UNIT 3: Natural Phenomena

CHAPTER 10

LIGHT-REFLECTION AND REFRACTION

Syllabus

Reflection of light by curved surfaces; Images formed by spherical mirrors, centre of curvature, principal axis, principal focus, focal length, mirror formula (Derivation not required), magnification, Refraction; Laws of refraction, refractive index, Refraction of light by spherical lens; Image formed by spherical lenses; Lens formula (Derivation not required); Magnification, Power of a lens.

Trend Analysis

List of Concepts	2018	2019		2020	
	Delhi/Outside Delhi	Delhi	Outside Delhi	Delhi	Outside Delhi
Reflection of light, Image formed by Spherical Mirrors	1 Q (2 M)	1 Q (3 M)		1 Q (3 M) 1 Q (5 M)	1 Q (1 M) 1 Q (5 M)
Refraction, Lens and Power of a Lens.	1 Q (3 M) Or 1 Q (3 M)	1 Q (2 M) Or 1 Q (3 M)	1 Q (5 M)	1 Q (5 M)	1 Q (5 M)

TOPIC - 1

Reflection of Light, Images Formed by Spherical Mirrors

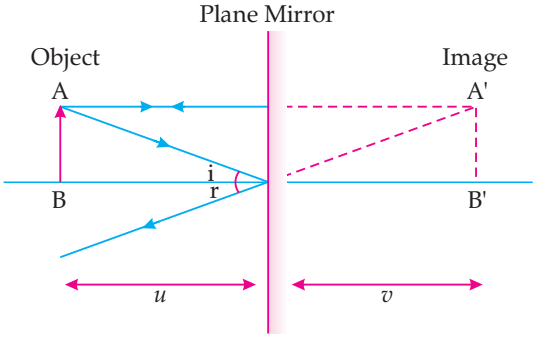
Revision Notes

Introduction

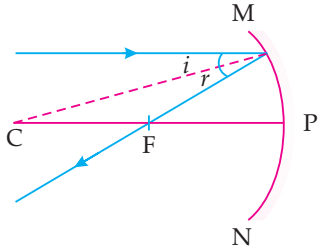
- When light falls on a body, it may be absorbed, may be transmitted or light may get reflected back to the same medium.
- **Reflection of light** is the phenomenon of bouncing back of the light rays in the same medium.
- **Laws of Reflection:**
  - **(i)** The incident ray, the reflected ray, the normal, all lie in the same plane at the point of incidence.
  - **(ii)** The angle of incidence is equal to the angle of reflection.
- **Real image** is obtained when the rays of light after reflection or refraction

actually meet at some point. It can be obtained on the screen and can be seen with the eye.

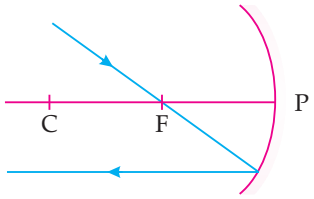
- **Virtual image** forms when rays of light do not actually meet, but appear to meet when produced backwards. It cannot be obtained on the screen.
- **Image Formed by plane Mirror:**



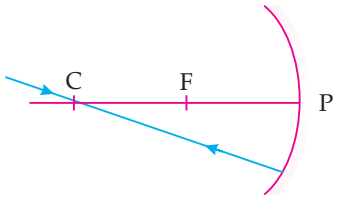
- **Characteristics of Image:**
  (i) Virtual and erect.
  (ii) Size of image is equal to the size of object.
  (iii) Image is formed as far as behind the mirror as the object is in front of it.
  (iv) Laterally inverted.
- **Lateral Inversion:** The phenomenon due to which the right side of the object appears as left and the left side of the object appears as right. *i.e.,* the image is inverted sideways.
- A spherical mirror whose reflecting surface recessed inward, is concave mirror.
- The spherical mirror, whose reflecting surface bulges towards light source, is a convex mirror.
- Concave mirror mostly forms real images, which can be obtained on the screen. Convex mirror always forms virtual images, which cannot be obtained on the screen.
- **Differentiating between a plane mirror, a concave mirror and a convex mirror, without touching them:**
  (i) If the formed image is erect, of same size and equidistant as of object, then it is a plane mirror
  (ii) If the formed image formed is erect but smaller in size, then it is a convex mirror
  (iii) If the formed image is erect, real and magnified when the mirror is close to the object, then it is a concave mirror
- Solar concentrators use huge concave mirrors to focus large amount of solar energy thereby producing high temperature conditions in a solar power plant.
- The centre of the reflecting surface of a spherical mirror is called the pole of the mirror and it is usually represented by P.
- The horizontal line passing through the centre of curvature and pole of the spherical mirror is known as principal axis.
- The centre of curvature of a spherical mirror is the centre of the hollow sphere of glass, of which the spherical mirror is a part and is usually represented by C.
- The radius of curvature of a spherical mirror is the radius of the hollow sphere of glass, of which the spherical mirror is a part and is usually represented by R.
- The diameter of the reflecting surface, *i.e.,* twice the radius is called its aperture.
- Radius of curvature (R) = 2 × focal length (f).
- **Rules for making ray diagrams by concave mirror:**
  (i) A ray parallel to the principal axis will pass through the principal focus, after reflection.



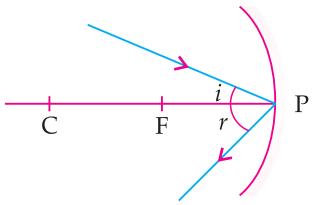
(ii) A ray passing through the principal focus of concave mirror will be parallel to principal axis after reflection.



(iii) A ray of light passing through the centre of curvature of a concave mirror is reflected back along the same path as it is a normally incident ray.



(iv) A ray incident obliquely to the principal axis of a concave mirror is reflected obliquely making equal angle.



➢ **Image formation by a concave mirror for different positions of the object:**

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

➢ **Image formation by a convex mirror for different positions of the object:**

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

➢ **Mirror Formula:**

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

Where,

v = Image distance
u = Object distance
f = Focal length

➢ **Magnification of Spherical Mirrors:**

It is the ratio of the height of image to the height of object.

$$m = \frac{\text{Height of image}}{\text{Height of object}}$$

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

If 'm' is negative, image is real.

If 'm' is positive, image is virtual.

If $h_i = h_o$ then $m = 1$, *i.e.*, image is equal to object.

If $h_i > h_o$ then $m > 1$ *i.e.*, image is enlarged.

If $h_i < h_o$ then $m < 1$ *i.e.*, image is diminished.

- Magnification of plane mirror is always + 1.

  '+' sign indicates virtual image.

  '1' indicates that image is equal to object's size.
- If 'm' is '+ve' and less than 1, it is a convex mirror.
- If 'm' is '+ve' and more than 1, it is a concave mirror.
- If 'm' is '–ve', it is a concave mirror.
- The phenomenon of change in the path of light from one medium to another is called refraction of light.
- The angle formed between the incident ray and the normal is called angle of incidence and the angle formed between the refracted ray and the normal is called angle of refraction.
- The cause of refraction is the change in the speed of light as it goes from one medium to another medium.
- Larger the difference in speed of light between the two media across the interface, the greater will be the deviation and vice-versa.
- When a ray of light passes from a rarer medium to a denser medium, it bends towards the normal. Also, the angle of incidence is greater than the angle of refraction.
- When a ray of light passes from a denser medium to a rarer medium, it bends away from the normal. Also, the angle of incidence is less than the angle of refraction.

Mnemonics

Concept: Image formation by concave mirror

Mnemonics: Mnemonics:54321 to be converted in 12345

At F	1
Between C and F	2
At C	3
Beyond C	4
Infinity	5
Between F and P	Exception

Object	1	2	3	4	5
Image	5	4	3	2	1

Interpretation:

If object is at infinity (5) , image will be formed at F (1)

If object is at beyond C (4), image will be formed at between C and F (2)

And so on.

How is it done on the GREENBOARD?

Q. The image of a candle flame placed at a distance of 30 cm from a mirror is formed on a screen placed in front of the mirror at a distance of 60 cm from its pole. What is the nature of the mirror? Find its focal length. If the height of the flame is 2.4 cm, find the height of its image. State whether the image formed is erect or inverted.

Solution:

Step I: Since the image is formed on a screen, the image is real. So, the nature of the mirror is concave.

Step II: Given, $u = -30$ cm, $v = -60$ cm, Using mirror formula,

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

or, $$\frac{1}{f} = \frac{1}{-60} + \frac{1}{-30}$$

or, $$\frac{1}{f} = -\frac{1}{60} - \frac{1}{30}$$

or, $$\frac{1}{f} = -\frac{3}{60}$$

or, $$\frac{1}{f} = -\frac{1}{20}$$

$\therefore$ $f = -20$ cm

so, focal length $= -20$ cm.

Step III: Given, $u = -30$ cm, $v = -60$ cm, $h_0 = 2.4$ cm,

$\therefore$ Magnification, $-\frac{v}{u} = -\frac{-60}{-30} = -2$

(Negative sign indicates that the image is real and inverted.)

Again magnification $= \frac{h_i}{h_o} = -2$

or, $$\frac{h_i}{2.4} = -2$$

$\therefore$ $h_i = -4.8$ cm

So, the height of the image is 4.8 cm. (Negative sign indicates that the image is inverted and real)

Step IV: From the sign of magnification it is concluded that the image is inverted.

Objective Type Questions — 1 mark each

A Multiple Choice Questions

Q. 1. The laws of reflection hold true for:
(a) plane mirrors only
(b) concave mirrors only
(c) convex mirrors only
(d) all reflecting surfaces R [CBSE Delhi 2020]

Ans. Correct option : (d)

Q. 2. When an object is kept within the focus of a concave mirror, an enlarged image is formed behind the mirror. This image is:
(a) real **(b) inverted**
(c) virtual and inverted **(d) virtual and erect**
A [CBSE Delhi, 2020]

Ans. Correct option : (d)

Q. 3. Consider the following properties of virtual images:
(A) cannot be projected on the screen
(B) are formed by both concave and convex lens
(C) are always erect
(D) are always inverted
The correct properties are:
(a) (A) and (D) **(b) (A) and (B)**
(c) (A), (B) and (C) **(d) (A), (B) and (D)**
A [CBSE Delhi 2020, Set-3]

Ans. Correct option : (c)

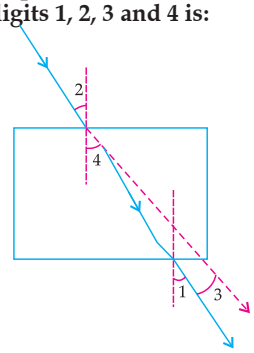
Q. 4. A real image is formed by the light rays after reflection or refraction when they:

(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?
(a) (A) and (D) **(b) (B) and (D)**
(c) (A) and (B) **(d) (B) and (C)**

AE **[CBSE Delhi 2020, Set-3]**

Ans. Correct option : (c)

Q. 5. The correct sequencing of angle of incidence, angle of emergence, angle of refraction and lateral displacement shown in the following diagram by digits 1, 2, 3 and 4 is: U **[Delhi Set-1, 2017]**



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

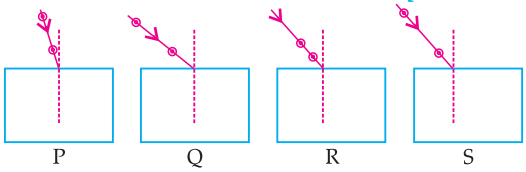
Ans. Correct option : (b)

Q. 6. A student obtained a sharp image of a candle flame placed at the distant end of the laboratory table on a screen using a concave mirror to determine its focal length. The teacher suggested him to focus a distant building about 1 km far from the laboratory, for getting more correct value of the focal length. In order to focus the distant building on the same screen the student should slightly move the:
(a) mirror away from the screen
(b) screen away from the mirror
(c) screen towards the mirror
(d) screen towards the building

AE **[CBSE Delhi Set-1, 2016]**

Ans. Correct option : (c)
Explanation : The object is at infinity , so to obtain sharp image screen should be moved towards mirror.

Q. 7. Select from the following the best experimental set-up for tracing the path of a ray of light passing through a rectangular glass slab:
[CBSE Delhi, 2016]



(a) P (b) Q
(c) R (d) S

Ans. Correct option : (b)

Q. 8. To determine the approximate value of the focal length of a given concave mirror, you focus the image of a distant object formed by the mirror on a screen. The image obtained on the screen, as compared to the object is always:
(a) Laterally inverted and diminished
(b) Inverted and diminished
(c) Erect and diminished
(d) Erect and highly diminished

[CBSE Outside Delhi Set-1, 2016]

Ans. Correct option : (b)
Explanation : When the object is at infinity, diminished, inverted and real image is formed.

Q. 9. In your laboratory you trace the path of light rays through a glass slab for different values of angle of incidence ($\angle i$) and in each case measure the values of the corresponding angle of refraction ($\angle r$) and angle of emergence ($\angle e$).
On the basis of your observation your correct conclusion is:
(a) $\angle i$ is more than $\angle r$, but nearly equal to $\angle e$
(b) $\angle i$ is less than $\angle r$, but nearly equal to $\angle e$
(c) $\angle i$ is more than $\angle e$, but nearly equal to $\angle r$
(d) $\angle i$ is less than $\angle e$, but nearly equal to $\angle r$

[CBSE Outside Delhi Set-1, 2016]

Ans. Correct option : (a)
Explanation : On passing through a glass slab emergent ray is parallel to incident ray.

Q. 10. Which of the following can make a parallel beam of light when light from a point source is incident on it?
(a) Concave mirror as well as convex lens
(b) Convex mirror as well as concave lens
(c) Two plane mirrors placed at 90° to each other
(d) Concave mirror as well as concave lens

[NCERT Exemp.]

Ans. Correct option : (a)
Explanation : When a point source of light is placed at the focus of concave mirror then all light rays after reflection through mirror will become parallel to the principal axis.
When this point source of light is placed at the focus of convex lens then after refraction by light rays convex lens will become parallel to the principal axis.

Q. 11. 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.

[NCERT Exemp.]

Ans. Correct option : (a)
Explanation : Convex mirror is used as rear-view mirror in vehicles. It forms virtual, erect, and diminished images of the objects.
Magnification is ratio of height of image to the height of the object, hence, magnification produced by a rear-view mirror fitted in vehicles is less than one.

Q. 12. Rays from sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?
(a) 15 cm in front of the mirror
(b) 30 cm in front of the mirror
(c) Between 15 cm and 30 cm in front of the mirror
(d) More than 30 cm in front of the mirror

[NCERT Exemp.]

Ans. Correct option : (b)

Explanation : The distance of the sun is infinite as compared to the radius of curvature of concave mirror, so, light rays from sun incident parallel all the rays converge at the principal focus. So, the focal length is 15 cm.

In case of a concave mirror, the size of image and object will be same if the object is placed at $2f$. Hence, in this case object must be placed at $2f$ or $2 \times 15 = 30$ cm.

Q. 13. In torches, search lights and headlights of vehicles, the bulb is placed

(a) between the pole and the focus of the reflector.

(b) very near to the focus of the reflector.

(c) between the focus and centre of curvature of the reflector.

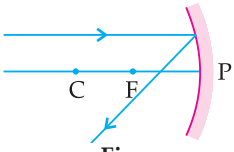
(d) at the centre of curvature of the reflector.

[NCERT Exemp.]

Ans. Correct option : (b)

Explanation : The rays of light passing through the principal focus will go parallel to principal axis after reflection thus, forming a concentrated beam of light. So, due to this reason in torches, search lights, and headlights of vehicles, the bulb is placed very near to the focus of the reflector.

Q. 14. Which of the following ray diagrams is correct for the ray of light incident on a concave mirror as shown in figure?



Fig

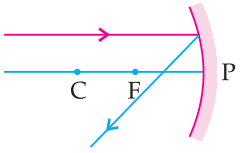


Fig. A

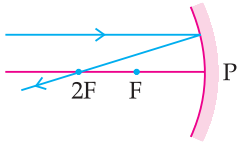


Fig. B

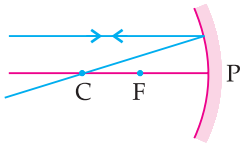


Fig. C

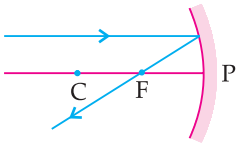


Fig. D

(a) Fig. A **(b) Fig. B**

(c) Fig. C **(d) Fig. D**

[NCERT Exemp.]

Ans. Correct option : (d)

Explanation : Ray of light incident parallel to the principal axis towards the mirror after reflection will pass through the principal focus. So, Figure D is correct.

Q. 15. A student determines the focal length of a device '*X*' by focussing the image of a distant object on a screen placed 20 cm from the device on the same side as the object. The device '*X*' is

(a) Concave lens of focal length 10 cm

(b) Convex lens of focal length 20 cm

(c) Concave mirror of focal length 10 cm

(d) Concave mirror of focal length 20 cm

[CBSE Board, Foreign Scheme, 2016]

Ans. Correct option : (d)

Explanation : Image formed by the concave mirror in this case is same as when object is at infinity. Due to the great distance, light rays will incident almost parallel to principal axis.

After reflection all the rays will converge and meet at principal focus.

So, focal length is 20 cm.

B Assertion and Reason Type Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

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

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

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

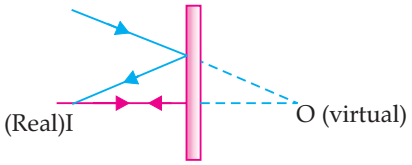
(d) Assertion (A) is false but reason (R) is true.

Q. 1. Assertion (A): Plane mirror may form real image.

Reason (R): Plane mirror forms virtual image, if object is real.

Ans. Correct option : (b)

Explanation : Plane mirror may form real image, if object is virtual.



Q. 2. Assertion (A): The focal length of the convex mirror will increase, if the mirror is placed in water.

Reason (R): The focal length of a convex mirror of radius *R* is equal to, $f = \frac{R}{2}$.

Ans. Correct option : (d)

Explanation : Focal length of the spherical mirror does not depend on the medium in which it is placed.

Q. 3. Assertion (A): The image formed by a concave mirror is certainly real if the object is virtual.

Reason (R): The image formed by a concave mirror is certainly virtual if the object is real.

Ans. Correct option : (c)

Explanation : The image of real object may be real in case of concave mirror.

Q. 4. Assertion (A): An object is placed at a distance of *f* from a convex mirror of focal length *f*, its image will form at infinity.

Reason (R): The distance of image in convex mirror can never be infinity.

Ans. Correct option : (d)

Explanation : The distance of image in convex mirror is always finite.

C Very Short Answer Type Questions

Q. 1. Both a spherical mirror and a thin spherical lens have a focal length of (–)15 cm. What type of mirror and lens are these? U [SQP 2020]

Ans. Both are concave.
Alternative answer that should be given credit: Plano-concave lens. **1**
[CBSE Marking Scheme, 2020]

Q. 2. The image formed by a concave mirror is observed to be real, inverted and larger than the object. Where is the object placed? A [SQP 2020]

Ans. Between the principal focus and the centre of curvature. [CBSE Marking Scheme, 2020]

Q. 3. Define the term principal axis of a spherical mirror. R [Delhi Comptt. 31/1/3 2017]

Ans. The line which joins the pole and the centre of curvature of a spherical mirror, is the principal axis of a spherical mirror. 1

COMMONLY MADE ERROR

- Many candidates write only mirror instead of writing spherical mirror.

ANSWERING TIP

- Specification of spherical mirror in answer is must.

Q. 4. Write two different uses of concave mirrors. R [Delhi Comptt. 31/1/1 2017]

Ans. It is used in torches, searchlights, headlights of vehicles etc. ½ + ½

Q. 5. We prefer a convex mirror as a rear view mirror in vehicles. Why ? A [Delhi Comptt. 31/1/1 2017]

Ans. Due to its wide field of view. **1**

COMMONLY MADE ERROR

- Candidates get confused between plane, convex and concave mirrors.

