UNIT – III

Natural Phenom-ena

CHAPTER

10 LIGHT-REFLECTION AND REFRACTION

Syllabus

➢ *Light-Reflection and Refraction : Reflection of light at 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.*

Quick Review

TOPIC - 1
Reflection of Light, Image Formed by Spherical Mirrors .... P. 245

TOPIC - 2
Refraction, Lenses, Power of Lens .... P. 261

➢ When light fall on a body, it may be absorbed, may be transmitted or light may get reflected back to the same medium.

➢ **Reflection of light** means light waves are neither transmitted nor absorbed but are deflected from the surface of the medium back into the same medium.

➢ **Laws of Reflection :**

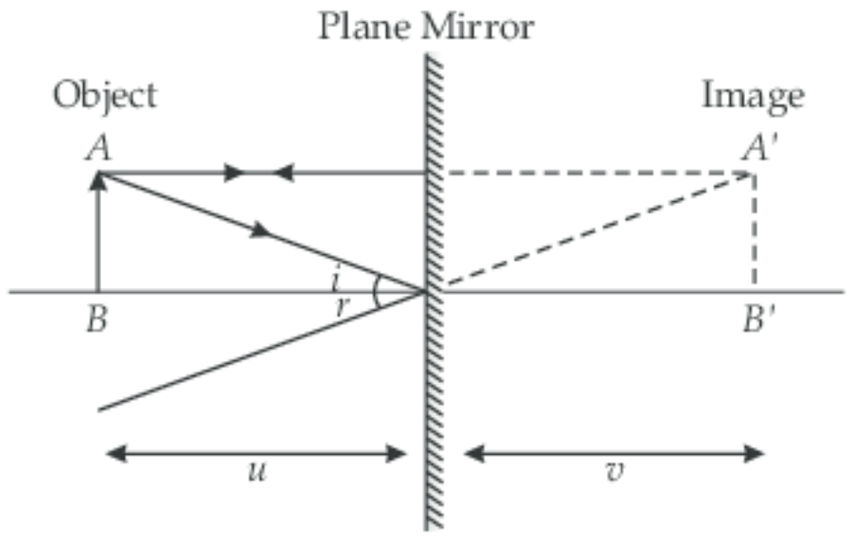
(i) The incident ray, the normal to the surface at the point of incidence and the reflected ray, all lie in the same plane.

(ii) The angle of incidence is equal to the angle of reflection.

➢ Real image is obtained when the rays of light after reflection, actually converge at a 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 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 is curved inwards and polished on the outer spherical surface is concave mirror.

➢ A spherical mirror whose reflecting surface is curved outwards and polished on the inner spherical surface is convex mirror.

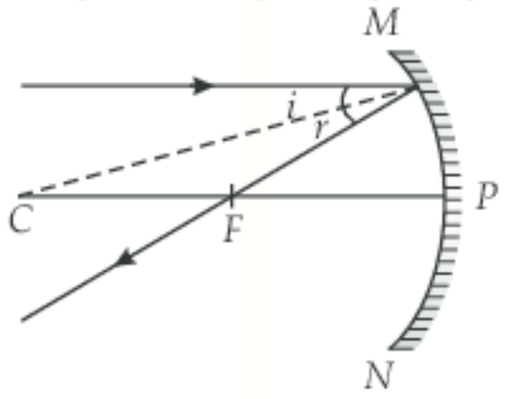
- Concave mirror mostly forms real images, which can be received on the screen. Convex mirror always forms virtual images, which cannot be received on the screen.
- **Differentiating between a plane mirror, a concave mirror and a convex mirror, without touching them:**

  (i) If the image formed is erect and is of same size as in reality then it is a plane mirror.

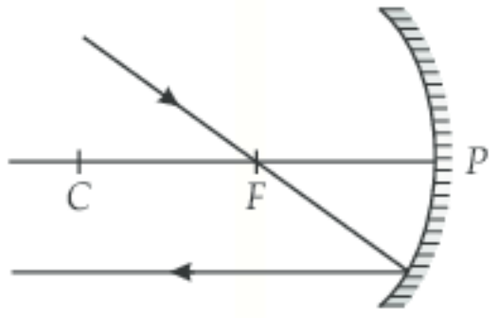
  (ii) If the image formed is still erect but smaller in size then it is a convex mirror.

  (iii) If the image formed is erect but magnified when the mirror is close to the object, then it is a concave mirror.
- Solar concentrations 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 a point called the pole of the mirror and 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**

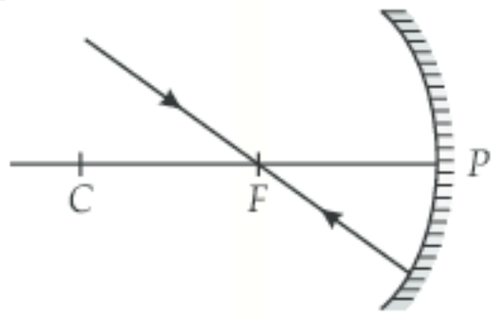
  (i) A ray parallel to the principal axis will pass through the principal focus, after reflection.



