convex lens. Mount it vertically on the optical bench. On one side of it, place a needle or burning candle at $2F_1$. On the opposite side of the lens, mount a white screen. Take the complete and sharp image of the burning candle on the screen by adjusting the position of screen which is obtained at $2F_2$.

Now cover the lower half part of the lens with black paper. Ensure yourself that the position of burning candle, half-covered lens and screen will not change. It will remain the same as in previous. You will observe that the complete and clear image of the burning candle is still formed on the screen at $2F_2$ as shown in figure but the brightness of the image decreases.



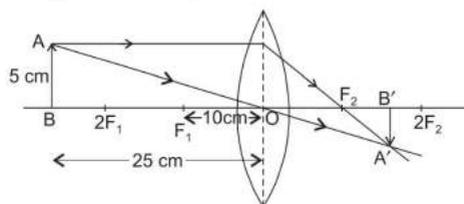
Note that the same result would also be obtained as shown in figure given below if the upper half part of the lens will be covered with black paper.



Explanation: This is because some of the rays, from large number of incident light rays, are refracted through the uncovered part of the lens but other rays are blocked by the covered part of the lens. So, the lesser number of refracted rays will now reach on the screen. Hence the less bright but complete image will be formed.

10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.

Ans. Given that $u = -25$ cm, $f = 10$ cm and $h_o = 5$ cm
Using lens formula, we have



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

$$\Rightarrow \frac{1}{10} = \frac{1}{v} - \frac{1}{(-25)}$$

$$\Rightarrow \frac{1}{10} - \frac{1}{25} = \frac{1}{v} \Rightarrow \frac{15}{250} = \frac{1}{v}$$

$$\Rightarrow v = \frac{250}{15} = \frac{50}{3} = 16.67 \text{ cm}$$

\therefore Magnification

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

$$\therefore \frac{50/3}{-25} = \frac{h}{5} \Rightarrow h = \frac{-10}{3} = -3.33 \text{ cm}$$

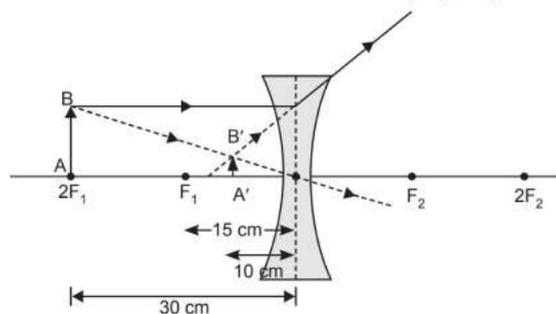
The position of image is at distance 16.67 cm from the lens. The image is formed on the right side of lens and it is real and inverted in nature.

11. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

Ans. For concave lens, $f = -15$ cm, $v = -10$ cm
Using lens formula, we have,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} - \frac{1}{u} \\ \Rightarrow \frac{1}{-15} &= \frac{1}{-10} - \frac{1}{u} \\ &= \frac{1}{-10} - \frac{1}{-15} = -\frac{1}{30} \\ \therefore u &= -30 \text{ cm} \end{aligned}$$

The negative value of u indicates that the object should be placed at 30 cm in front of the concave lens. This is shown in the following ray diagram.



12. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image. [DoE, KVS]

Ans. Focal length of convex mirror, $f = +15$ cm
Object distance, $u = -10$ cm
According to the mirror formula,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} + \frac{1}{u}, \text{ we get} \\ \therefore \frac{1}{15} &= \frac{1}{v} + \frac{1}{-10} \\ \Rightarrow \frac{1}{v} &= \frac{1}{15} + \frac{1}{10} = \frac{5}{30} = \frac{1}{6} \\ \text{or } v &= +6 \text{ cm} \end{aligned}$$

The positive value of v shows that the image is formed on the other side of the mirror, i.e. behind the mirror.

$$\begin{aligned} \text{Magnification} &= \frac{\text{Image distance}}{\text{Object distance}} \\ &= \frac{v}{u} = \frac{+6}{-10} = +0.6 \end{aligned}$$

The positive value of magnification shows that the image is virtual and erect.

13. The magnification produced by a plane mirror is +1. What does it mean?

Ans. The positive sign in magnification shows that the image formed by a plane mirror is virtual, erect and exactly of the same size as that of the object.

14. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

Ans. For convex mirror,

$$\begin{aligned} h_o &= +5.0 \text{ cm}, u = -20 \text{ cm}, \\ \therefore f &= \frac{R}{2} = \frac{30}{2} \text{ cm} = +15 \text{ cm} \end{aligned}$$

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

$$\begin{aligned} \frac{1}{v} &= \frac{1}{f} - \frac{1}{u} \\ \frac{1}{v} &= \frac{1}{15} - \frac{1}{-20} = \frac{4+3}{60} \\ \therefore v &= \frac{60}{7} = +8.57 \text{ cm} \end{aligned}$$

Magnification, $m = \frac{h_i}{h_o} = \frac{-v}{u}$ we get,

$$h_i = 5 \times \frac{-8.57}{-20} = +2.14 \text{ cm}$$

Since v is +ve, the image is virtual.

Since $h_i = 2.14$ cm < 5.0 cm, i.e. $h_i < h_o$, the image is diminished.

Hence a virtual, erect and diminished image of size 2.14 cm is formed behind the mirror at a distance of 8.57 cm from the pole of the convex mirror.

15. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image.

Ans. For concave mirror, $h_o = 7.0$ cm, $u = -27$ cm, $f = -18$ cm

Using mirror formula,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{v} + \frac{1}{u}, \text{ we get} \\ \frac{1}{v} &= \frac{1}{f} - \frac{1}{u} = \frac{1}{-18} - \frac{1}{(-27)} \\ &= \frac{-1}{18} + \frac{1}{27} = \frac{-3+2}{54} = \frac{-1}{54} \end{aligned}$$

$$\therefore v = -54 \text{ cm}$$

Hence the screen should be placed at a distance of 54 cm in front of the concave mirror to get the sharp focussed image of the object on it.

Magnification of spherical mirror is given by

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

$$\Rightarrow h_i = -h_o \frac{v}{u} = -7 \times \frac{-54}{-27} = -14 \text{ cm}$$

\therefore The height of image is 14 cm.
 Since $h_i > h_o$, the image is enlarged.
 Since v is $-ve$, the image is real and inverted.

16. Find the focal length of a lens of power -2.0 D . What type of lens is this?

Ans. Power of lens is given by

$$P = \frac{1}{f \text{ (in metres)}} \Rightarrow -2.0 = \frac{1}{f}$$

$\therefore f = -0.5 \text{ m} = -50 \text{ cm}$
 Since the negative focal length of spherical lens indicates that it is concave in nature, hence, it is a concave lens.

17. A doctor has prescribed a corrective lens of power $+1.5 \text{ D}$. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Ans. Power of lens, $P = \frac{1}{f \text{ (in metres)}}$

$$\Rightarrow 1.5 = \frac{1}{f}$$

$$\Rightarrow f = \frac{1}{1.5} = \frac{2}{3} = +0.67 \text{ m} = +67 \text{ cm}$$

Hence the focal length of the given corrective lens is 0.67 m . The positive value of focal length indicates that the prescribed lens is converging, i.e. convex lens.

SELECT NCERT EXEMPLAR PROBLEMS

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

- (a) -30 cm (b) -20 cm
 (c) -40 cm (d) -60 cm

Ans. (b) Given $h_o = +10 \text{ mm} = +0.1 \text{ cm}$,

$$h_i = -5 \text{ mm} = -0.5 \text{ cm}$$

for real image, $v = -30 \text{ cm}$

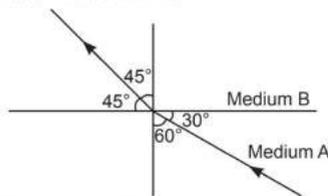
$$\text{Now, magnification, } m = \frac{h_i}{h_o} = -\frac{v}{u}$$

On solving, we get, $u = -60 \text{ cm}$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-30} + \frac{1}{-60} = \frac{-2-1}{60} = -\frac{1}{20}$$

$$\therefore f = -20 \text{ cm}$$

2. 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



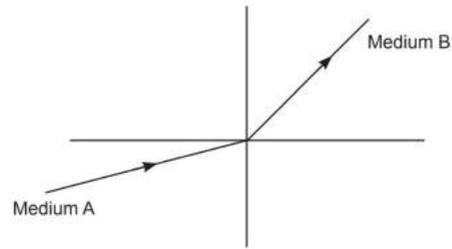
- (a) $\frac{\sqrt{3}}{\sqrt{2}}$ (b) $\frac{\sqrt{2}}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\sqrt{2}$

Ans. (a) Here, $\angle i = 60^\circ$, $\angle r = 45^\circ$

Using Snell's law of refraction, refractive index of medium B with respect to medium A.

$${}_A n_B = \frac{\sin i}{\sin r} = \frac{\sin 60^\circ}{\sin 45^\circ} = \frac{(\sqrt{3}/2)}{(1/\sqrt{2})} = \frac{\sqrt{3}}{\sqrt{2}}$$

3. A light ray enters from medium A to medium B as shown in figure. The refractive index of medium B relative to A will be



- (a) greater than unity (b) less than unity
 (c) equal to unity (d) zero

Ans. (b) In medium B, light ray bends away from the normal. It indicates that medium B is optically rarer than medium A. Hence speed of light in medium B is more than that in medium A.