ANSWERING TIP

- Candidates should learn that convex mirror forms small, erect and virtual image.

Q. 6. What is the magnification of the images formed by plane mirror and why ? U [Board Term II Delhi Set-I, 2015]

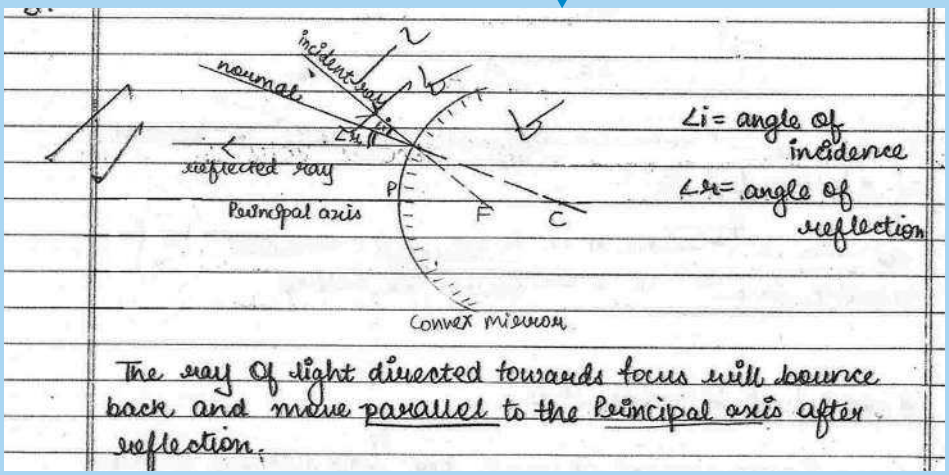
Ans. Its magnification is +1 because plane mirror always forms image equal to object's size. **1**
[CBSE Marking Scheme, 2015]

Short Answer Type Questions-I — 2 marks each

Q. 1. Draw a labelled ray diagram to show the path of the reflected ray corresponding to the ray which is directed towards the principal focus of a convex mirror. Mark the angle of incidence and angle of reflection on it. A [Delhi 2019]

Topper Answer, 2018

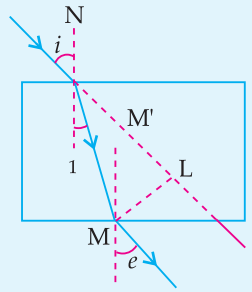
Ans.



Q. 2. Draw the path of a ray of light when it enters one of the faces of a glass slab at an angle of nearly 45°. Label on it (i) angle of refraction, (ii) angle of emergence and (iii) lateral displacement.

A [OD 2019, Set-1]

Ans.



½

Labelling

- Angle or refraction (r_1)
- Angle of emergence (e)
- Lateral displacement (ML) ½×3

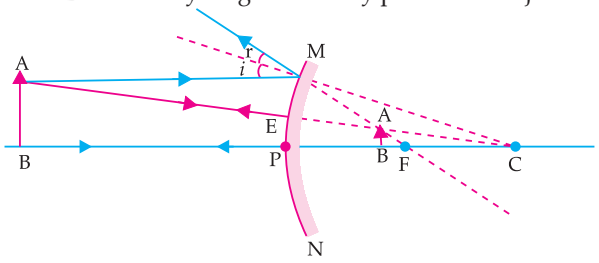
[CBSE Marking Scheme, 2019]

Q. 3. If the image formed by a spherical mirror for all position 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.

AE [CBSE, Delhi, 2018]

Ans. ● Convex Mirror

● Labelled Ray diagram for any position of object.



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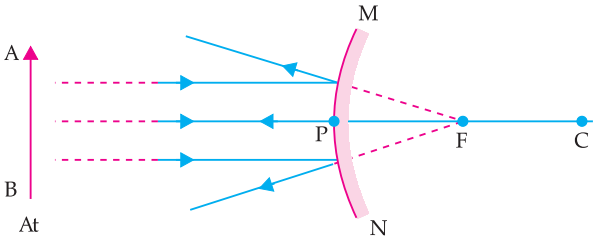
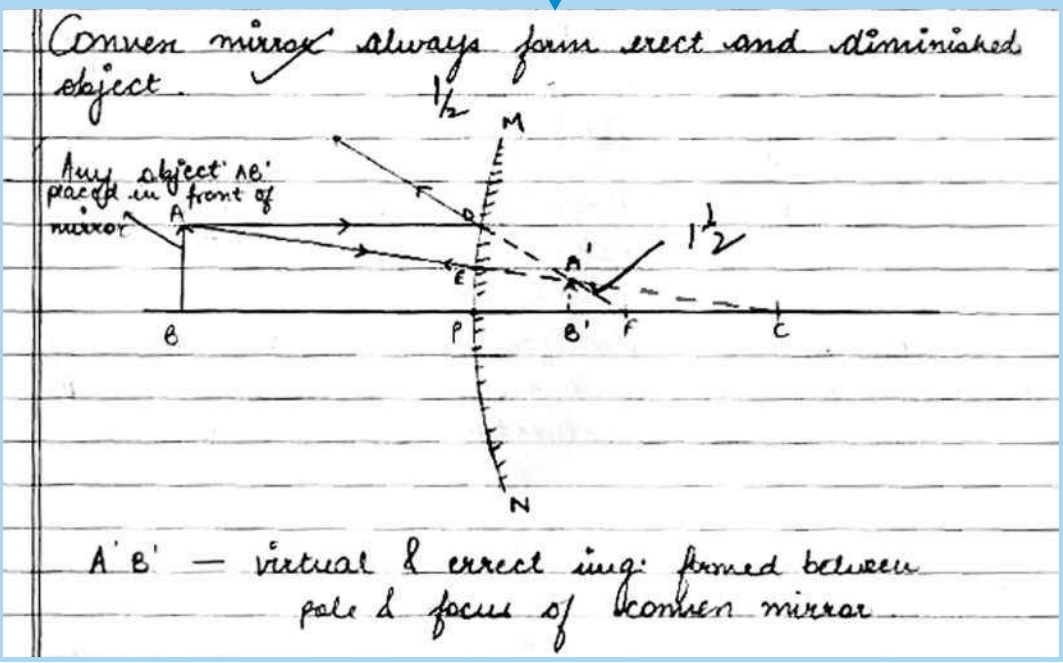


Note: If arrows not marked, ½ mark to be deduced. **1+1=2**

Topper Answer, 2018



Q. 4. An object is placed at a distance of 30 cm in front of a convex mirror of focal length 15 cm. Write four characteristics of the image formed by the mirror.

A [2017,Delhi Set-1]

Ans. Virtual, erect, diminished, laterally inverted. 4×½

[CBSE Marking Scheme, 2017]

Detailed Answer:

Four properties of image formed by the given convex mirror are:

(i) Image is always erect.
(ii) Small in size
(iii) Virtual
(iv) Laterally Inverted.

Q. 5. An object is placed at a distance of 12 cm in front of a concave mirror of radius of curvature 30 cm. List four characteristics of the image formed by the mirror.

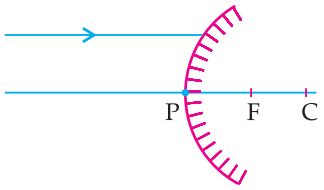
U [Delhi 2017, Set-3]

Ans. Virtual, erect, magnified, laterally inverted.
[CBSE Marking Scheme, 2017]

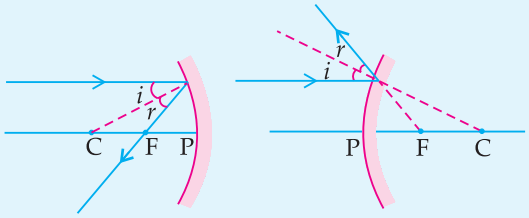
Q. 6. State two positions in which a concave mirror produces a magnified image of a given object. List two differences between the two images.
AE [Delhi 2017]

Ans. Two positions:
(i) between its pole and focus
(ii) between the focus and centre of curvature
Two differences:
(i) the image is virtual and erect
(ii) the image is real and inverted

Q. 7. A ray of light is incident on a convex mirror as shown. Redraw the diagram and complete the path of this ray after reflection from the mirror. Mark angle of incidence and angle of reflection on it.
R [Delhi 2017, Set-2]



Ans.



Tracing the reflected ray **1**
Marking $\angle i$ & $\angle r$ ½ + ½
[CBSE Marking Scheme, 2017]

Q. 8. Name the type of mirrors used in the design of solar furnaces. Explain how high temperature is achieved by this device. [OD Set-1, 2016]

Ans. Concave Mirrors / Converging Mirrors. **1**
When a solar furnace is placed at the focus of a large concave mirror/ reflector it focuses a parallel beam of light on the furnace, consequently a high temperature is achieved after some time. **1**

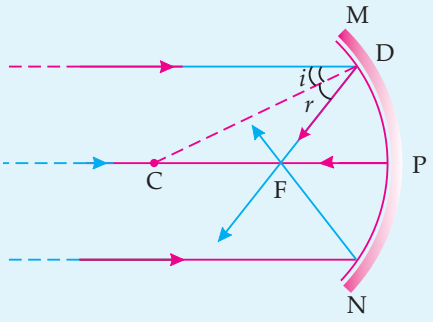
Q. 9. "The magnification produced by a spherical mirror is – 3". List four information you obtain from this statement about the mirror/image.
R [OD Set-2,2016]

Ans. (i) magnified
(ii) inverted
(iii) concave mirror
(iv) real image.

Short Answer Type Questions-II — 3 marks each

Q. 1. A student holding a mirror in his hand, directed the reflecting surface of the mirror towards the Sun. He then directed the reflected light on to a sheet of paper held close to the mirror.
(a) What should he do to burn the paper ?
(b) Which type of mirror does he have ?
(c) Will he be able to determine the approximate value of focal length of this mirror from this activity ? Give reason and draw ray diagram to justify your answer in this case.
A [Board Outside Delhi, Set-I, 2019]

Ans. (a) Move the mirror/paper to focus the rays at one point. ½
(b) Concave mirror. ½
(c) Yes, distance between mirror and the point the sharp focussed image of sun is formed gives approximate focal length. ½ + ½



[CBSE Marking Scheme, 2019] ½ + ½

Detailed Answer:

(a) He should move the sheet of paper back and forth gradually until he finds a bright and sharp spot of lights. He should hold the mirror and paper in the same position for a few minutes to burn the paper.
(b) He has a concave mirror.
(c) Yes, he will be able to determine the approximate value of focal length of this mirror from this activity because the spot of light is the image of the sun which is at the focus of the concave mirror. Therefore, the distance of this image from the position of this mirror gives the approximate value of focal length of this mirror.
Ray diagram: Same as in marking scheme answer.

Q. 2. A 5 cm tall object is placed at a distance of 30 cm from a convex mirror of focal length 15 cm. Find the position, size and nature of the image formed.
A [Comptt. Delhi, 2018]

Ans. $h = +5$ cm; $u = -30$ cm; $f = +15$ cm; $v = ?$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \qquad ½$$

$$\therefore \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(+15)} - \frac{1}{(-30)} \qquad ½$$

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

$$\therefore \quad v = +10 \text{ cm} \qquad ½$$

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

$$\therefore \quad h_2 = -\frac{(+10)}{(-30)} \times (+5) = +\frac{5}{3} = +1.67 \text{ cm}$$ ½

Nature = virtual, erect **1**

[CBSE Marking Scheme, 2018]

Q. 3. 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. A **[Delhi 31/1/1 2017]**

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

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$ ½

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

as, $$\frac{1}{v} = \frac{1}{-10 \text{ cm}} - \frac{1}{-15 \text{ cm}}$$ ½

$\therefore \quad v = -30$ cm **1**

$$\frac{h_2}{h_1} = -\frac{v}{u}$$ ½

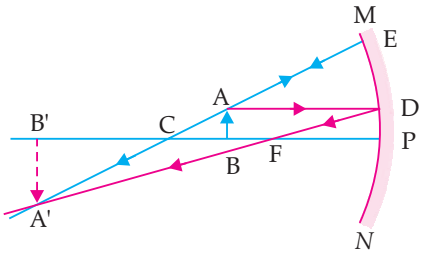
or, $$h_2 = -\frac{v}{u} \times h_1$$

or, $$h_2 = -\frac{-30 \text{ cm}}{-15 \text{ cm}} \times 4 \text{ cm}$$

$\therefore \quad h_2 = -8$ cm ½

[CBSE Marking Scheme, 2017] 1+1+1

Detailed Answer:



Using the mirror formula,

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

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

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

or, $$\frac{1}{v} = \frac{(-15+10)}{150}$$

or, $$\frac{1}{v} = \frac{-5}{150}$$

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

Thus, to obtain a sharp image of the object the screen should be placed in front of the mirror at a distance of 30 cm from the mirror.

Magnification,

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

or, $$m = -\left(\frac{-30}{-15}\right) = -2$$

or, $$-2 = \frac{h_i}{4}$$

$\therefore \quad h_i = -8$ cm

-ve sign indicates image will be inverted

Hence, the height of image will be 8 cm.

Q. 4. The image of a candle flame placed at a distance of 30 cm from a mirror is formed on a screen placed in front of the mirror at a distance of 60 cm from its pole. What is the nature of the mirror ? Find its focal length. If the height of the flame is 2.4 cm, find the height of its image. State whether the image formed is erect or inverted.

A **[Delhi 31/1/3 2017]**

Ans. The nature of the mirror is concave since the image formed is real.

Given, $u = -30$ cm, $v = -60$ cm, $h = 2.4$ cm,

Using mirror formula,

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

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

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

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

Therefore; $f = -20$ cm

Magnification, $$m = \frac{v}{u} = -\frac{\text{Height of image}}{\text{Height of object}}$$

$$\frac{v}{u} = -\frac{-60}{-30} = \frac{h'}{2.4}$$

$$h' = \frac{60}{-30} \times 2.4 = -4.8 \text{ cm}$$

The required height of the image is – 4.8 cm

The image formed by the mirror is inverted. **1 + 1 + 1**

COMMONLY MADE ERROR

- Many candidates make lengthy calculations, which are not required. In some cases, incorrect formula is used to find the focal length.

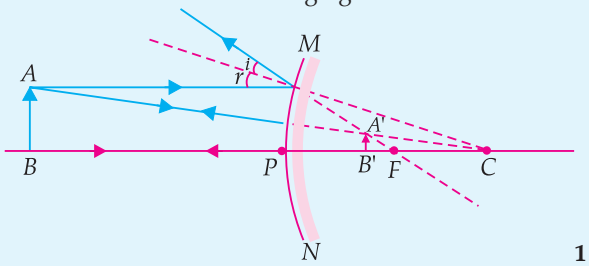
ANSWERING TIP

- First write the formula, then start calculation to avoid confusion. Avoid unnecessary steps and don't have the answer without mentioning unit.

Q. 5. If the image formed by mirror for all positions of the object placed in front of it is always virtual and diminished, state the type of the mirror. Draw a ray diagram in support of your answer. Where are such mirrors commonly used and why ?

A [Board Term II O.D. Set I, 2017]

Ans. Convex mirror or diverging mirror **1**



1

Convex mirrors can be used as rear view mirror in vehicles because they always give erect image with large field of view. 1

[CBSE Marking Scheme, 2016] **1**

Q. 6. Define the magnification as referred to spherical mirrors. If a concave mirror forms a real image 40 cm from the mirror, when the object is placed at a distance of 20 cm from its pole, find the focal length of the mirror.

R [Delhi Comptt. 31/1/1 2017]

Ans. (a) Magnification is the relative extent to which the image of an object is magnified with respect to object size. It is the ratio of size of the image to the size of the object. **1**

(b) $v = -40$ cm, $u = -20$ cm, $f = ?$ ½

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad ½$$

$$\frac{1}{f} = \frac{1}{-40} + \frac{1}{-20} \quad ½$$

$$f = \frac{-40}{3}\text{ cm}$$

[CBSE Marking Scheme, 2017]

Q. 7. A 3 cm tall object is placed 18 cm in front of a concave mirror of focal length 12 cm. At what distance from the mirror should a screen be placed to see a sharp image of the object on the screen. Also calculate the height of the image formed.

U [Delhi, 2017,Set-2]

Ans. $h_1 = +3$ cm, $f = -12$ cm, $u = -18$ cm, $v = ?$, $h_2 = ?$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad ½$$

or, $$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} \quad ½$$

or, $$\frac{1}{v} = \frac{1}{-12\text{cm}} - \frac{1}{-18\text{cm}} \quad ½$$

$\therefore$ $$v = -36\text{ cm} \quad ½$$

$$m = \frac{h_2}{h_1} = -\frac{v}{u} \quad ½$$

$\therefore$ $$h_2 = -\frac{v}{u} \times h_1$$

$$= \frac{-36\text{cm}}{-18\text{cm}} = -6\text{ cm} \quad ½$$

[CBSE Marking Scheme, 2017]

Q. 8. The image of an object formed by a mirror is real, inverted and is of magnification – 1. If the image is at a distance of 40 cm from the mirror, where is the object placed ? Where would the image be if the object is moved 20 cm towards the mirror? State reason and also draw ray diagram for the new position of the object to justify your answer.

A [Board Term II O.D. Set I, 2016]

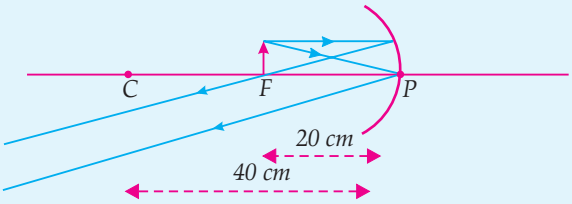
Ans. Object position: At C (Centre of curvature) ½

Object distance = 40 cm, ½

Position of the image - at infinity, ½

Reason: Focal length of the mirror = 20 cm,

If the object is moved 20 cm towards the mirror then its new position would be at the focus of the mirror. ½

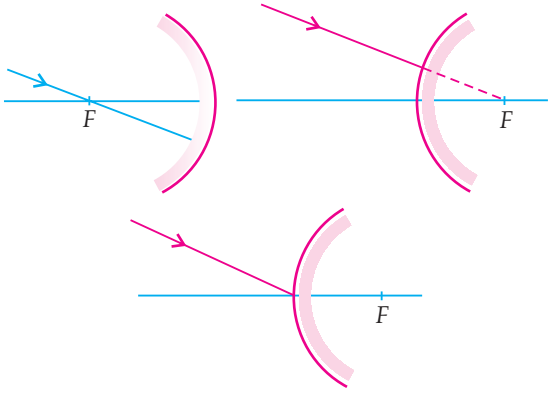


(deduct ½ mark if arrows are missing/not marked) **1**

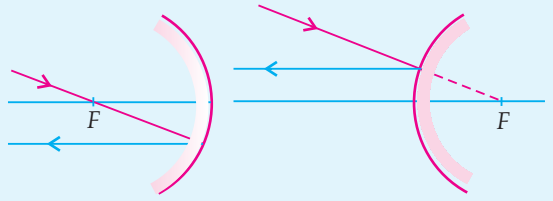
[CBSE Marking Scheme, 2016]

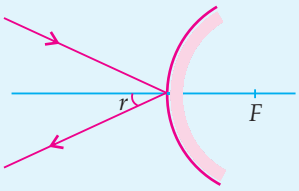
Q. 9. Draw the following diagram, in which a ray of light is incident on a concave/convex mirror, on your answer sheet. Show the path of this ray, after reflection, in each case.

U [Board Term II Delhi Set I, 2016]



Ans.





[CBSE Marking Scheme, 2016] 3 × 1 = 3

Q. 10. The image formed by a spherical mirror is real, inverted and is of magnification – 2. If the image is at a distance of 30 cm from the mirror, where is the object placed ? Find the focal length of the mirror. List two characteristics of the image formed if the object is moved 10 cm towards the mirror.