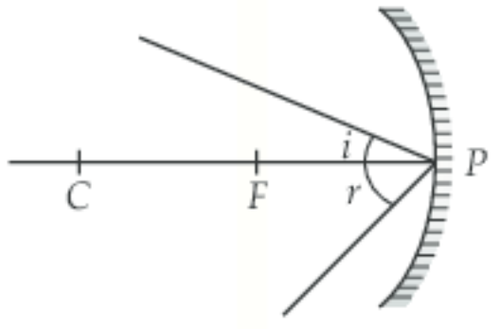
  (ii) A ray passing through the principal focus of concave mirror will emerge parallel to principal axis after reflection.



  (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 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 mirror	Enlarged	Virtual and erect

➢ **Nature, position and relative size of the image formed by a convex mirror :**

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

➢ **Mirror Formula :**

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

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.

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

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

Also,

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

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 $h_i > h_i$ 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 that 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 convex 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 angle of bending 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.

- **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.
- **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.

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

- 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 ${}_1n^{air}$, and
If refractive index of medium 2 w.r.t. air is given as ${}_2n^{air}$

Then, refractive index of medium 1 w.r.t. medium 2 $= \frac{{}_1n^{air}}{{}_2n^{air}}$

- 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 :** $m = \frac{h_i}{h_o}$

Also,

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

- **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

$$1 \text{ D} = 1 \text{ m}^{-1}$$

1 dioptre is the power of lens whose focal length is one meter.

Know the Terms

- **Ray and beam :** Light travels in a straight line–Rectilinear propagation. 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 containing such rays are 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 containing such rays are 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 image.
- **Aperture :** The width of the reflecting surface from which reflection 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 is a part, is called centre of curvature (C).
- **Radius of curvature :** The separation between the pole and the centre of curvature cut of the hollow sphere, of which the mirror is a part, is called radius of curvature (R).
- **Principal axis :** The straight line joining the pole 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 or appear to come it from it is called its principal focus.
- **Focal length :** The length or separation between the pole and the focus is called focal length.

TOPIC-1

Reflection of Light, Image Formed by Spherical Mirrors

Very Short Answer Type Questions (1 mark each)

R **Q. 1. Define the term principal axis of a spherical mirror. [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

R **Q. 2. What is virtual image ?**

Ans. If the rays of light do not actually meet after reflection or refraction, but appear to meet when produced backwards, then that point constitutes virtual image. 1

R **Q. 3. Define the principal focus of a concave mirror.**

Ans. Light rays that are parallel to the principal axis of a concave mirror converge at a specific point on its principal axis after reflection from the mirror. This point is known as the principal focus of the concave mirror. 1

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

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

R **Q. 5. What do you mean by lateral inversion of the image in mirrors ?**

Ans. If we look into the mirror to see the image, we see that the image is inverted sideways, *i.e.*, if we move our left hand, the image appears to move its right hand. 1

U **Q. 6. What are the two factors on which the lateral displacement of an emergent ray from a glass slab depends ?**

Ans. Angle of incidence and thickness of slab. ½+½

U **Q. 7. What is the magnification of the images formed by plane mirror and why ? [Board Term II Delhi Set-I, 2015]**

Ans. Its magnification is + 1 because plane mirror always forms a laterally inverted image. 1
[CBSE Marking Scheme, 2015]

R **Q. 8. What is the range of wavelengths of the visible light ?**

Ans. Wavelength of visible light = 4×10^{-7} m to 8×10^{-7} m. 1

R **Q. 9. What is the minimum distance between an object and its real image in case of a concave mirror ? [Board Term II, Set B1, 2011]**

Ans. Zero (0). When the object is at C. 1

A **Q. 10. Why are convex mirrors preferred over plane mirrors as rear view mirrors ?**

Ans. The field of view of convex mirror is wider in comparison to plane mirror. The convex mirror is preferred as a rear view mirror as it enables the driver to view much larger area than with a plane mirror. 1

A **Q. 11. We prefer a convex as a rear view mirror in vehicles. Why ? [Delhi Comptt. 31/1/1 2017]**

Ans. Due to its wide field of view. 1

R **Q. 12. When a light ray passes obliquely through the atmosphere in an upward direction, how does its path generally change ? [Board Term II, Set B1, 2011]**

Ans. Light will bend away from its normal direction. 1

A **Q. 13. What makes things visible ?**

Ans. In a lighted room, when light falls on an object, it gets either partially or completely reflected. This reflected light when received by our eyes, enables us to see things. 1

A **Q. 14. Explain why a ray of light passing through the centre of curvature of a concave mirror, gets reflected along the same path. [Board Term II Delhi 2010]**

Ans. The ray passing through the centre of curvature is incident to the mirror along its normal so $\angle i = \angle y = 0$. Therefore, the ray retrace its path. 1

R **Q. 15. Name the mirror that can give an erect and enlarged image of an object.**

Ans. When an object is placed between the pole and the principal focus of a concave mirror, the image formed is virtual, erect and enlarged. **1**