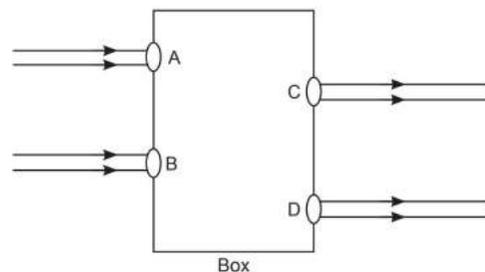
Now, refractive index

$${}_A n_B = \frac{v_A}{v_B}$$

$$\text{As } v_B > v_A \Rightarrow \frac{v_B}{v_A} > 1 \text{ or } \frac{v_A}{v_B} < 1$$

$$\therefore {}_A n_B < 1$$

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



- (a) A rectangular glass slab

- (b) A convex lens
- (c) A concave lens
- (d) A prism

Ans. (a) Figure shows that emergent ray are parallel to the incident ray and shifted side ward slightly. This can be done by the rectangular glass slab only.

5. Which of the following statements is/are true?

- (a) A convex lens has 4 dioptre power having a focal length 0.25 m
- (b) A convex lens has -4 dioptre power having a focal length 0.25 m
- (c) A concave lens has 4 dioptre power having a focal length 0.25 m
- (d) A concave lens has - 4 dioptre having a focal 0.25 m

Ans. (a) Positive sign with power and focal length indicates that the given lens is convex.

$$\text{Also } f = \frac{1}{P} = \frac{1}{4} = 0.25\text{m}$$

6. Magnification produced by a rear view mirror fitted in vehicles

- (a) is less than one
- (b) is more than one
- (c) is equal to one
- (d) can be more than or less than one depending upon the position of the object in front of it.

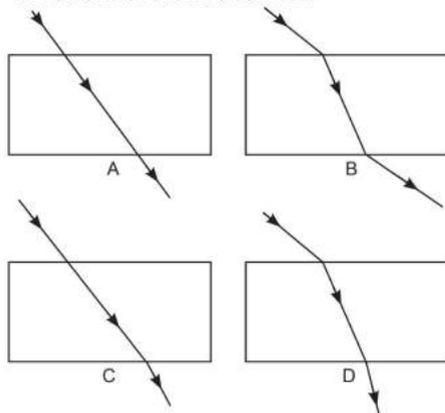
Ans. (a) Convex mirror is used as rear view mirror and always forms virtual, erect and diminished image. So magnification produced by a rear view mirror is less than one.

7. The laws of reflection hold good for

- (a) plane mirror only
- (b) concave mirror only
- (c) convex mirror only
- (d) all mirrors irrespective of their shape

Ans. (d) The laws of reflection hold good for light reflected from any smooth surface irrespective of their shapes.

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



- (a) A
- (b) B
- (c) C
- (d) D

Ans. (b) When a light ray is incident obliquely on one face of rectangular glass slab, the emergent ray will be parallel to the incident ray and shifted sideward slightly.

9. In which of the following, the image of an object placed at infinity will be highly diminished and point sized?

- (a) Concave mirror only
- (b) Convex mirror only
- (c) Convex lens only
- (d) Concave mirror, convex mirror, concave lens and convex lens.

Ans. (d) The incident ray coming from the object placed at infinity will be parallel to the principal axis. When the parallel beam of light incident on a mirror or lens, irrespective of their nature, after reflection/refraction, will pass or appear to pass through their principal focus. Hence highly diminished and point size image will be formed at their focus.

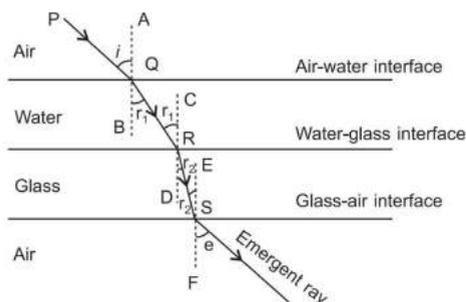
10. Identify the device used as a spherical mirror or lens in following cases, when the image formed is virtual and erect in each case.