A [OD 2016,Set -3]

Ans. $m = -2$, $\frac{v}{u} = 2$, $v = -30$ cm, u = – 15 **1**

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

$$= \frac{-15\text{cm} \times -30\text{ cm}}{-15\text{cm} + (-30)\text{cm}} = \frac{450}{-45}$$

$$= -10\text{ cm}$$ **1**

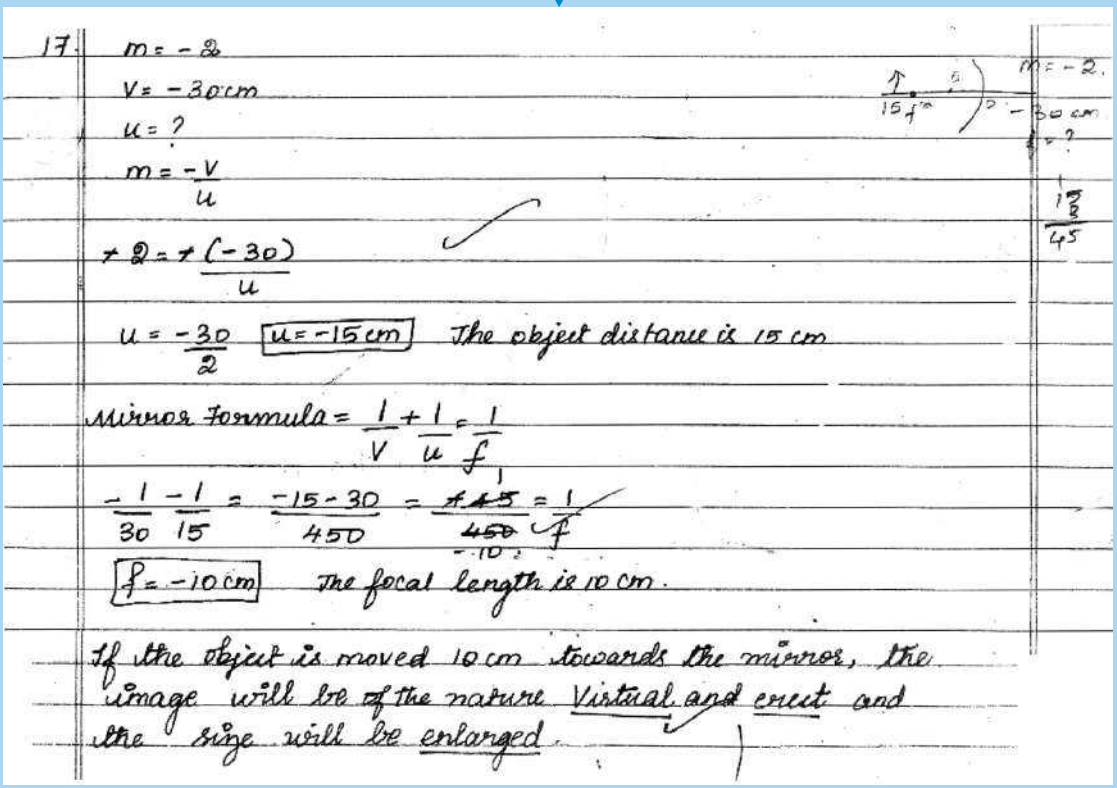
If the object is shifted 10 cm towards the mirror $u = -5$ cm

Therefore the object is between pole and focus and the image formed is

(i) Virtual **(ii)** Erect

(iii) Magnified **(Any two)** ½+½

Topper Answer, 2016



Q. 11. A student wants to project the image of a candle flame on a screen 80 cm in front of a mirror by keeping the candle flame at a distance of 20 cm from its pole.

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

(ii) Find the magnification of the image produced.

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

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

C [Board Term II Foreign Set I, 2015]

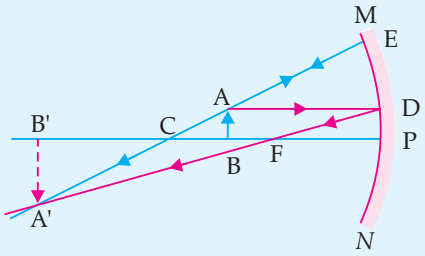
Ans. (i) Concave mirror ½

(ii) $u = -20$ cm, $v = -80$ cm and $m = ?$

$$m = \frac{-v}{u} = \frac{-(-80\text{cm})}{(-20\text{ cm})} = -4$$ **1**

(iii) $v - u = -60$ cm ½

(iv)



1

In diagram B' to B = 60 cm (distance between object and image)

[CBSE Marking Scheme, 2015]

COMMONLY MADE ERROR

- Mostly errors are found in ray diagrams.

ANSWERING TIP

- Students should carefully do the calculation. Practice drawing the ray diagram with correct labelling.

Q. 12. 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.

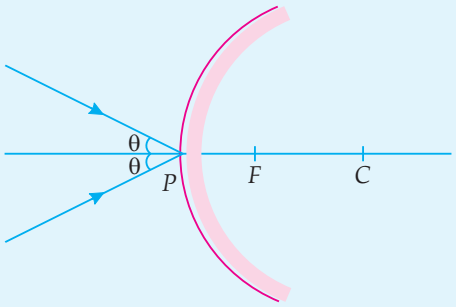
(i) Strikes at its pole making an angle θ from the principal axis.

(ii) Is directed towards its principal focus.

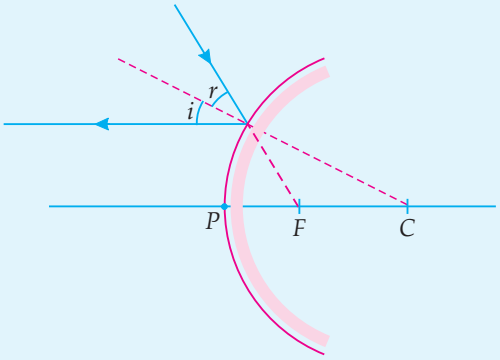
(iii) Is parallel to its principal axis.

C [Board Term II, Foreign Set I, 2015]

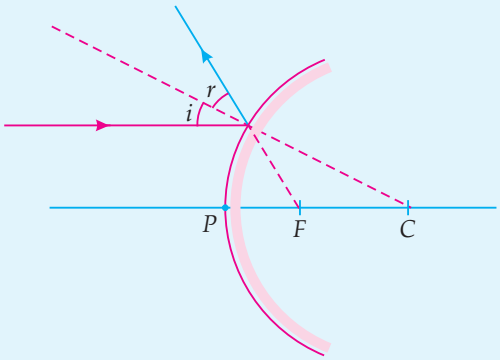
Ans. (i)



(ii)



(iii)



[CBSE Marking Scheme, 2015] 3

Long Answer Type Questions — 5 marks each

Q. 1. A security mirror used in a big showroom has radius of curvature 5 m. If a customer is standing at a distance of 20 m from the cash counter, find the position, nature and size of the image formed in the security mirror.

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

[CBSE OD Set-1,2020]

Ans. (a) Given, R = 5 m, $f = \frac{5}{2}$ m, $u = -20$ m and $v = ?$

Hence, on applying the values,

$$\frac{2}{R} = \frac{1}{v} + \frac{1}{u}$$

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

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

or $$\frac{1}{v} = \frac{8+1}{20}$$

or $$\frac{1}{v} = \frac{9}{20}$$

or $$v = \frac{20}{9}$$

$\therefore$ $$v = 2.2 \text{ m}$$

Nature of the image: Erect, virtual, small and diminished.

(b) Mirror used by dentist is: Concave mirror.

Reason: It produces enlarged, erect and virtual images of the object, so it is used to see the large image of teeth of patients.

Q. 2. A 6 cm tall object is placed perpendicular to the principal axis of a concave mirror of focal length 30 cm. The distance of the object from the mirror is 45 cm. Use mirror formula to determine the position, nature and size of the image formed. Also, draw labelled ray diagram to show the image formation in this case.

A [Board Outside Delhi, Set- III, 2019]

Ans. Given:

$h = 6$ cm

$f = -30$ cm

$u = -45$ cm

By mirror formula,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$ ½

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

$$= -\frac{1}{30} - \frac{1}{(-45)} = -\frac{1}{30} + \frac{1}{45} = -\frac{1}{90}$$ ½

$v = -90$ cm from the pole of mirror

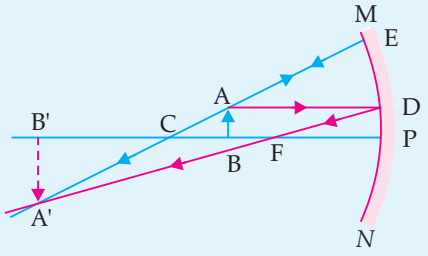
Size of the image

$$m = \frac{-v}{u}$$ ½

$$= -\frac{90}{45} = -2$$

$h' = -2 \times 6$ cm $= -12$ cm ½

Image formed will be real, inverted and enlarged. **1**



2

Well labelled diagram

[CBSE Marking Scheme, 2019]

COMMONLY MADE ERROR

➲ Students sometimes start solving the numerical without writing the formula.

ANSWERING TIP

➲ While solving numerical it is advisable that the formula need to be written in the beginning. Essential steps need to be shown and final answer needs to be expressed along with a proper unit.

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

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

A [Delhi 31/1/1 2017]

Ans. (a) (i) Listing of any two (out of four) rays and stating their path after reflection from a concave mirror. **1 + 1**

(ii) Ray diagram:

Using these two rays for the ray diagram when the object is in between the pole and the focus of the mirror. **1**

(b) $u = -20$ cm, m $= -3$

$$m = \frac{-v}{u}$$ ½

$$\therefore \quad -3 = -\left(\frac{v}{-20}\right)$$ ½

$v = -3 \times 20 = -60$ cm ½

Distance between the object and the screen is 40 cm

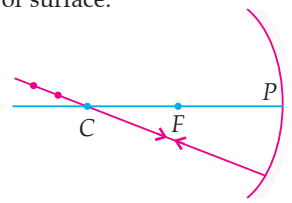
$= -60$ cm $- (-20$ cm$) = -40$ cm ½

[CBSE Marking Scheme, 2017]

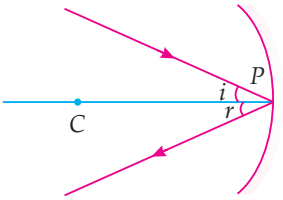
Detailed Answer:

(a) Two light rays whose path of reflection are known are:

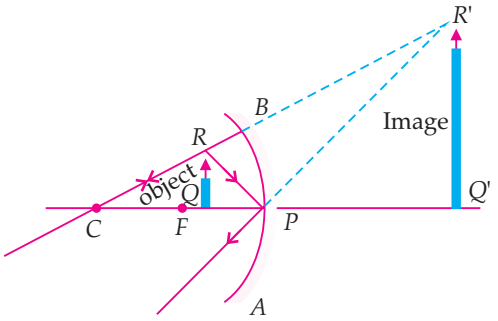
(i) The incident ray passing through the centre of curvature: In this case, light after reflecting from the concave mirror moves back in the same path. This happens because light is incident perpendicular on the mirror surface.



(ii) The ray incident obliquely to the principal axis: In this case, the incident ray will be reflected back by the reflecting surface of the concave mirror obliquely and making equal angle with the principal axis.



Let an object is placed between the focus and pole of the concave mirror. Then using above two rays, image of the candle can be located as shown below:



The image is formed behind the mirror. The image is virtual, erect and magnified. **1 + 1 + 1**

(b) Given, $m = -3$, $u = -20$ cm, $v = ?$

As we know,

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

$$-3 = -\left(\frac{v}{-20}\right)$$

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

The screen is placed in front of the mirror at a distance of 60 cm from the pole of the mirror. Thus, the screen is placed 40 cm away from the object. **2**

COMMONLY MADE ERROR

- Sometimes students do not make fully labelled diagram and also arrows are not put on the rays of light.

ANSWERING TIP

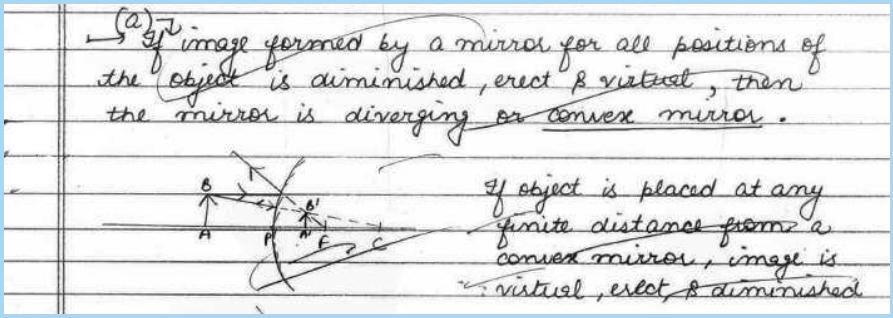
- Draw full labelled diagram and do not forget to put arrows on the rays of light.

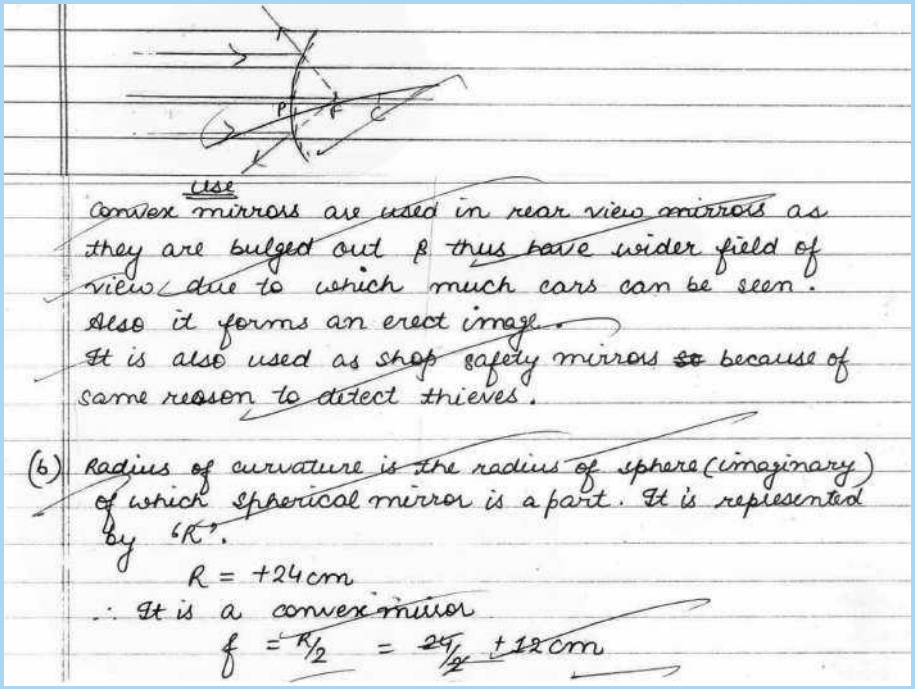
Q. 4. (a) If the image formed by a mirror for all positions of the object placed in front of it is always diminished, erect and virtual state the type of the mirror and also draw a ray diagram to justify your answer. Write one use of such mirrors are put to and why.

(b) 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. AE **[OD 31/1 2017]**

Topper Answer, 2016

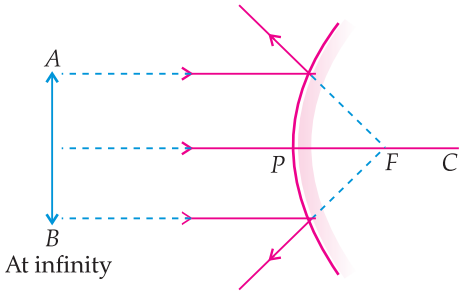
Ans.





Detailed Answer:

(a) A convex mirror forms an erect, diminished and virtual image for all the positions of the object placed in front of it. **1**



Convex mirrors are commonly used as rear-view mirrors in vehicles as they always give an erect, diminished image. **1**

(b) The radius of the sphere of which the reflecting surface of spherical mirror forms a part is called the radius of curvature of the mirror. **1**

$$f = \frac{R}{2}$$

Radius of curvature, $R = 24$ cm

So, $f = \frac{+24}{2} = +12$ cm

Thus, the focal length of a convex spherical mirror is +12 cm. and convex is nature. **2**

Q. 5. (a) Define the following terms in the context of spherical mirrors:

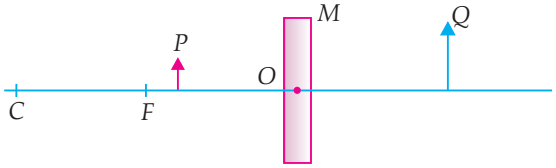
(i) Pole **(ii) Centre of curvature**

(iii) Principal axis **(iv) Principal focus**

(b) Draw ray diagrams to show the principal focus of a:

(i) Concave mirror **(ii) Convex mirror**

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



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

R [Board Term II Delhi Set I, 2016]

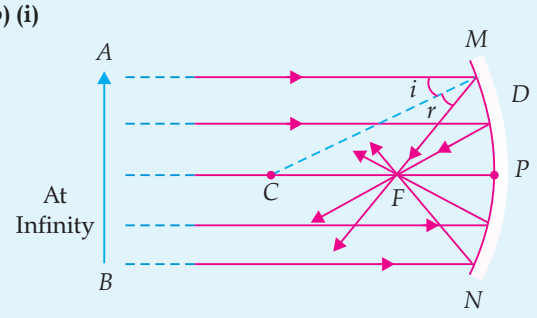
Ans. (a) (i) Pole – Centre of the reflecting surface of the mirror.

(ii) Centre of curvature – The centre of the hollow sphere of which the reflecting surface is a part.

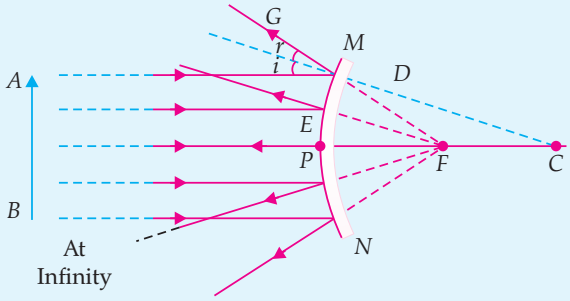
(iii) Principal axis – Straight-line passing through the pole and the centre of curvature of a spherical mirror.

(iv) Principal focus – Incident rays parallel to principal axis, after reflection, either converge or appear to diverge from a fixed point on the principal axis called principal focus of the spherical mirror. **4×½**

(b) (i)



(ii) **1**



1

(c) Concave mirror ½

Image formed is virtual. ½

[CBSE Marking Scheme, 2016]

COMMONLY MADE ERROR

- Students mostly commit errors in drawing ray diagrams of convex and concave mirror.

ANSWERING TIP

➲ Students should practice ray diagrams of concave mirror and convex mirror. Putting arrows on the rays should be stressed upon.

Q. 6. 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. By giving reason, answer the following:

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

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

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

C [Board Term II Foreign I, 2016]

Ans. $f_a = -10$ cm; $f_b = -15$ cm; $f_c = -20$ cm

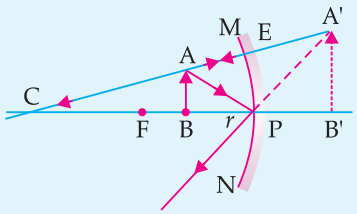
$u_1 = -10$ cm; $u_2 = -20$ cm; $u_3 = -30$ cm

(i) Mirror A will form image of $m = -1$ for object distance 20 cm since $u_2 = 2f_a$ **3 × ½ = 1½**

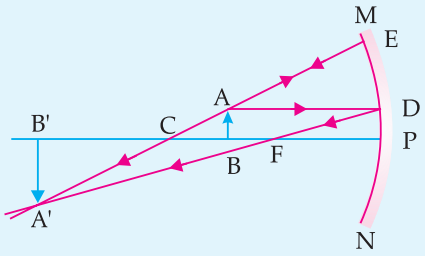
(ii) Mirror B or C - distance should be less than focal length for erect and magnified image, face is generally kept at a distance more than 10 cm.

3 × ½ = 1½

(iii)



1



1

[CBSE Marking Scheme, 2016]

Q. 7. It is desired to obtain an erect image of an object, using concave mirror of focal length of 12 cm.

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

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

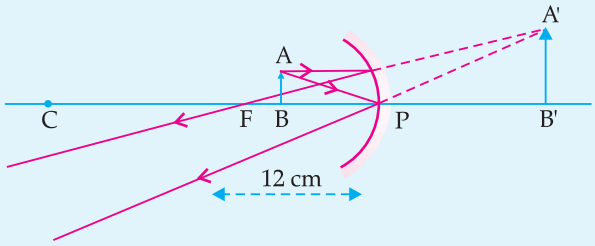
(iii) Where will the image of this object be, if it is placed 24 cm in front of the mirror ? Draw ray diagram for this situation also to justify your answer.

Show the positions of pole, principal focus and the centre of curvature in the above ray diagrams.

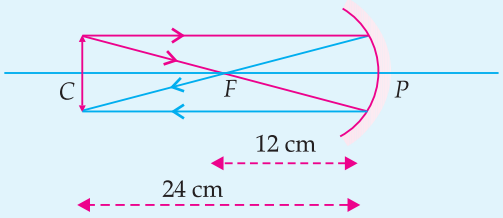
U [Board Term II, O.D. Set I, 2016]

Ans. (i) Range of distance – between 0 cm to 12 cm **1**

(ii) Larger than the object ½ **1½**



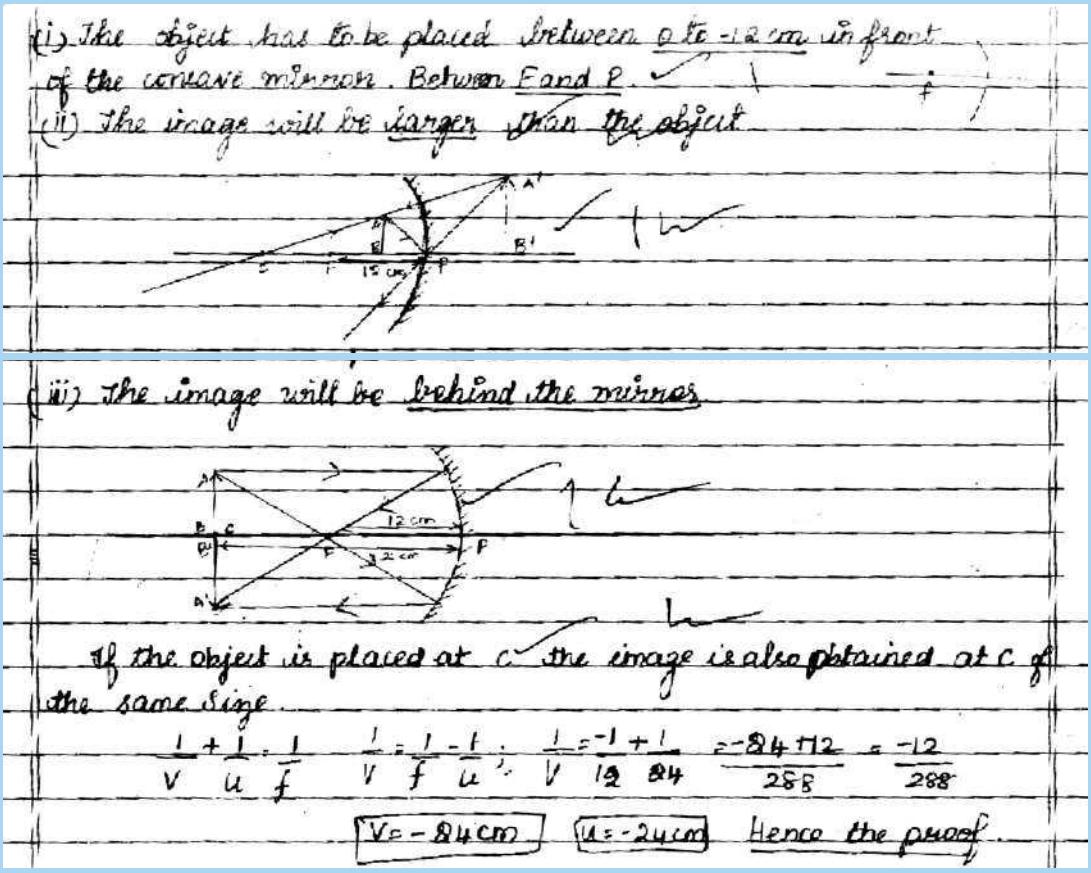
(iii) Image is also at 24 cm in front of the mirror, ½



[CBSE Marking Scheme, 2016] **1½**

OR

Topper Answer, 2016



Q. 8. 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:

(i) Distance of the image from the mirror

Length of the image

(ii) 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.

AE **[Board Term II Foreign Set I, 2015]**

Ans. (i) $h = +1.5$ cm; $f = -12$ cm; $u = -18$ cm; $v = ?$ $h' = ?$

(a) $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ ½

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

or, $\frac{1}{v} = \frac{1}{(-12)} - \frac{1}{(-18)}$ ½

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

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

$\therefore$ $v = -36$ cm **1**

(b) $h' = -\frac{v}{u} \times h$

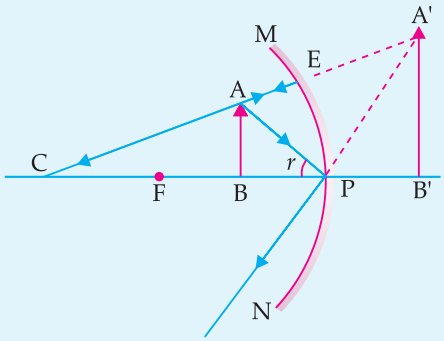
$\therefore$ $h' = -\frac{-36\text{cm}}{-18\text{ cm}} \times 1.5 = -3$ cm

(Magnified inverted image)

(ii) Now, $u = -10$ cm **1**

No image would be formed on the screen. In this case, the image formed will be virtual. (Since the object will be between focus & pole) **1**

(iii)



1

[CBSE Marking Scheme, 2015]

TOPIC - 2
Refraction, Lenses and Power of Lens

Revision Notes

- **Laws of refraction:**
  First law: The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.
  Second law: The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given color and for the given pair of media. This law is also known as **Snell's law** of refraction.

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

- **Refractive index (n):** The ratio of speed of light in a given pair of media,

$$n = \frac{\text{Velocity of light in medium 1}}{\text{Velocity of light in medium 2}}$$

  n_{21} means refractive index of second medium with respect to first medium and,

$$n_{21} = \frac{v_1}{v_2}$$

  n_{12} means refractive index of first medium with respect to second medium.

$$n_{12} = \frac{v_2}{v_1}$$

- **Absolute Refractive Index:** Refractive index of a medium with respect to vacuum or air.

$$n = \frac{c}{v} \text{ where, } c = 3 \times 10^8 \text{ ms}^{-1}$$

- Refractive index of one medium is reciprocal of other's refractive index in a given pair.

$$n_{12} = \frac{1}{n_{21}}$$

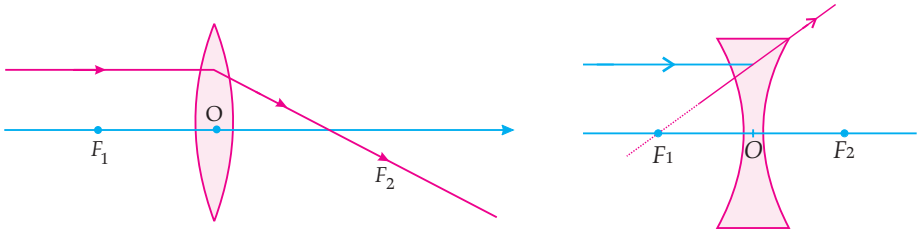
- If refractive index of medium 1 w.r.t. air is given as ${}_1n^{\text{air}}$ and if refractive index of medium 2 w.r.t. air is given as ${}_2n^{\text{air}}$, then refractive index of medium 1 w.r.t. medium 2 $= \frac{{}_1n^{\text{air}}}{{}_2n^{\text{air}}} = {}_1n^2$
- Refractive index of diamond is the highest till date. It is 2.42. It means speed of light is $\frac{1}{2.42}$ times less in diamond than in vacuum.
- **Lens Formula:** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

- **Magnification:** $m = \frac{h_i}{h_o} = \frac{v}{u}$
- **Power of a lens:** It is defined as the reciprocal of focal length in meter.
- The degree of convergence or divergence of light rays is expressed in terms of power.

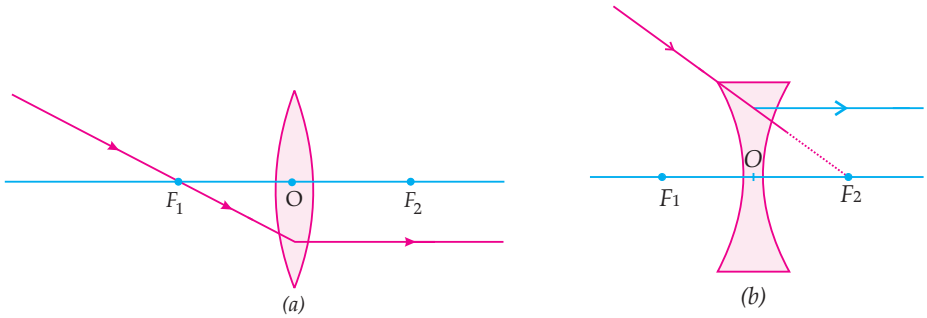
$$\text{Power} = \frac{1}{\text{Focal length (in meter)}} \text{ or } P = \frac{1}{f}$$

- SI unit of Power = dioptre = D, 1 D = 1 m^{-1}
- 1 dioptre is the power of lens whose focal length is one meter.
- **Rules for making ray diagrams by lens:**

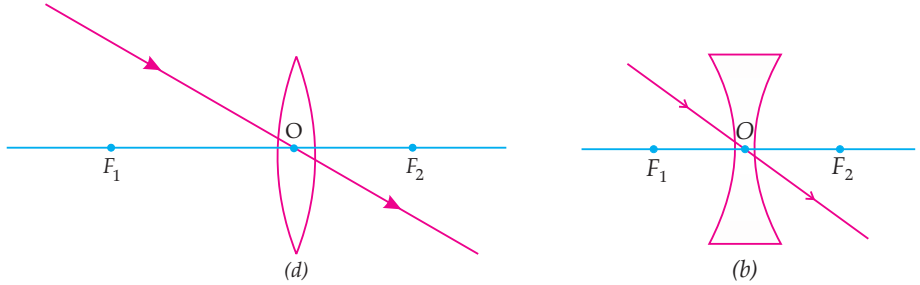
(i) A ray of light from the object parallel to the principal axis passes through the focus after refraction.



(ii) A ray of light passing through a principal focus becomes parallel to the principal axis after refraction.



(iii) A ray of light passing through the optical centre travels undeuiated even after refraction.



- **Nature, position and relative size of the image formed by a convex lens for various positions of the object:**

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly diminished, point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_1 and optical centre	On the same side of the lens as the object	Enlarged	Virtual and erect

➢ **Nature, position and relative size of the image formed by a concave lens for various positions of the object:**

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

How is it done on the GREENBOARD?

Q. A 10 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 12 cm. The distance of the object from the lens is 18 cm. Find the nature, position and size of the image formed.

Solution:

Step I: Given, focal length = f = 12 cm
Object distance = u = – 18 cm
using lens formula

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

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

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

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

$\therefore$ v = 36 cm
$\therefore$ Image distance = 36 cm.

Step II: Given, h_0 = 10 cm,
u = – 18 cm
v = 36 cm

$$\text{Magnification} = \frac{v}{u} = \frac{36\text{ cm}}{-18\text{ cm}} = -2$$

(Negative sign indicates that the image is real and inverted)

$$\text{Again magnification} = \frac{h_i}{h_o} = -2$$

or, $$\frac{h_i}{10} = -2$$

$\therefore$ h_i = – 20 cm
So, the image size is 20 cm.
It is two times magnified, real and inverted.

Objective Type Questions — 1 mark each

A Multiple Choice Questions

Q. 1. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen he should move the lens

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

[CBSE Board, All India Region, 2017]

Ans. Correct option : (d)

Explanation : The incident rays coming from the distant object will be parallel to the principal axis and as we know the rays parallel to the principal axis, after refraction by convex lens, will pass through the principal focus. Hence, a distinct image will be obtained immediately when distance between screen and lens is equal to focal length, so option (d) is correct choice.

Q. 2. A student very cautiously traces the path of a ray through a glass slab for different values of the angle of incidence ($\angle i$). He then measures the corresponding values of the angle of refraction ($\angle r$) and the angle of emergence ($\angle e$) for every value of the angle of incidence. On analyzing these measurements of angles, his conclusion would be

(a) $\angle i > \angle r > \angle e$ (b) $\angle i = \angle e > \angle r$

(c) $\angle i < \angle r < \angle e$ (d) $\angle i = \angle e < \angle r$

[CBSE Board, All India Region, 2017]

Ans. Correct option : (b)

Explanation : (Angle of incidence) $\angle i = \angle e$ (angle of emergence) because the direction of incident ray and emergent ray is parallel to each other. $\angle e > \angle r$ (angle of refraction) because at point of emergence light is entering into optically rarer medium (air) from optically denser medium (glass), so light will bend away from the normal making the angle bigger.

Q. 3. An optical device has been given to a student and he determines its focal length by focusing the image of the sun on a screen placed 24 cm from the device on the same side as the sun. Select the correct statement about the device

(a) Convex mirror of focal length 12 cm

(b) Convex lens of focal length 24 cm

(c) Concave mirror of focal length 24 cm

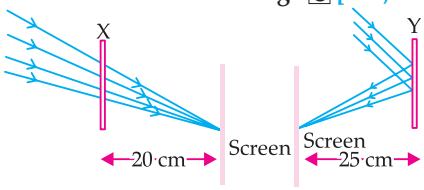
(d) Convex lens of focal length 12 cm

[CBSE Board, Foreign Scheme, 2017]

Ans. Correct option : (c)

Explanation : Because the screen is on the same side of the object which means it cannot be a lens because it happens behind the lenses in such case. Moreover, concave mirror forms real images, that is, image can be obtained on a screen.

Q. 4. Study the given ray diagrams and select the correct statement from the following: U [OD, Set-1, 2017]



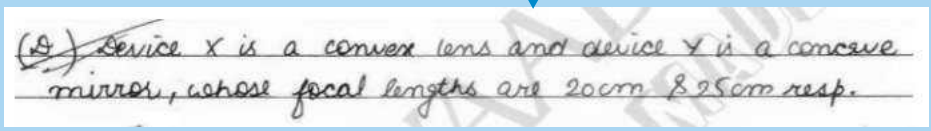
(a) Device X is a concave mirror and device Y is a convex lens, whose focal lengths are 20 cm and 25 cm respectively

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

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

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

Topper Answer, 2017



Q. 5. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen he should move the lens:

(a) away from the screen

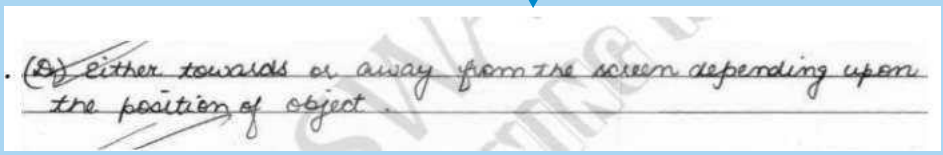
(b) towards the screen

(c) to a position very far away from the screen

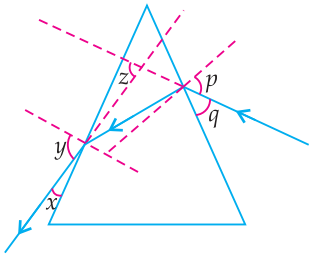
(d) either towards or away from the screen depending upon the position of the object.

R [OD, Set-1, 2017]

Topper Answer, 2017



Q. 6. Study the following ray diagram: U [OD, Set-1, 2017]



In this diagram, the angle of incidence, the angle of emergence and the angle of deviation respectively have been represented by:

(a) y, p, z **(b)** x, q, z

(c) p, y, z **(d)** p, z, y

Topper Answer, 2017

Q. 7. A teacher sets up the stand carrying a convex lens of focal length 15 cm at 42.7 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 distant tree is obtained almost immediately on it. The positions suggested by the students were as :

A. 12.7 cm **B. 29.7 cm**

C. 57.7 cm **D. 72.7 cm**

The correct position of the screen was suggested by

(a) *A* **(b) *B***

(c) *C* **(d) *D***

[CBSE Board, Foreign Scheme, 2016]

Ans. Correct option : (c)

Explanation : The incident rays coming from the distant tree placed will be parallel to the principal axis and as we know the rays parallel to the principal axis, after refraction by convex lens, will pass through the principal focus. Hence, a distinct image will be obtained immediately when distance between screen and lens is equal to focal length.

42.7 cm (position of lens on optical bench) + 15 cm (focal length of lens) = 57.7 (the position of screen on optical bench)

Q. 8. To determine the approximate focal length of the given convex lens by focussing a distant object (say, a sign board), you try to focus the image of the object on a screen. The image you obtain on the screen is always: A **[CBSE,Delhi-2016]**

(a) erect and laterally inverted

(b) erect and diminished

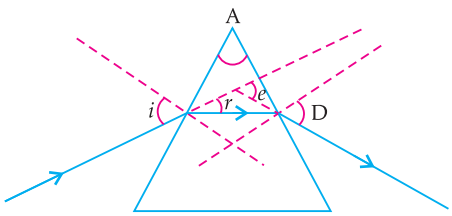
(c) inverted and diminished

(d) virtual, inverted and diminished

Ans. Correct option : (c)

Q. 9. Study the following figure in which a student has marked the angle of incidence (∠*i*), angle of refraction (∠*r*), angle of emergence (∠*e*), angle of prism (∠A) and the angle of deviation (∠D). The correctly marked angles are:

U **[CBSE, Delhi-2016, Set-1]**



(a) ∠A and ∠*i* **(b) ∠A, ∠*i* and ∠*r***

(c) ∠A, ∠*i*, ∠*e* and ∠D **(d) ∠A, ∠*i*, ∠*r* and ∠D**

Ans. Correct option : (a)

Q. 10. Suppose you have focussed on a screen the image of candle flame placed at the farthest end of the laboratory table using a convex lens. If your teacher suggests you to focus the parallel rays of sun, reaching your laboratory table, on the same screen, what you are expected to do is to move the:

(a) lens slightly towards the screen

(b) lens slightly away from the screen

(c) lens slightly towards the sun

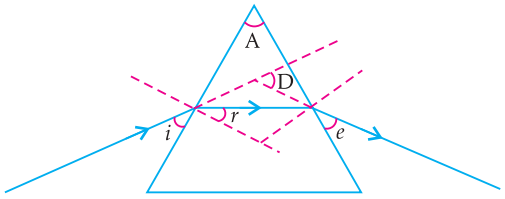
(d) lens and screen both towards the sun

A **[OD set-1, 2016]**

Ans. Correct option : (a)

Explanation : The candle is at the farthest end of the laboratory. So, it may be considered at a distance greater that $2F_1$ and hence the image of formed between F_2 and $2F_2$. when the sun will be focussed, the image will be formed as F_2. So, the lens is to the shifted towards the screen.

Q. 11. In the following ray diagram, the correctly marked angle are: AE **[OD-Set-1, 2016]**



Ans. Correct option : (b)

Q. 12. 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.

[NCERT Exemp.]