- (a) Object is placed between device and its focus, image formed is enlarged and behind it.
- (b) Object is placed between the focus and device, image formed is enlarged and on the same side as that of the object.
- (c) Object is placed between infinity and device, image formed is diminished and between focus and optical centre on the same side as that of the object.
- (d) Object is placed between infinity and device, image formed is diminished and between pole and focus, behind it.

Ans. (a) Concave mirror
(b) Convex lens
(c) Concave lens
(d) Convex mirror

11. Why does a light ray incident on a rectangular glass slab immersed in any medium emerge parallel to itself? Explain using a diagram. [Delhi 2013, HOTS]

Ans. Due to variation in the speed of light in different media, the light ray bends as it moves from one medium to another. Since there are two surfaces for refraction which are parallel, the light ray would bend in opposite sense in them equally, the emerging light ray is always parallel to the incident.



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

Ans. No, it will be dependent on the refractive index of the liquid in which the pencil is dipped. The tip at the bottom will get elevated as per the relation.

$$\text{Refractive index } (n) = \frac{\text{real depth}}{\text{apparent depth}}$$

13. Refractive index of diamond with respect to glass is 1.6 and absolute refractive index of glass is 1.5. Find out the absolute refractive index of diamond.

Ans. Given: $n_{dg} = 1.6$, $n_g = 1.5$

$$\text{Since } n_{dg} = \frac{n_d}{n_g}$$

$$\text{We have } n_d = n_g \times n_{dg} = 1.5 \times 1.6 = 2.4$$

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

Ans. Yes, for getting a virtual image, the object has to be placed between the optical centre and the focus. For a real and enlarged image, the object should be between F_1 and $2F_1$.

15. Sudha finds out that a sharp image of the windowpane of her science laboratory is formed at a distance of 15 cm from the lens. She now tries to focus the building visible to her outside the window instead of the windowpane without disturbing the lens. In which direction will she move the screen to obtain the sharp image of the building? What is the approximate focal length of this lens? [HOTS]

Ans. She will move the screen towards the lens such that the final image is at the focus. The focal length will be slightly less than 15 cm as building can be treated as the object at infinite distance.

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

Ans. Power of a lens is defined as the reciprocal of the focal length.

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

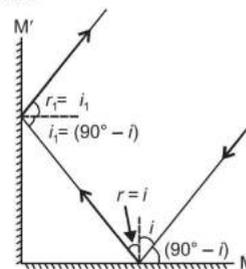
$$\therefore P_{20} = \frac{100}{20} = 5 \text{ D}$$

$$P_{40} = \frac{100}{40} = 2.5 \text{ D}$$

So, the lens of 20 cm focal length will converge more.

17. Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.

Ans. When the two mirrors are placed at 90° to each other, the incident and the reflected rays will remain parallel to each other.



18. The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. If the image is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the lens? What is the nature of the image at a distance of 80 cm and the lens?

Ans. $\therefore m = \frac{h_i}{h_o} = \frac{v}{u}$ for a lens.

\therefore Image is real.

$$\therefore m = -3 = \frac{v}{u}$$

$$\text{With } v = 80 \text{ cm, } u = \frac{v}{-3} = \frac{80}{-3} \text{ cm. The image is}$$

obtained on the screen placed on the other side of the lens, it is possible only in the case of convex lens.

Hence, the candle should be placed at a distance of $\frac{80}{3} = 26.6$ cm to the left of the convex lens to form

the real and inverted image at a distance of 80 cm on the right side of the lens.

19. The 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?

Ans. If the image is real (as in concave mirror),

$$m = -\frac{1}{3}. \text{ Therefore, } -\frac{v}{u} = -\frac{1}{3}.$$

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

$$\frac{1}{-20} = \frac{1}{\frac{u}{3}} + \frac{1}{u} = \frac{3}{u} + \frac{1}{u} = \frac{4}{u} \Rightarrow u = -80 \text{ cm}$$

If the image is virtual (as in convex mirror),

$$m = \frac{1}{3}. \text{ Therefore, } -\frac{v}{u} = \frac{1}{3}.$$

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

$$\frac{1}{20} = \frac{1}{\left(\frac{-u}{3}\right)} + \frac{1}{u} = \frac{1}{u}(1-3) = \frac{-2}{u}$$
$$\Rightarrow u = -40 \text{ cm}$$