Ans. Correct option : (a)

Explanation : As per the sign convention, the focal length of a concave mirror and a concave lens are taken as negative. Hence, both the spherical mirror and the thin spherical lens are concave in nature.

Q. 13. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

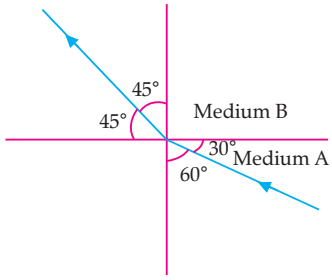
(a) A convex lens of focal length 50 cm
(b) A concave lens of focal length 50 cm
(c) A convex lens of focal length 5 cm
(d) A concave lens of focal length 5 cm

[NCERT Exemp.]

Ans. Correct option (c)

Explanation : A magnified image of an object will be obtained when it is placed between the optical centre and focus of a convex lens. Magnification is also higher for convex lenses having shorter focal length. Therefore, for reading small letters, a convex lens of focal length 5 cm should be used.

Q. 14. 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)** $\sqrt{2}$

[NCERT Exemp.]

Ans. Correct option : (a)

Explanation : Here, angle of incidence = 60°

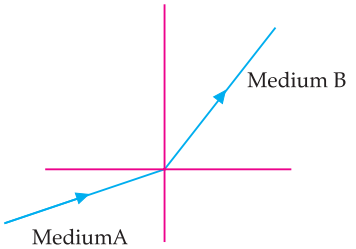
Angle of refraction = r = 45

Refractive index of the medium B relative to medium A

$$= n_{BA} = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 45°}$$

$$= \frac{\frac{\sqrt{3}}{2}}{\left(\frac{1}{\sqrt{2}}\right)} = \frac{\sqrt{3}}{\sqrt{2}}$$

Q. 15. A light ray enters from medium A to medium B as shown in the 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**

[NCERT Exemp.]

Ans. Correct option : (a)

Explanation : Since, light rays in medium B go towards normal, so it has greater refractive index and lesser velocity of light with respect to medium A. So refractive index of medium B with respect to medium A is greater than unity.

Q. 16. Which of the following statements is 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 power having a focal length 0.25 m [NCERT Exemp.]

Ans. Correct option : (a)

Explanation : The power (P) of a lens of focal length (f) is given by $P = 1/f$ where f is the focal length meter and power in dioptre.

Now, $P = 1/f$

or, $4 = \frac{1}{f}$

or $f = \frac{1}{4}$ m = 0.25 m.

B Assertions and Reasons Type Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

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

Q. 1. Assertion (A): If the rays are diverging after emerging from a lens; the lens must be concave.

Reason (R): The ST lens can give diverging rays.

Ans. Correct option : (d)

Explanation : If the rays crossing focal point of convex lens, become diverging.

Q. 2. Assertion (A): Refractive index of glass with respect to air is different for red light and violet light.

Reason (R): Refractive index of a pair of media depends on the wavelength of light used.

Ans. Correct option : (a)

Explanation : Refractive index of any pair of media is inversely proportional to wavelength of light.

Hence, $\lambda_v < \lambda_r$

so, $\mu_r < \mu_v$

where, λ_v and λ_r are the wavelengths of violet and red light. μ_v and μ_r are refractive index of violet and red light.

Q. 3. Assertion (A): The refractive index of diamond is $\sqrt{6}$ and refractive index of a liquid is $\sqrt{3}$. If the light travels from diamond to the liquid, it will be initially reflected when the angle of incidence is 30°.

Reason (R): $\mu = \frac{1}{\sin C}$, where μ is the refractive index of diamond with respect to liquid.

Ans. Correct option : (a)

Explanation : Refractive index of diamond *w.r.t.* liquid

$$^{d}\mu_l = \frac{1}{\sin C} = \frac{\mu_d}{\mu_l} \Rightarrow \frac{\sqrt{6}}{\sqrt{3}} = \frac{1}{\sin C}$$

$$\Rightarrow \quad \sin C = \frac{1}{\sqrt{2}} = \sin 45°$$

$$\therefore \quad C = 45°.$$

C Very Short Answer Type Questions

Q. 1. Name the part of a lens through which a ray of light passes without suffering any deviation.

[SQP 2020]

Ans. Optical centre.

[CBSE Marking Scheme, 2020]

Q. 2. What is meant by power of a lens ?

R **[Board Term II Delhi Set I, 2015]**

Ans. The ability of a lens to converge or diverge the rays of light, is called power of a lens. It is equal to the reciprocal of the focal length (*i.e.*, $P = \frac{1}{f}$).

[CBSE Marking Scheme, 2015] 1

AI **Q. 3. How does the size of the image change as the object is brought closer from infinity towards the convex lens ?** AE

Ans. The size of the image is formed keeps on increasing as the object is brought closer towards the convex lens. **1**

AI **Q. 4. The refractive index of diamond is 2·42. What is the meaning of this statement ?** U

Ans. The refractive index of diamond 2·42 suggests that the speed of light in diamond will reduce by a factor 2.42 as compared with its speed in air. **1**

AI **Q. 5. Arrange the following common substances in the increasing order of refractive indices, Ice, Kerosene, Glass, Diamond, Alcohol and Water.** AE

Ans. Order of increasing refractive indices:

Ice, Water, Alcohol, Kerosene, Glass, Diamond. **1**

COMMONLY MADE ERROR

- Students usually get confused in increasing and decreasing order of refractive index.

ANSWERING TIP

- Understand the increasing and decreasing order of refractive indices of common substances.

Short Answer Type Questions-I — 2 marks each

Q. 1. A teacher gives a convex lens and a concave mirror of focal length of 20 cm each to his student and asks him to find their focal lengths by obtaining the image of a distant object. The student uses a distant tree as the object and obtains its sharp image, one by one, on a screen.

The distances d_1 and d_2 between the lens/ST and the screen in the two cases and the nature of their respective sharp images are likely to be

(a) (20 cm, 40 cm) and (erect and erect)

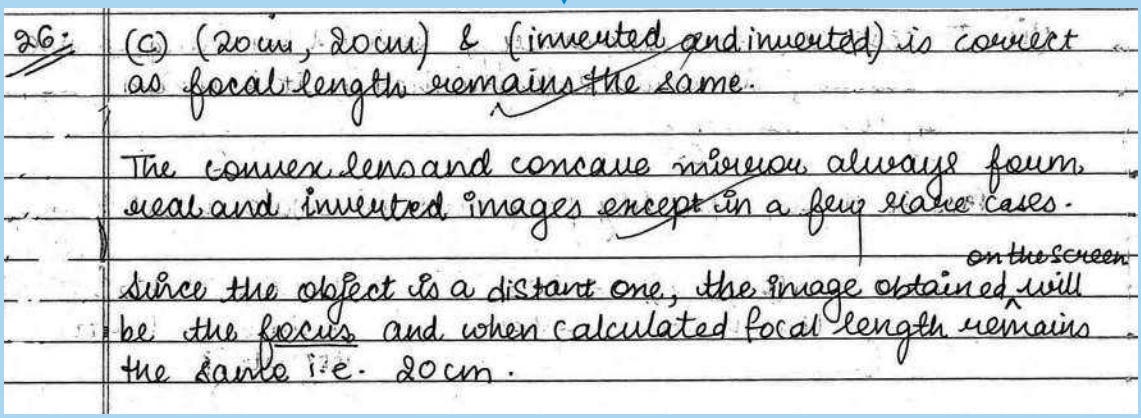
(b) (20 cm, 40 cm) and (inverted and inverted)

(c) (20 cm, 20 cm) and (inverted and inverted)

(d) (20 cm, 40 cm) and (erect and inverted)

Give reason for your answer. A **[Delhi 2019]**

Topper Answer, 2019


26. (c) (20 cm, 20 cm) & (inverted and inverted) is correct as focal length remains the same.

The convex lens and concave mirror always form real and inverted images except in a few rare cases.

Since the object is a distant one, the image obtained on the screen will be the focus and when calculated focal length remains the same i.e. 20 cm.

Q. 2. List four precautions which a student should observe while determining the focal length of a given convex lens by obtaining image of a distant object on a screen. R [Delhi 2019]

Ans. Precautions:

(1) Lens should be held in vertical position with its faces parallel to the screen.

(2) Clear and sharpest image should be obtained by adjusting the position of lens.

(3) Three observations should be taken at least.

(4) Base of lens, screen and measuring scale should be in straight line. **(or any other)**

[CBSE Marking Scheme, 2019] ½×4 = 2

Q. 3. The absolute refractive index of Ruby is 1.7. Find the speed of light in Ruby. The speed of light in vacuum is 3×10^8 m/s. C [OD, 2019, Set-1]

Ans. $\mu = \dfrac{\text{Speed of light in vacuum}}{\text{Speed of lught in Ruby}} = \dfrac{c}{v}$ ½

$v = \dfrac{c}{\mu}$

Where, c = velocity of light in vacuum

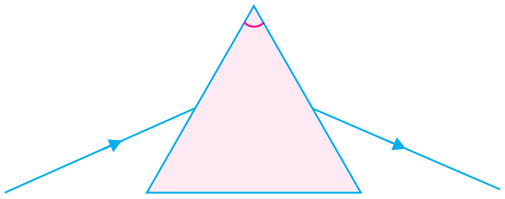
μ = refractive of light

$v = \dfrac{3\times10^8}{1.7} = 17.76 \times 10^8$ m/s ½×4 = 2

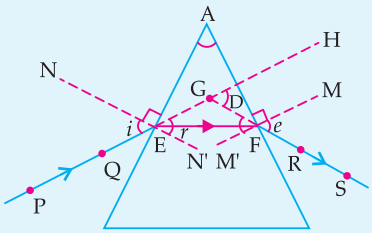
[CBSE Marking Scheme, 2019]

Q. 4. A student traces the path of a ray of light through a glass prism as shown in the diagram but leaves it incomplete and unlabelled. Redraw and complete the diagram. Also label on it $\angle i$, $\angle e$, $\angle r$ and $\angle D$.

AE [OD-2019, Set-1]



Ans.



Labelling of $\angle i$, $\angle e$, $\angle r$ & $\angle D$

[CBSE Marking Scheme, 2019] ½×4 = 2

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

C [OD,Set-2, 2019]

Ans. P = +5D

$f = 1/P = 100/5 = 20$cm

Nature of lens = convex (converging)

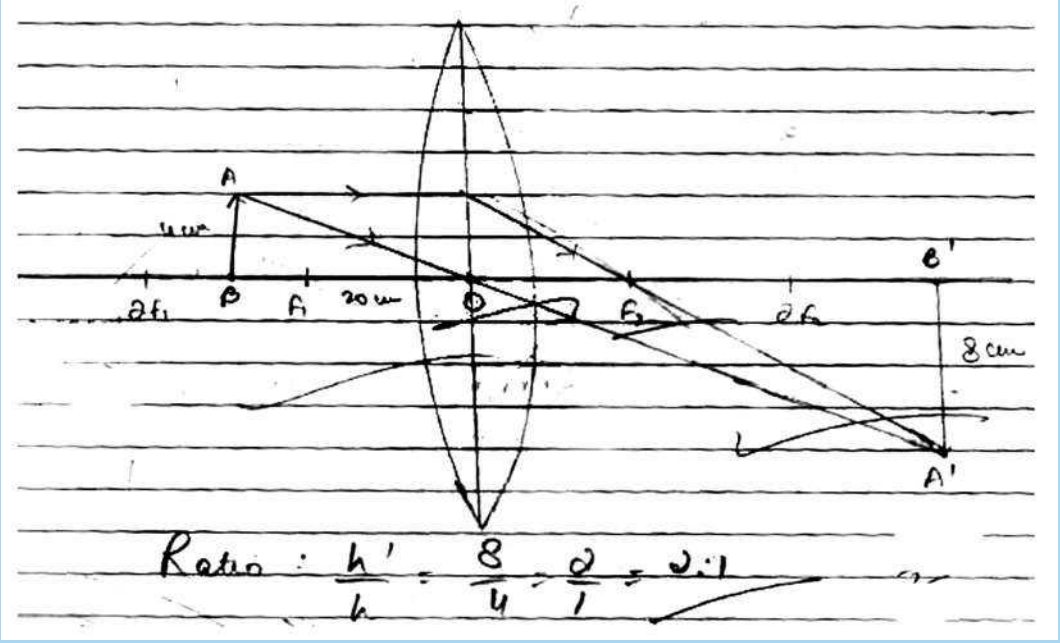
Distance is 40 cm (at C)

[CBSE Marking Scheme, 2019] ½×4 = 2

Q. 6. An object of height 4.0 cm is placed at a distance of 30 cm from the optical centre 'O' of a convex lens of focal length 20 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical centre 'O' and principal focus 'F' on the diagram. Also find the approximate ratio of size of the image to the size of the object.

C [2018, Toppers answer]

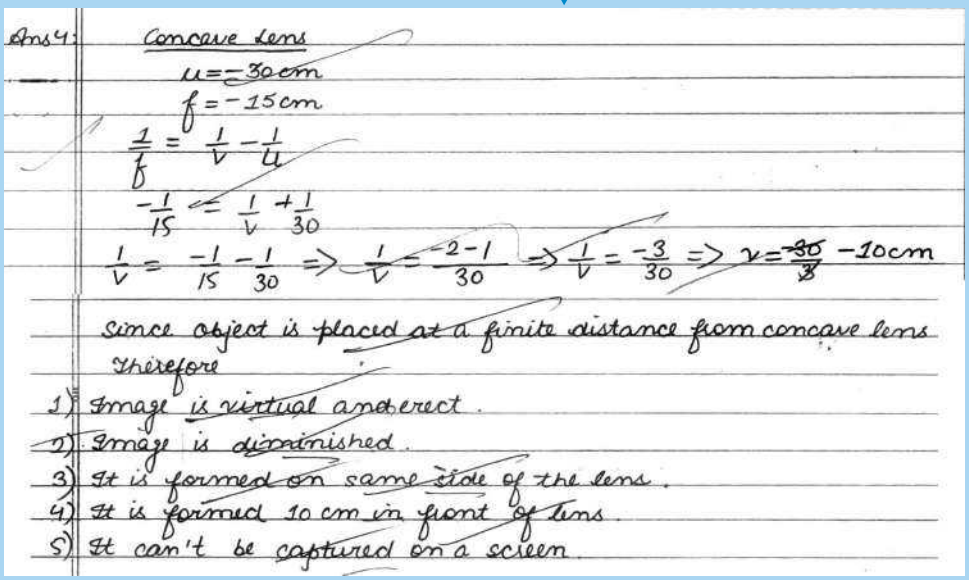
Topper Answer, 2018



Q. 7. An object is placed at a distance of 30 cm from a concave lens of focal length 15 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. R **[Outside Delhi, 2017, set 1]**

Ans. (a) Virtual
(b) Erect
(c) Diminished
(d) On the same side as the object / or any other characteristic. **[CBSE Marking Scheme, 2017]**

Topper Answer, 2017



Q. 8. The refractive indices of glass and water with respect to air are 3/2 and 4/3 respectively. If speed of light in glass is 2×10^8 m/s, find the speed of light in water. C **[OD 2016,Set -3]**

Ans. Refractive index of a medium

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

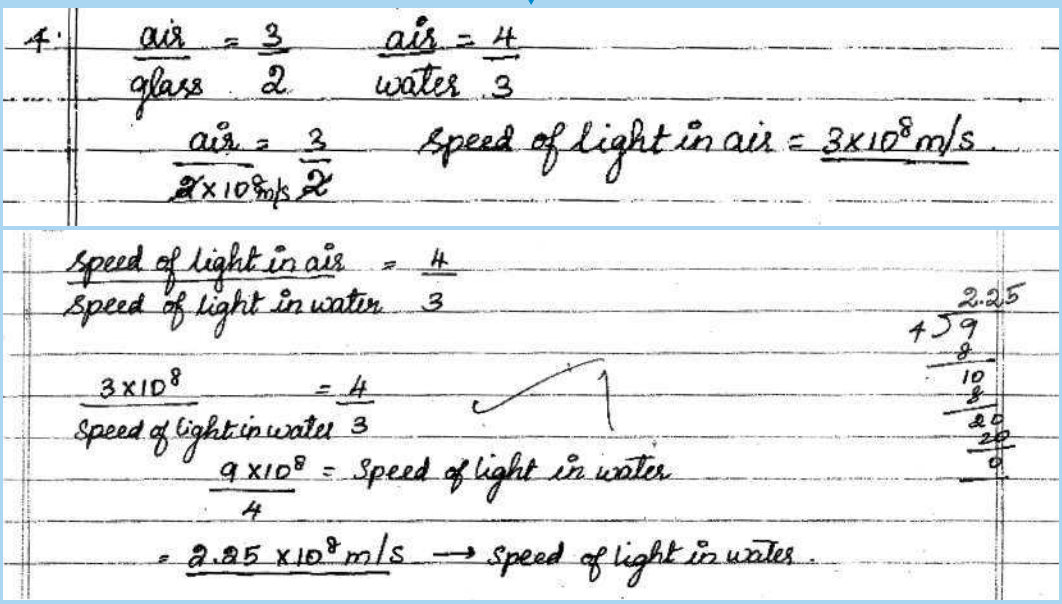
$$\frac{3}{2} = \frac{\text{Speed of light in air}}{2\times10^8 \text{ m/s}}$$ **1**

Speed of light in air = 3×10^8 m/s

Speed of light in water

$$= \frac{3\times10^8 \text{ m/s}}{4/3} = 2.25 \times 10^8 \text{ m/s}$$ **1**

Topper Answer, 2016



Short Answer Type Questions-II — 3 marks each

Q. 1. Refractive index of water with respect to air is 1.33 and that of diamond is 2.42.

(i) In which medium does the light move faster, water or diamond?

(ii) What is the refractive index of diamond with respect to water? C [SQP-2020]

Ans. Refractive index = speed of light in vaccum/speed of light in medium.

Since the refractive index of diamond is more, hence the speed of light is lesser in diamond.

Let speed of light in water v_w and in diamond be v_d.

Refractive index of diamond w.r.t. water is say n = Speed of light in water/speed of light in diamond.

$$n = v_w/v_d$$

Dividing both numerator and denominator by speed of light (c) we get

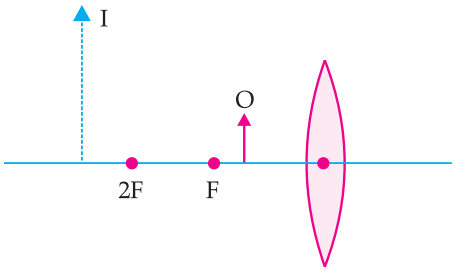
$$n = \frac{v_{w/c}}{v_{d/c}}$$

$\therefore n = 2.42/1.33 = 1.82$ (approx.)

[CBSE Marking Scheme, 2020]

Q. 2. The diagram given below shows an object O and its image I.

Without actually drawing the ray diagram state the following:



(i) Type of lens (Converging / Diverging)

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

(iii) List three characteristic of the image formed if this lens is replaced by a concave mirror of focal length f and an object is placed at a distance *f*/2 in front of the mirror. AE [CBSE, OD Set-1, 2020]

Ans. (i) Converging lens ½

(ii) Microscope and Telescope **1**

(iii) Characteristic of the image formed are: **1½**

(a) Virtual image

(b) Magnified image

(c) Image behind the mirror

Q. 3. (a) Water has refractive index 1.33 and alcohol has refractive index 1.36. Which of the two medium is optically denser ? Give reason for your answer.

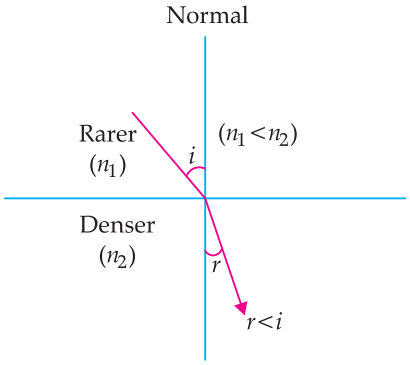
(b) Draw a ray diagram to show the path of a ray of light passing obliquely from water to alcohol.

(c) State the relationship between angle of incidence and angle of refraction in the above case.

C **[OD 2020,Set 2]**

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

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



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

AI **Q. 4. A 10 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 12 cm. The distance of the object from the lens is 18 cm. Find the nature, position and size of the image formed.** A **[Board Outside Delhi, Set-I, 2019]**

Ans. $\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \therefore \frac{1}{v}=\frac{1}{f}+\frac{1}{u}$ ½

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

$\therefore \quad v = 36$ cm ½

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

$\Rightarrow \quad \therefore \quad m=\frac{36}{-18}=\frac{h'}{10}$ ½

$\Rightarrow \quad h' = -20$ cm (size of the image) ½

Nature of image : Real and inverted

[CBSE Marking Scheme, 2019]

Detailed Answer :

Given, object size, $h = +10$ cm ; focal length, $f = +12$ cm (f is positive for a convex lens); object distance, $u = -18$ cm

Using lens formula,

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

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

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

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

Therefore, $v = 36$ cm $\rightarrow$ Image distance

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

Therefore, $m=\frac{36\,\text{cm}}{-18\,\text{cm}}=-2$

So, image size $h' = \frac{v \times h}{u}$

$$=\frac{36\times 10}{(-18)}=20$$

That image is 36 cm on right side of lens. So, the image is real.

Negative sign of h' signifies that the image is inverted. The image is two times enlarged in size than the object.

Q. 5. State the laws of refraction of light. Explain the term 'absolute refraction index of a medium' and write an expression to relate it with the speed of light in vacuum. U **[CBSE Delhi/OD, 2018]**

Ans. 1st law: The incident ray, refracted ray and normal to the interface at the point of incidence lie in the same plane.

2nd law: The sine of angle of incidence bears a constant ratio with sine of angle of refraction for a given pair of media.

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

Absolute refractive index of a medium,

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

(Award full marks if the same thing is given in the form of statement) **1 + 1 + 1**

[CBSE Marking Scheme, 2018]

Q. 6. What is meant by power of a lens ? Write the SI unit. A student uses a lens of focal length 40 cm and another of – 20 cm. Write the nature and power of each lens. U **[CBSE Delhi/OD, 2018]**

Ans. Power of lens = Ability to converge/diverge light rays passing through it/ reciprocal of the focal length in meters $\frac{1}{f}$ (in meters),

SI unit of power is Dioptre

Power of 1st lens $P_1 = \frac{100}{f}=\frac{100}{40\text{ cm}} = +2.5\text{D}$

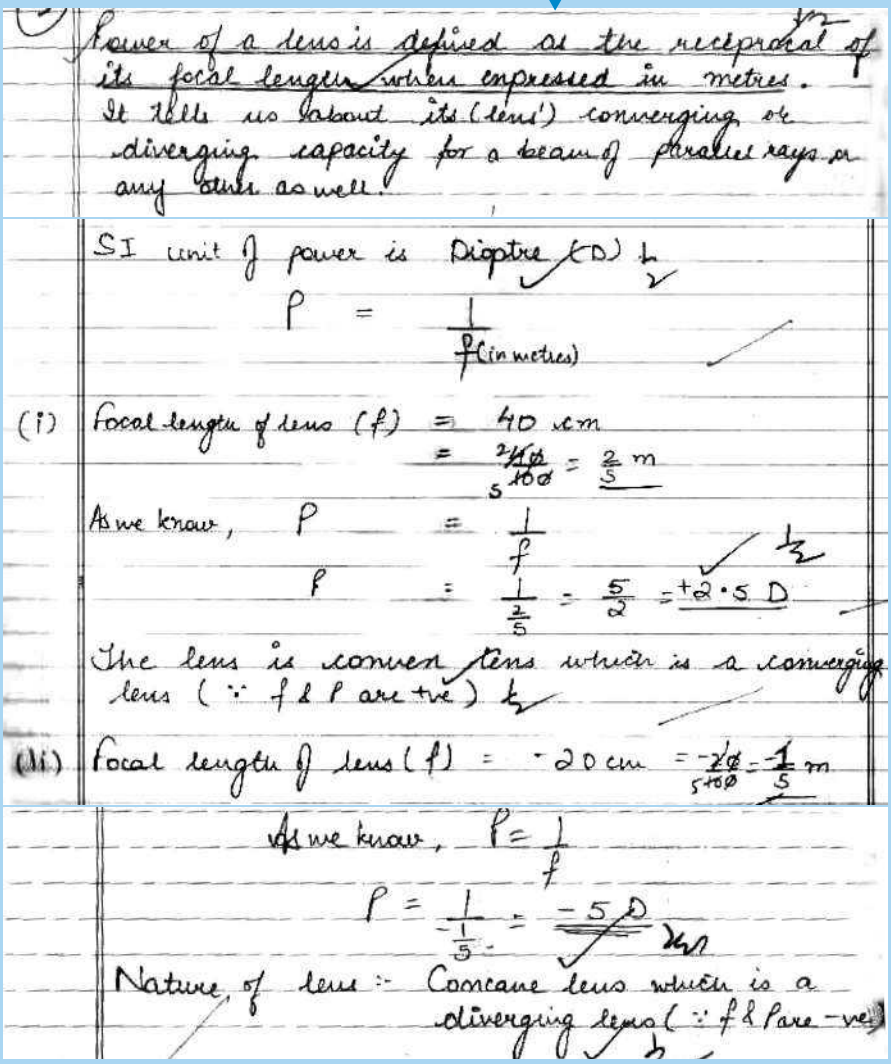
Nature: Converging lens/Convex lens,

Power of 2nd lens $P_2 = \frac{100}{f}=\frac{100}{-20\text{ cm}} = -5\text{D}$

Nature: Diverging lens / Concave lens **1 + 1 + 1**

[CBSE Marking Scheme, 2018]

Topper Answer, 2017


Power of a lens is defined as the reciprocal of its focal length when expressed in metres. It tells us about its (lens') converging or diverging capacity for a beam of parallel rays or any other as well.

SI unit of power is Dioptre (D) ½

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

(i) Focal length of lens (f) = 40 cm = $\frac{40}{100} = \frac{2}{5}$ m

As we know, $P = \frac{1}{f}$ ½

$P = \frac{1}{\frac{2}{5}} = \frac{5}{2} = +2.5$ D

The lens is convex lens which is a converging lens (∵ f & P are +ve) ½

(ii) Focal length of lens (f) = −20 cm = $\frac{-20}{100} = -\frac{1}{5}$ m

As we know, $P = \frac{1}{f}$

$P = \frac{1}{-\frac{1}{5}} = -5$ D ½

Nature of lens :- Concave lens which is a diverging lens (∵ f & P are −ve) ½

Q. 7. State the laws of refraction of light. If the speed of light in vacuum is 3×10^8 m/s, find the absolute refractive index of a medium in which light travels with a speed of 1.4×10^8 m/s.

A [Board Term II, Outside Delhi Set I, III, 2015]
[DDE, 2017]

Ans. (i) Two laws of refraction:

Try yourself. Refer Q.No. 4 of Short Answer Type Question-II.

(ii) Given $c = 3 \times 10^8$ m/s
$v = 1.4 \times 10^8$ m/s

Absolute refractive index

$= \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$ ½

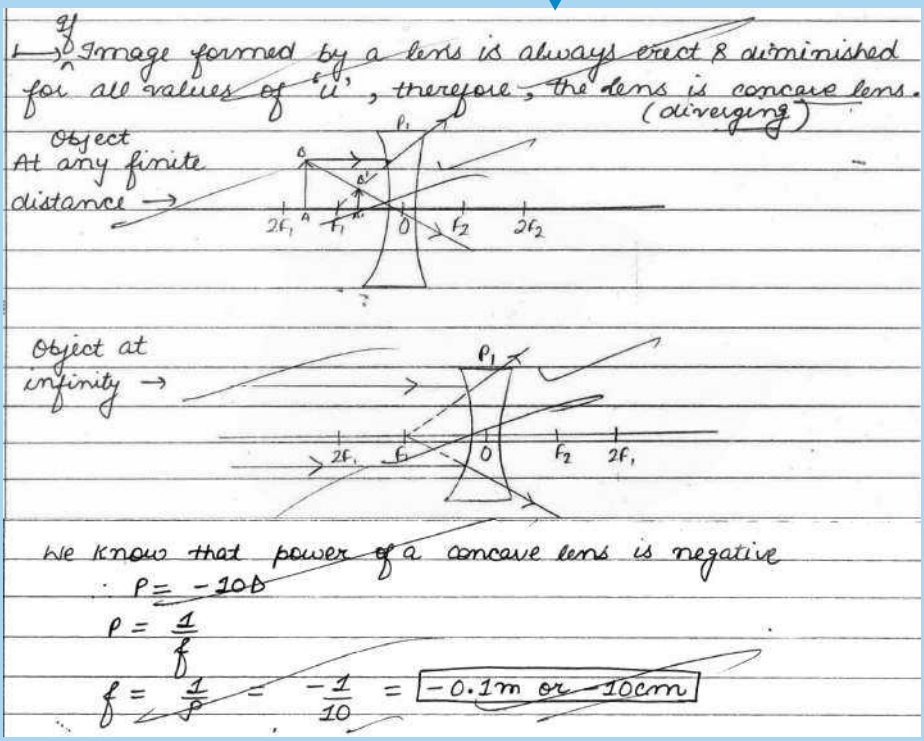
$= \frac{3 \times 10^8 \text{ m/s}}{1.4 \times 10^8 \text{ m/s}} = 2.14$ ½

[CBSE Marking Scheme, 2015]

Q. 8. 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 of 10 D, what is its focal length in the Cartesian system ? AE [OD 31/1 2017]

Topper Answer, 2017

Ans.



COMMONLY MADE ERROR

- Students often forget to convert focal length to meter while finding out the power.

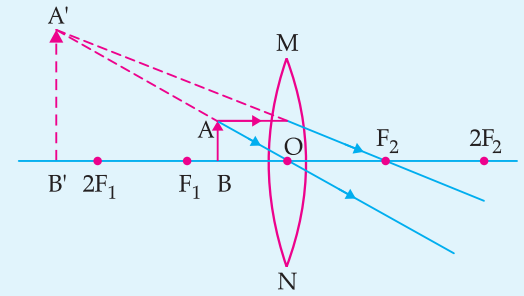
ANSWERING TIP

- Always convert focal length to meter for power calculation and use proper sign i.e. 'f' for convex lens and '–' concave lens.

Q. 9. "A lens can form a magnified erect image as well as magnified inverted image of an object placed in front of it." State the nature of this lens and draw ray diagrams to justify the above statement. Mark the positions of O, F and 2F in the diagram.

U [CBSE, Marking Scheme, 2017]

Ans.



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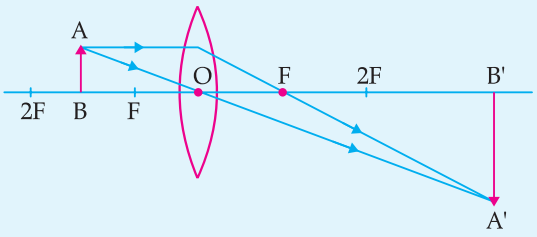


1

Labelling O, F and 2F. ½

Types of lens : Convex/Converging. ½

[CBSE Marking Scheme, 2017]

Q. 10. An object of height 5 cm is placed perpendicular to the principal axis of a concave lens of focal length 10 cm. If the distance of the object from the optical centre of the lens is 20 cm, determine the position,

nature and size of the image formed using the lens formula. A [Board Term II O.D. III, 2015]

Ans. $f = -10$ cm, $u = -20$ cm, $v = ?$

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

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

or, $\frac{1}{v} = \frac{1}{-10} + \frac{1}{(-20)}$

or, $\frac{1}{v} = \frac{-2-1}{20} = -\left(\frac{3}{20}\right)$

$\therefore \quad v = \frac{-20}{3}$ cm

$m = \frac{h_i}{h_0} = -\frac{v}{u}$

$= h_1 = -\frac{v}{u} \times h_0$

$= -\frac{-20}{3 \times 20} \times -5$

$= \frac{5}{3} = 1.6$ cm

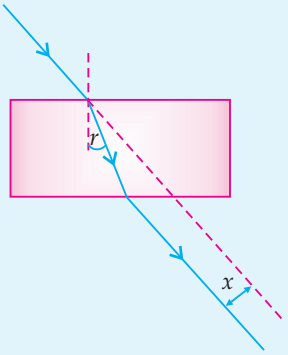
Image is virtual and diminished. 3

[CBSE Marking Scheme, 2015]

Q. 11. (i) Draw a ray diagram to show the refraction of light through a glass slab and mark angle of refraction and the lateral shift suffered by the ray of light while passing through the slab. U

(ii) If the refractive index of glass for light going from air to glass is 3/2, find the refractive index of air for light going from glass to air. [Delhi Set III, 2016]

Ans. (i)



1

Marking $\angle r$ and x ½+½

(ii) $_an_g = \frac{3}{2}$

$\therefore \quad _gn_a = \frac{1}{_an_g} = \frac{1}{3/2} = \frac{2}{3}$

Alternately, $\frac{c_{air}}{c_{glass}} = \frac{3}{2}$

$\therefore \quad \frac{c_{glass}}{c_{air}} = \frac{2}{3}$ 1

[CBSE Marking Scheme, 2016]

Q. 12. If the image formed by a lens for all positions of the object placed in front of it is always virtual, erect and diminished, state the type of the lens. Draw a ray diagram in support of your answer. If the numerical value of focal length of such a lens is 20 cm, find its power in new cartesian sign conventions. A [Board Term II Foreign Set I, 2016]

Ans. Try yourself. Refer Question No. 8 of Short Answer Type Qustion-II.

Focal length = −20 cm (lens is concave, hence f is – *ve*) ½

Power = P

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

or, $P = -\frac{100}{20}$ cm

$\therefore \quad = -5$D ½ + ½

[CBSE Marking Scheme, 2016]

Q. 13. What is meant by power of a lens ? What does its sign (+ve or –ve) indicate ? State its S.I. unit. How is this unit related to focal length of a lens ? A [2016, Delhi Set-3]

Ans. Ability of lens to converge or diverge the light rays. ½

+ve sign → converging lens/ convex lens

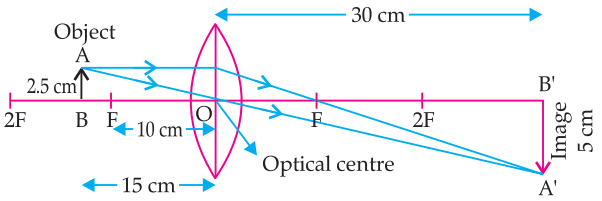
− ve sign → diverging lens/ concave lens

S.I. unit is dioptre ½

1 dioptre = 1/ focal length (m)

Q. 14. An object of height 2.5 cm is placed at a distance of 15 cm from the optical centre 'O' of a convex lens of focal length 10 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical centre 'O', principal focus F and height of the image on the diagram. R [OD, Set -2,2016]

Ans.



Size of the image formed is 5 cm beyond 2F.

Q. 15. The image of an object formed by a lens is of magnification – 1. If the distance between the object and its image is 60 m, what is the focal length of the lens ? If the object is moved 20 cm towards

the lens, where would the image be formed ? State reason and also draw a ray diagram in support of your answer. [OD Set -2, 2016]

Ans. Image with magnification –1 means image is inverted and of the same size.

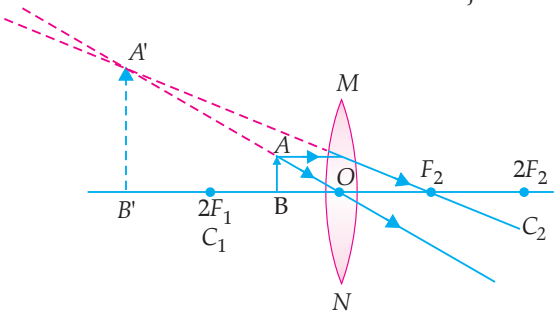
Therefore, object is at 2F and the image is also at 2F on the other side of the lens.

Therefore, distance between the object and its image is $4f = 60$ cm **1**

$\therefore \quad f = 15$ cm ½

Object distance $2f = 30$ cm, if the object is shifted towards the lens by 20 cm, the new object distance $= 30\text{ cm} - 20\text{ cm} = 10\text{ cm}$. ½

This distance is less than the focal length, and the image formed in this case would be virtual, erect and will form on the same side as the object. **1**

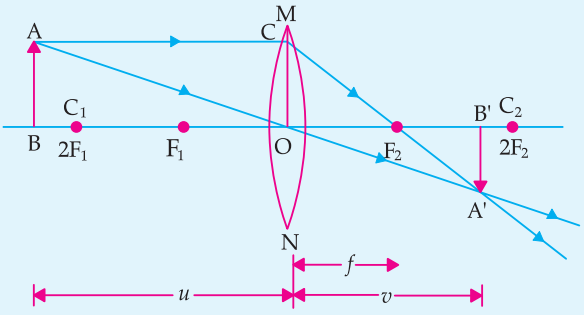


Long Answer Type Questions — 5 marks each

AI **Q. 1. (i) A lens produces a magnification of –0.5. Is this a converging or diverging lens? If the focal length of the lens is 6 cm, draw a ray diagram showing the image formation in this case.**

(ii) A girl was playing with a thin beam of light from a laser torch by directing it from different directions on a convex lens held vertically. She was surprised to see that in a particular direction, the beam of light continues to move along the same direction after passing through the lens. State the reason for her observation. Draw a ray diagram to support your answer. A [Board SQP, 2020]

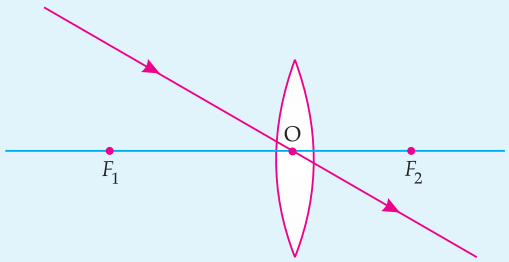
Ans. (i) The image will be real and inverted, since the magnification has negative value. The lens that can produce a real and inverted image is a converging/ convex lens.



In the figure $OF_1 = OF_2 = 6$ cm.

(*Marks will be deducted if arrows are not shown*)

(ii) The girl must have directed the ray of light along the direction of the optical centre of the lens because the ray of light passes straight through the optical centre of the lens.



3 + 2

[CBSE Marking Scheme, 2020]

AI **Q. 2. (i) On entering in a medium from air, the speed of light becomes half of its value in air. Find the refractive index of that medium with respect to air?**

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

U [Board SQP, 2020]

Ans. (i) Refractive Index of a medium (μ)

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

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

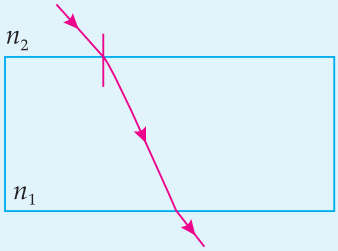
$$\frac{v_1}{2} = v_2 .$$

Hence $\mu = \frac{v_1}{v_2}$.

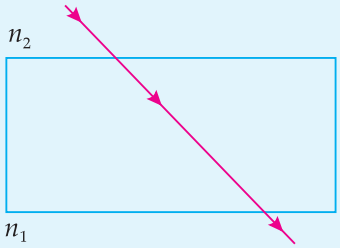
or, $\mu = \frac{v_1}{\frac{v_1}{2}}$.

$\therefore \quad \mu = 2$

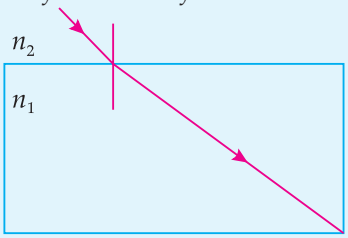
(ii) (a) The ray moves towards the normal. ½



(b) The ray moves undeviated.



(c) The ray moves away from the normal.



5

[CBSE Marking Scheme, 2019]

Q. 3. Draw a ray diagram in each of the following cases to show the formation of image, when the object is placed:

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

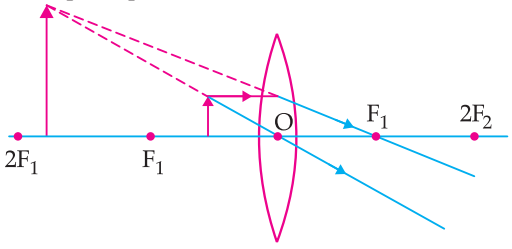
(ii) anywhere in front of a concave lens.

(iii) at 2F of a convex lens.

State the signs and values of magnifications in the above-mentioned cases (i) and (ii).

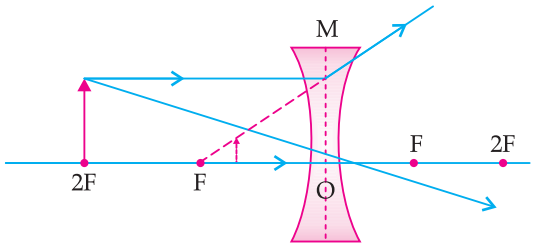
AE **[CBSE Delhi 2020]**

Ans. (i) When object is placed between optical centre and principal focus of a convex lens:



The image formed is virtual and erect, so the sign of magnification is positive. Also, since, image formed is magnified, so value of magnification is greater than one.

(ii) When object is placed anywhere in front of a concave lens:



The image formed is virtual and erect, so the sign of magnification is positive. Also, since, image formed is diminished, so value of magnification is less than one.

(iii) When an object is placed at 2F of a convex lens:

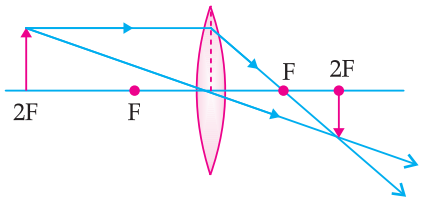


Image is formed at 2F, A real inverted image of same size is produced.

Q. 4. Rishi went to a palmist to show his palm. The palmist used a special lens for this purpose.

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

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

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

A **[CBSE OD Set-1, 2020]**

Ans. (i) Nature of the lens used is convex lens because it produces a magnified image of the palm.

(ii) Real and magnified image of the object can be obtained in convex lens, when the object is placed between focus and centre of curvature of the lens.

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

$u = -5$ cm

$v = ?$

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

Or $\frac{1}{10} = \frac{1}{v} - \left(-\frac{1}{5}\right)$

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

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

$\therefore \quad v = -10$ cm

By using magnification formula, $m = \frac{v}{u}$

Or $$m = \frac{-10}{-5}$$

$$m = 2 \text{ cm}$$

Image is formed twice the size of the object.

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

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

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

(iii) Draw ray diagram to justify your answer of part (ii). A **[CBSE Board Delhi, Set- I, 2019]**

Ans. (i) $u = -60$ cm, $f = -30$ cm, $v = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \qquad ½$$

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

$$\frac{1}{v} = \frac{1}{(-30\,\text{cm})} + \frac{1}{(-60\,\text{cm})} = \frac{-3}{60}$$

$\therefore \quad v = -20$ cm **1**

$$m = \frac{v}{u} = \frac{-20\text{ cm}}{-60\text{ cm}} = \frac{1}{3} \qquad ½$$

Distance of the image will be 20 cm in front of lens. ½

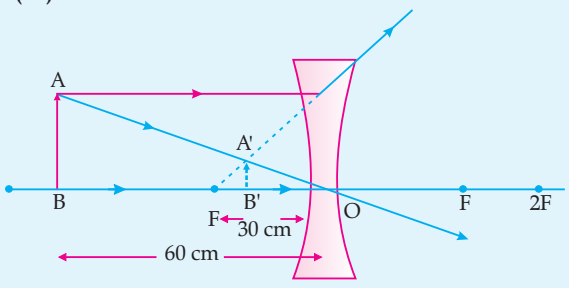
(ii) Nature: Virtual ½

Position: 20 cm from lens on the same side as the object ½

Size: Diminished ½

Erect/Inverted: Erect

(iii)



1

[CBSE Marking Scheme, 2019] 5

AI **Q. 6. An object is placed at a distance of 30 cm from a concave lens of focal length 30 cm.**

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

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

(iii) Draw a labelled diagram to justify your answer of part (ii). A **[CBSE Board Delhi, Set- II, 2019]**

Ans. (i) $u = -30$ cm, $f = -30$ cm, $v = ?$ ½

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

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

or, $$\frac{1}{v} = \frac{1}{(-30\,\text{cm})} + \frac{1}{(-30\,\text{cm})}$$

or, $$\frac{1}{v} = \frac{-2}{30}\ \text{cm}$$

$\therefore \quad v = -15$ cm **1**

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

$$\frac{(-15\text{ cm})}{(-30\text{ cm})} = -\frac{1}{2} \qquad ½$$

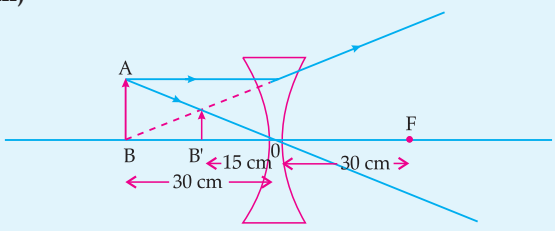
(ii) Nature — Virtual ½

Position — 15 cm away from the lens, on the same side as the object ½

Size — Diminished ½

Erect / inverted – Erect ½

(iii)



[CBSE Marking Scheme, 2019] 1

Q. 7. A concave lens of focal length 60 cm is used to form an image of an object of length 9 cm kept at a distance of 30 cm from it. Use lens formula to determine the nature, position and length of the image formed. Also draw labelled ray diagram to show the image formation in the above case. AE **[Delhi, 2019]**

Ans. 16.

Concave lens

~~f = −60 cm~~

~~h' = 9 cm~~

$f = -60\ cm$

$h' = +\ ?$

$h = +\ 9\ cm$

$u = -\ 30\ cm$

$v = -\ ?$

According to lens formula,

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

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

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

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

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

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

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

$$\boxed{v = (-20)\ cm}$$

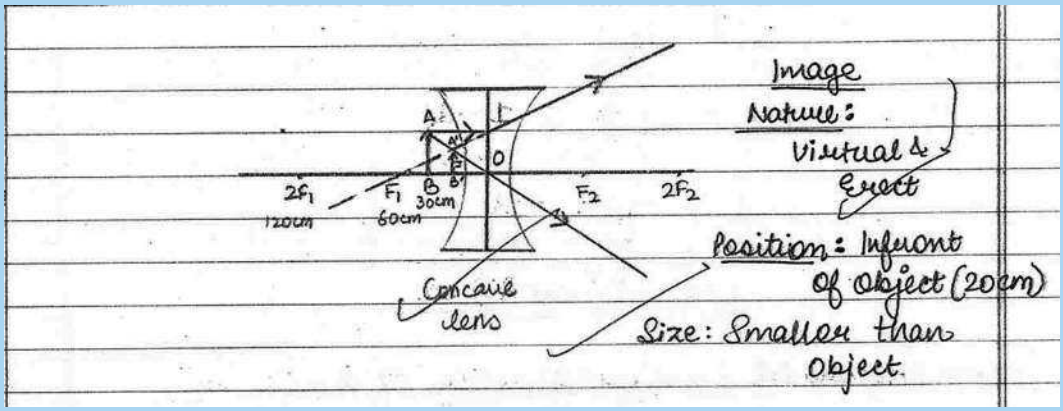
According to linear magnification of lens,

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

$$\frac{+20}{-30} = \frac{h'}{9}$$

$$h' = \frac{2 \times 9^{3}}{3}$$

$$\boxed{h' = 6\ cm}$$



Q. 8. 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) What is the focal length of the convex lens? Give reason in support of your answer.

(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. 4 and find the approximate value of magnification.

AE **[Delhi 31/1/1 2017]**

Ans. (a) $f = +15$ cm ½

Reason: Objects at S. No. (3) indicates $u = -30$ cm, $v = +30$ cm

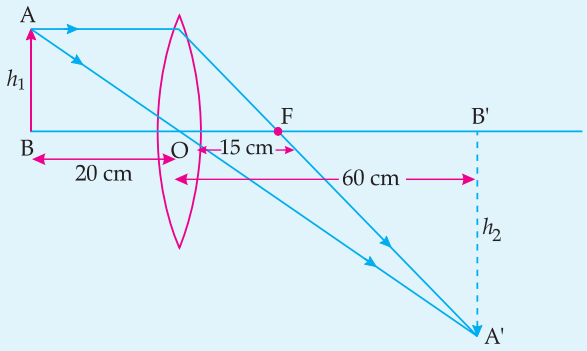
Thus, object is at 2F ($2f = 30$ cm)

$\therefore$ $f = 15$ cm **1**

(b) Observation at S. No. (6) ½

The value, $u = -10$ cm, indicates that the object is in between the optical centre and the focus (*i.e.*, less than the focal length) of the lens and hence the image should be on the same side as the object. Thus the image distance cannot be positive. **1**

(c) u = – 20 cm ; v = + 60 cm: f = + 15 cm



$$m = \frac{h_2}{h_1} = \frac{-4.5\text{ cm}}{+1.5\text{ cm}} = -3$$ ½

[CBSE Marking Scheme, 2017]

Detailed Answer:

(i) From S. No- 3, we can say that the radius of curvature of the lens is 30 cm because when an object is placed at the centre of curvature of a convex lens, its image is formed on the other side of the lens at the same distance from the lens. And, we know that focal length is half of the radius of curvature. Thus, the focal length of the lens is + 15 cm.

(ii) S. No- 6 is not correct as the object distance is between focus and pole so for such cases the image formed is always virtual but in this case a real image is forming as the image distance is positive.

(iii) For Diagram refer page 53.

Q. 9. Analyse the following observation table showing variation of image-distance (v) with object-distance (u) in case of a convex lens and answer the questions that follow without doing any calculations:

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

(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 ?

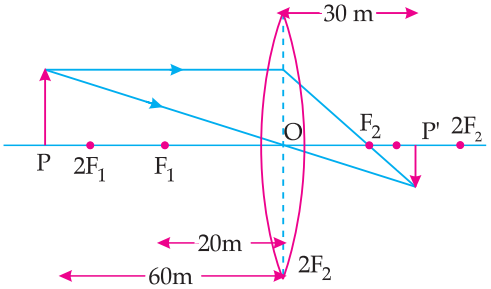
(c) Select an appropriate scale and draw a ray diagram for the observation at S.No. 2. Also find the approximate value of magnification.

AE **[OD 31/1 2017]**

Ans. (a) The focal length of the convex lens can be calculated from S.No. 3 as when an object is placed at a distance from the convex lens its image is formed on the other side of the lens at the same distance from the lens. So, the focal length is + 20 cm.

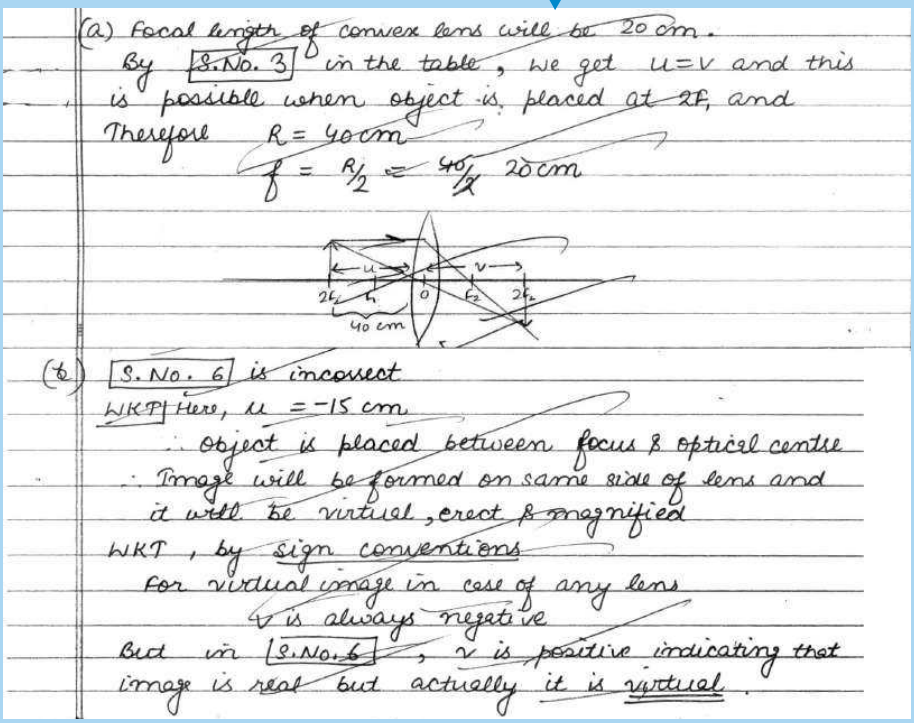
(b) S.No. 6 is incorrect as the object distance is between focus and pole and here the real image is formed as the image distance is positive. But in such situation virtual image should form.

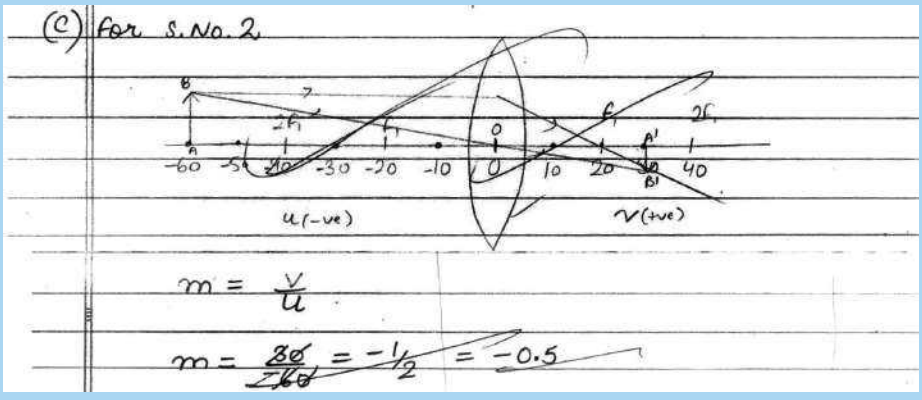
(c) Approximate value magnification for object distance – 60 cm and image distance +30 cm is – 0.5.



OR

Topper Answer, 2017





Q. 10. (a) Define focal length of a divergent lens.

(b) A divergent lens of focal length 30 cm forms the image of an object of size 6 cm on the same side as the object at a distance of 15 cm from its optical centre. Use lens formula to determine the distance of the object from the lens and the size of the image formed.

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

U **[Board Term II O.D. Set II, 2016]**

Topper Answer, 2016

Ans.

(a) The distance between the principal focus and the optical centre of the concave lens or diverging lens is called the focal length of a diverging lens.

(b) $f = -30$ cm.

$h = 6$ cm

$v = -15$ cm. $u = ?$ $h' = ?$

Lens formula:

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

$$\frac{-1}{15} - \frac{1}{u} = \frac{-1}{30} \qquad \frac{-1}{u} = \frac{-1}{30} - \left(\frac{-1}{15}\right)$$

$$-\frac{1}{u} = -\frac{1}{30} + \frac{1}{15}$$

$$-\frac{1}{u} = \frac{-15+30}{450}$$

$$-\frac{1}{u} = \frac{15}{450_{30}}$$

$$-u = 30$$

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

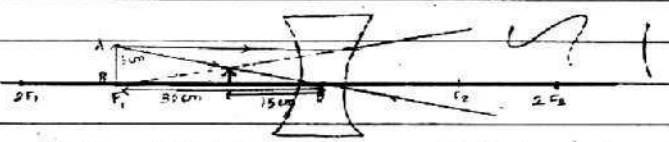
$$m = \frac{v}{u} = \frac{h'}{h}$$

$$\frac{-15}{-30} = \frac{h'}{6} \qquad \frac{6}{2} = h'$$

$h' = 3$ cm

The height of the image is 3 cm

(c)



Position of object is between Infinity and optical centre.

Image position is between Focus, and optical centre.

COMMONLY MADE ERROR

- Students get confused between divergent and convergent lens.
- Mistakes are also made by candidates in simplifying the calculations.

ANSWERING TIPS

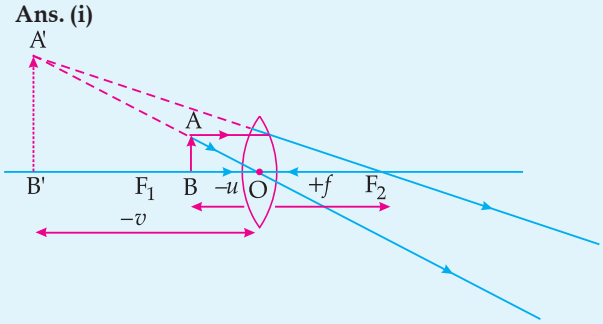
- Diverging lens is concave lens and converging lens is convex lens.
- Lens formula should be correctly mentioned and calculated.

Q. 11. (i) Draw a ray diagram to show the formation of image by a convex lens when an object is placed in front of the lens between its optical centre and principal focus.

(ii) In the above ray diagram mark the object-distance (u) and the image-distance (v) with their proper signs (+ve or – ve as per the new Cartesian sign convention) and state how these distances are related to the focal length (f) of the convex lens in this case.

(iii) Find the power of a convex lens which forms a real, and inverted image of magnification –1 of an object placed at a distance of 20 cm from its optical centre. A [Board Term II Delhi Set I, 2016]

Ans. (i)



(ii) Relation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ ½ + ½

(iii) $m = -1$; $u = -20$ cm; $v = ?$, $f = ?$

Marking of u & v, ½

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

$\therefore$ $v = +20$ cm ½

Thus, object is at 2F

i.e., $2f = 20$ cm

$\therefore$ $f = 10$ cm $= 0.1$ m **1**

$$p = \frac{1}{f} = \frac{1}{0.1} = +10 \text{ D}$$ **1**

[CBSE Marking Scheme, 2016]

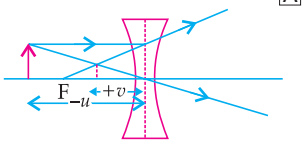
Q. 12. (a) Draw a ray diagram to show the formation of image by a concave lens when an object is placed in front of it.

(b) In the above diagram mark the object-distance (u) and the image-distance (v) with their proper signs (+ve or –ve as per the 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 a lens which forms a real and inverted image of magnification –1 at a distance of 40 cm from its optical centre.

A [Delhi,Set-2, 2016]

Ans. (a)



(b) Marking $-u$ and $-v$ ½+½

Relation:

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

(c) As, $m = -1$ hence, the lens is convex ½

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

$\therefore$ $v = -u$ ½

This, object is at 2F

$2f = 40$ cm

$\therefore$ $f = 10$ cm $= 0.2$ m

$$P = \frac{1}{f} = \frac{1}{0.2}$$

$= +5$D (convex lens) **1**

Q. 13. (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. R [OD, Set-1, 2016]

Ans. (a) Optical centre: The optical centre of a spherical lens is defined as a point on the principal axis through which light ray from undeviated. It is the centre point of the lens. **1**

(b) $f = -20$ cm

$h_1 = 4$ cm, $v = -10$, $u = ?$, $h_2 = ?$ ½

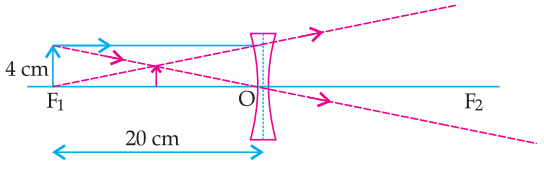
$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{-1}{-10} - \frac{1}{-20} = \frac{-1}{10} + \frac{1}{20}$$ ½

or, $$\frac{1}{f} = \frac{-2+1}{20} = -\frac{1}{20}$$

$u = -20$ cm **1**

$$h_i = \frac{v}{u} h_0 = \frac{-10\text{cm}}{-20\text{cm}} \times 4 = 2 \text{ cm}$$ ½

(c)



1

Q. 14. (a) Define focal length of a divergent lens.

(b) A divergent lens of focal length 30 cm forms the image of an object of size 6 cm on the same side

as the object at a distance of 15 cm from its optical centre. Use lens formula to determine the distance of the object from the lens and the size of the image formed.

(c) Draw a ray diagram to show the formation of image in the above situation. U **[OD, Set -3, 2016]**

Ans. (a) Focal length is the distance between optical centre pole and principal focus of a divergent lens.

(b) $f = -30$ cm, $u = ?$, $v = -15$ cm, $h_1 = 6$ cm, $h_2 = ?$ **1**

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

or, $$\frac{1}{u} = \frac{-1}{f} + \frac{1}{v}$$ ½

or, $$u = \frac{vf}{f - v}$$

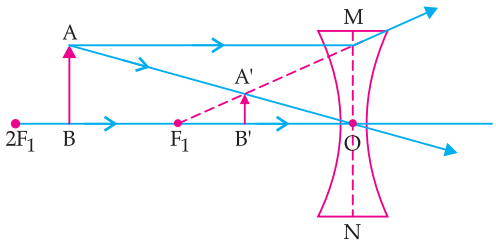
or, $$= \frac{-15 \text{ cm} \times -30 \text{ cm}}{-30 \text{ cm} - (-15) \text{ cm}}$$

or, $$= \frac{450}{-15} = -30 \text{ cm}$$ **1½**

$$h_2 = \frac{v}{u} \times h_1 = \frac{-15\text{cm}}{-30\text{cm}} \times 6 \text{ cm}$$

$\therefore$ $= 30$ cm **1**

(c)



1

Topper Answer, 2016

24

(a) The distance between the principal focus and the optical centre of the concave lens or diverging lens is called the focal length of a diverging lens.

(b) $f = -30$ cm.

$h = 6$ cm

$v = -15$ cm. $u = ?$ $h' = ?$

Lens formula:

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

$\frac{-1}{15} - \frac{1}{u} = \frac{-1}{30}$ $\quad \frac{-1}{u} = \frac{-1}{30} - \left(\frac{-1}{15}\right)$.

$-\frac{1}{u} = -\frac{1}{30} + \frac{1}{15}$

$-\frac{1}{u} = \frac{-15 + 30}{450}$

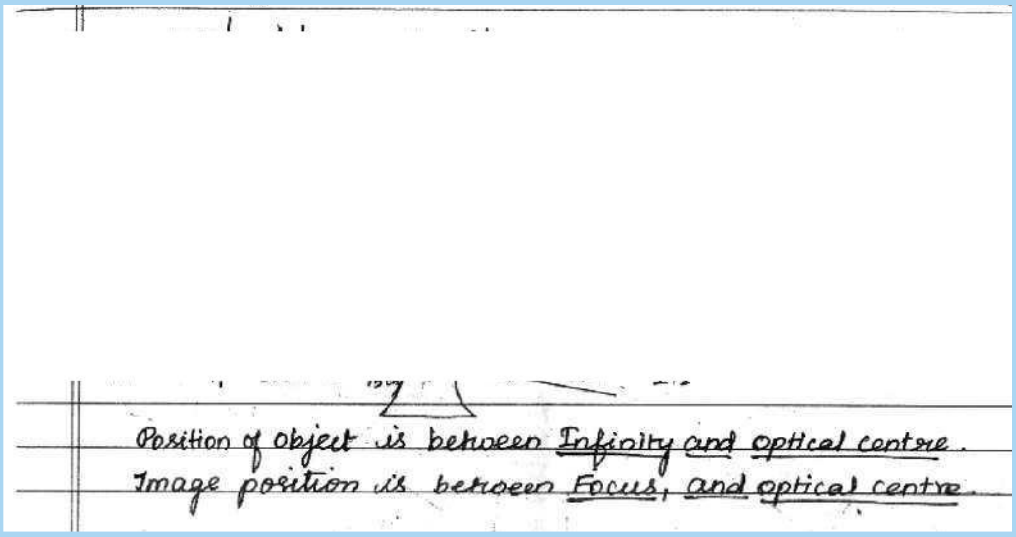
$-\frac{1}{u} = \frac{15}{450}$ 30

$-u = 30$

$\boxed{u = -30}$

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

ue is -30 cm.



Q. 15. (a) 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.

(b) The absolute refractive indices of two media 'A' and 'B' are 2.0 and 1.5 respectively. If the speed of light in medium 'B' is 2×10^8 m/s, calculate the speed of light in:

(i) vacuum,

(ii) medium 'A' U **[Board Term II Delhi Set II, 2015]**

Ans. (a) Laws of refraction of light:

Try Yourself. Refer Q.No. 4 of Short Answer Type Questions-II.

(b) Given $n_A = 2.0$ and $n_B = 1.5$

Speed of light in medium B $= 2\times10^8$ m/s

$$n_B = \frac{\text{Speed of light in vacuum (c)}}{\text{Speed of light in media B}}$$

$$1.5 = \frac{c}{2\times10^8}$$

Speed of light in vacuum $c = 2\times10^8\times1.5$

$= 3.0\times10^8$ m/s

Speed of light in medium 'A'

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

$$2.0 = \frac{3\times10^8}{\text{Speed of light in media 'A'}}$$

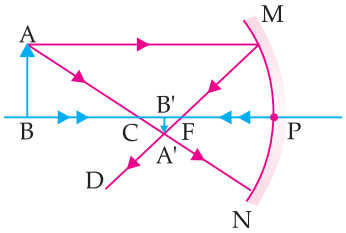
$$\text{Speed of light in medium A} = \frac{3\times10^8}{2}$$

$= 1.5\times10^8$ m/s **2 + 3**

[CBSE Marking Scheme, 2015]

Visual Case-based Questions — 4 marks each

Q. 1. Following figure illustrates the ray diagram for the formation of image by a concave mirror. The position of the object is beyond the centre of curvature of the concave mirror. On the basis of given diagram answer any four questions from (a) to (e).



(a) If the focal length of the concave mirror is 10 cm, the image formed will be at a distance _____.

(i) Between 10cm and 15cm

(ii) Between 10cm and 20cm

(iii) Beyond 20cm

(iv) At 20 cm

(b) In case of concave mirror, the image distance is _____ when image is formed in front of the mirror and _____ when the image is formed behind the mirror.

(a) positive, negative

(b) negative, negative

(c) negative, positive

(d) positive , positive

(c) If the size of the object in the given figure is 5 cm and the magnification produced is –0.5. The size of the image is (in cm) _____

(i) –2.5 **(ii) –0.1**

(iii) 2.5 **(iv) 0.1**

(d) A negative sign in the magnification value indicate that the image is _____

(i) Real and inverted

(ii) Real and erect

(iii) Virtual and erect

(iv) Virtual and inverted

(e) An image formed by concave mirror is virtual, when the object is placed:

(i) at infinity **(ii) at C**

(iii) Between C and F **(iv) Between P and F**

Ans. (a) (ii) Between 10 cm and 20 cm

(b) (iii) negative, positive

(c) (i) – 2.5

As we know, magnification,

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

$$h_2 = \frac{-0.5 \times 5}{10}$$

$$h_2 = -2.5 \text{ cm}$$

(d) (i) Real and inverted

(e) (iv) Between P and F **1+1+1+1+1**

Q. 2. Read the following passage and answer any four questions from (a) to (e).

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

(a) Which type of mirror should he use and why ? U

(i) Convex mirror, it forms virtual image

(ii) Concave mirror, it forms virtual image

(iii) Concave mirror, it forms real image

(iv) Convex mirror, it forms real image

(b) At what distance, in terms of focal length '*f*' of the mirror, should he place the candle flame to get the magnified image on the wall ? C

(i) At F **(ii) Between F and C**

(iii) At C **(iv) At infinity**

(c) To get the diminished image of the candle flame, the object must be placed at: U

(i) infinity **(ii) at C**

(iii) between F and C **(iv) At F**

(d) If the image formed by this mirror is inverted and real, the magnification will be: A

(i) Positive **(ii) Negative**

(iii) Either of them **(iv) None of the above**

(e) A virtual image formed by concave mirror is: C

(i) erect and enlarged

(ii) erect and diminished

(iii) inverted and diminished

(iv) inverted and enlarged

Ans. (a) (iii) Concave mirror, it forms real image.

(b) (ii) Between F and C

(c) (i) at infinity

(d) (ii) negative

(e) (i) erect and enlarged **1+1+1+1+1**

Q. 3. Read the following passage and answer any four questions from (a) to (e)

A student wants to project the image of a candle flame on a screen 30 cm in front of a mirror by keeping the flame at a distance of 15 cm from its pole.

(a) Suggest the type of mirror he should use:

(i) convex mirror **(ii) plane mirror**

(iii) concave mirror **(iv) none of the above**

(b) Find the linear magnification of the image produced.

(i) – 4 **(ii) + 4**

(iii) – 900 **(iv) + 900**

(c) When object distance is less than focal length the image is _____ and when object distance is more than focal length the image is _____.

(i) real, real **(ii) virtual. Virtual**

(iii) real, virtual **(iv) virtual, real**

(d) What is the distance between the object and its image ?

(i) 15 cm **(ii) 35 cm**

(iii) 75 cm **(iv) 0 cm**

(e) The image formed in the above case is:

(i) virtual, inverted and magnified.

(ii) real, erect and magnified

(iii) real , inverted and magnified

(iv) real, erect and diminished

Ans. (a) (iii) Concave mirror

(b) (i) – 4

(c) (iv) virtual, real

(d) (i) 15 cm

(e) (i) real, inverted and magnified **1+1+1+1+1**

Q. 4. Read the following passage and answer any four questions from (a) to (e).

A student focuses the image of a candle flame, placed at about 2 m from a convex lens of focal length 10 cm, on a screen. After that he moves gradually the flame towards the lens and each time focuses its image on the screen.

U **[OD 2017,Set-1]**

(a) In which direction does he move the lens to focus the flame on the screen ?

(i) away from screen

(ii) towards the screen

(iii) should not move the screen

(iv) away from flame

(b) What happens to the size of the image of the flame formed on the screen?

(i) size of image will decrease

(ii) size of image will increase

(iii) remains unchanged

(iv) size will become too small

(c) What difference is seen in the intensity (brightness) of the image of the flame on the screen ?

(i) intensity of flame increases

(ii) intensity of flame remains same

(iii) intensity of flame reduces

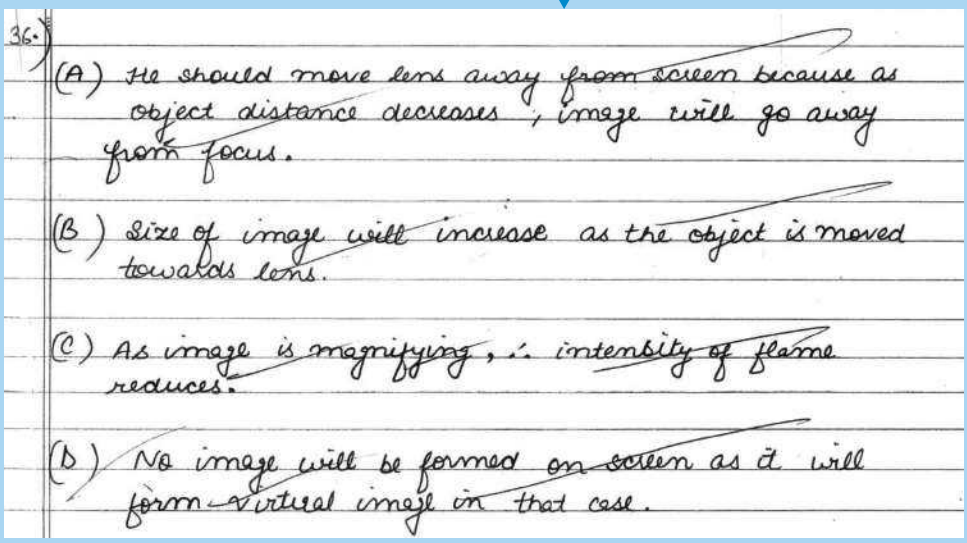
(iv) the flame disappears

(d) What is seen on the screen when the flame is very close (at about 5 cm) to the lens ?

(i) a bright image (ii) a magnified image

(iii) diminished image (iv) no image

Topper Answer, 2017


36.
(A) He should move lens away from screen because as object distance decreases, image will go away from focus.

(B) Size of image will increase as the object is moved towards lens.

(C) As image is magnifying, ∴ intensity of flame reduces.

(D) No image will be formed on screen as it will form virtual image in that case.

Q. 5. Read the passage and note the following observations. Answer any four questions from (a) to (e)

A student focussed the image of a candle flame on a white screen by placing the flame at various distances from a convex lens. He noted his observations as:

S. No.	Distance of flame from the lens (cm)	Distance of the screen from the lens (cm)
(i)	60	20
(ii)	40	24
(iii)	30	30
(iv)	24	40
(v)	15	70

(a) From the above table, find the focal length of lens without using lens formula: AE

(i) 15cm (ii) 30cm

(iii) 40cm (iv) 60cm

(b) Which set of observations is incorrect and why? A

(i) Object distance can not be smaller than image distance

(ii) Image should form at 15cm only

(iii) Image should form at infinity

(iv) Object is kept at optical centre

(c) In which case, the size of the object and image will be same: U

(i) In (iv) case (ii) In (ii) case

(iii) In (iii) case (iv) In (i) case

(d) What is the change in image observed as the object is moved from infinity towards the concave lens? U

(i) Size of image decreases

(ii) Size of image becomes highly diminished

(iii) Size of the image remains unchanged

(iv) Size of the image increases slightly

(e) Which of the following statement is false for the formation of images by convex lens: R

(i) It forms real,inverted and diminished image.

(ii) It forms virtual erect and enlarged image.

(iii) It forms virtual, erect, and diminished image.

(iv) It forms real,inverted and enlarged image.

Ans. (a) (i) 15 cm

(b) (iii) Image should form at infinity

(c) (iii) In (iii) case

(d) (iv) Size of the image increases slightly

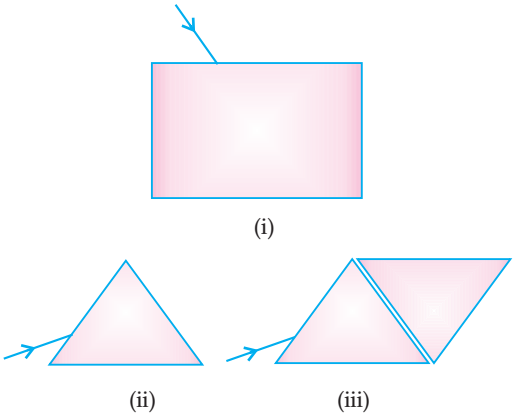
(e) (iii) It forms virtual, erect and diminished image.

1+1+1+1+1

Q. 6. Study the given diagram and answer any four questions from (a) to (e).

A very thin narrow beam of white light is made incident on three glass objects shown below.

Study the nature and behaviour of the emergent beam in all the three cases.



(i)

(ii) (iii)

(a) Following are the possibility of two emergent beams being similar. Choose the correct answer: C

(i) (i) and (ii)
(ii) (i) and (iii)
(iii) (ii) and (iii)
(iv) No similar emergent beams

(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 $\sin 45° = \frac{1}{\sqrt{2}}$; $\sin 30° = \frac{1}{2}$) A

(i) $\sqrt{2}$ **(ii) $2\sqrt{2}$**
(iii) $1/(\sqrt{2})$ **(iv) 1**

(c) The light changes its path as its medium changes. Which of the following is incorrect statement. U

(i) Speed of light is different in different media.
(ii) Light changes its path because light only travels in straight line.
(iii) Speed of light is dependent on medium through which it is passing.
(iv) The light chooses the path with minimum time, as it changes its medium.

(d) What is the unit of refractive index? R

(i) Pascal **(ii) Joule**
(iii) No unit **(iv) μ m**

(e) Light travel fastest in: R

(i) Air **(ii) Vacuum**
(iii) Glass **(iv) diamond**

Ans. (a) (ii) (i) and (iii)
Explanation: In (i) emergent beam is white and laterally displaced.
In (ii) emergent beam is a spectrum of seven colours bent in different angles.
In (iii) emergent beam from the second prism is white only.
Similarity between (i) and (iii) as both emergent rays are white in colour

(b) (i) $\sqrt{2}$
(c) (ii) Light changes its path because light only travels in straight line.
(d) (iii) No unit
(e) (ii) vacuum. **1+1+1+1+1**

Q. 7. An object is kept at a distance of 18 cm, 20 cm, 22 cm and 30 cm, from a lens of power + 5D.

(a) The focal length of the given lens is: C

(i) 0.2 cm **(ii) 20 cm**
(iii) 5cm **(iv) 0.5 cm**

(b) In which case or cases would you get a magnified image ? U

(i) 18cm **(ii) 20cm**
(iii) 22cm **(iv) All the above**

(c) Which of the magnified image can we get on a screen ? AE

(i) At 18 cm
(ii) At 18 cm and 22 cm
(iii) At 20 cm and 22 cm
(iv) At 22 and 30 cm

(d) The power of a lens of focal length 1 metre is called as: R

(i) Refractive index **(ii) 1 dioptre**
(iii) Speed of light **(iv) Wavelength**

(e) Name the lens/mirror used in film projectors and telescopes: R

(i) Convex lens **(ii) Concave lens**
(iii) Convex mirror **(iv) Concave mirror**

Ans. (a) (ii) 20 cm
(b) (iv) all the above
(c) (iv) at 22 cm and 30 cm, image can be obtained on a screen.
(d) (ii) 1 dioptre
(e) (i) Convex lens **1+1+1+1+1**

Know the Terms

- **Ray and beam:** Rectilinear propagation light travels in a straight line. The straight line indicating the path of the light (arrow–direction) is called a ray. A bundle of rays originating from the same source of light in a particular direction is called a beam of light.
- **Parallel beam:** When the rays which constitute the beam are parallel to one another, then it is called a parallel beam of light.
- **Convergent beam:** When the rays actually meet or appear to meet at a point, then the beam is called convergent beam and rays are called convergent rays.

- **Divergent beam:** When the rays actually diverge or appear to diverge from a point, then the beam is called divergent beam and rays are called divergent rays.
- **Image:** The point of convergence or the point from where the light appears to diverge after reflection or refraction is called an image.
- **Aperture:** The width of the reflecting refractions surface from which reflection refraction takes place is called aperture.
- **Pole:** The central point of the reflecting spherical surface is called pole (P). It lies on the surface of the mirror.
- **Centre of curvature:** The centre of the hollow sphere of which the spherical mirror lens is a part, is called centre of curvature (C).
- **Radius of curvature:** The separation between the pole optical centre and the centre of the hollow sphere, of which the mirror lens is a part, is called radius of curvature (R).
- **Principal axis:** The straight line joining the pole optical centre and the centre of curvature is called principal axis.
- **Focus:** The point F on the principal axis, where a beam of light parallel to the principal axis actually meet after reflection refraction or appear to come from it is called its principal focus.
- **Focal length:** The distance between the pole optical centre and the focus is called focal length.

❑❑❑