A **Q. 16. Why does the bottom of a tank or a pond containing water appear to be raised ?**

Ans. Light from the bottom of the pond undergoes change in path at the interface of air and water. As a result, the rays appear to come from a raised surface rather than the actual bottom surface of the pond. **1**

A **Q. 17. Does the speed of light increases or decreases in a medium in comparison to its value in vacuum ? Give an illustrative example.**

Ans. Speed of light decreases in the presence of a medium *e.g.*, When a light ray enters in water from air, its speed decreases. **1**

R **Q. 18. What are the values of angle of incidence *i* and angle of reflection *r* for a normal incidence ?**

Ans. Normal incidence implies, $i = 0°$. Hence, from the second law of reflection, $r = 0°$. **1**

A **Q. 19. Find the focal length of a convex mirror whose radius of curvature is 32 cm.**

Ans. Radius of curvature,

$$R = 32 \text{ cm}$$

$$\text{Radius of curvature} = 2 \times \text{Focal length } (f)$$

$$R = 2f$$

$$\therefore \quad f = \frac{R}{2} = \frac{32}{2} = 16 \text{ cm.}$$

Hence, the focal length of the given convex mirror is 16 cm. **1**

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

Ans. Radius of curvature,

$$R = 20 \text{ cm}$$

Radius of curvature of a spherical mirror

$$= 2 \times \text{focal length } (f)$$

$$R = 2f$$

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

Hence, the focal length of the given spherical mirror is 10 cm. **1**

Short Answer Type Questions-I

(2 marks each)

R **Q. 1. List four characteristics of the image formed by plane mirrors.** **[Board Term II Delhi II, 2015]** **[Delhi Comptt. 31/1/1 2017]**

Ans. Four characteristics of the image formed by plane mirror :

(i) It is always virtual and erect.

(ii) Size of image is equal to that of the object.

(iii) Image is formed at the same distance behind the mirror as the object is in front of the mirror.

(iv) Image is laterally inverted. ½ + ½ + ½ + ½

U **Q. 2. 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.** **[Delhi 31/1/1 2017]**

Ans. Image is—

(i) Virtual

(ii) Erect

(iii) Diminished

(iv) Laterally invented $4 \times ½ = 2$

[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) Always form behind the mirror between focus and pole **2**

U **Q. 3. An object is placed at a distance of 40 cm in front of a convex mirror of radius of curvature 40 cm. List four characteristics of the image formed by the mirror.** **[Delhi 31/1/1 2017]**

Ans. Image is—

(i) Virtual

(ii) Erect

(iii) Diminished

(iv) Laterally invented $4 \times ½ = 2$

U **Q. 4. 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.** **[Delhi 31/1/1 2017]**

Ans. Four properties of the image formed by the given concave mirror of the object placed between focus and pole of the mirror are :

(i) Image is always erect.

(ii) Big in size

(iii) Virtual

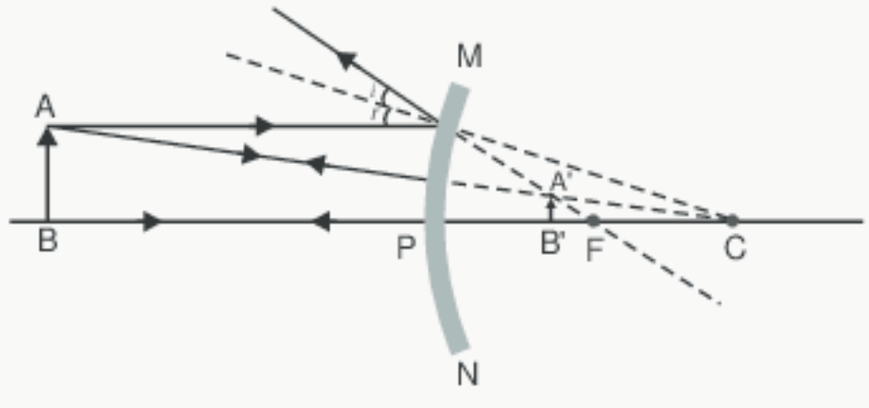
(iv) Always forms behind the mirror. ½ × 4

A **Q. 5. List two properties of the images formed by convex mirrors. Draw ray diagram in support of your answer.** **[Board Term II Foreign Set II 2016]**

Ans. (i) It forms virtual and erect image.

(ii) It forms image smaller than the object.

(Any two) $2 \times ½ = 1$



[CBSE Marking Scheme, 2016] 1

A Q. 6. **You are given a concave mirror, plane mirror and a convex mirror. How can you distinguish between them by just looking your face in them. State the common nature of the image that you see in all of them.** **[Board Term II SQP 2013]**

Ans. (i) Image is of same size in plane mirror.

(ii) Image is enlarged in concave mirror.

(iii) Image is diminished in convex mirror.

(iv) Image in all the three is virtual. ½+½+½+½

R Q. 7. **List four specific characteristics of the images of the objects formed by convex mirrors.**

[Board Term II Delhi Set I 2015]

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

(i) It is always formed behind the mirror, between the pole and its focus.

(ii) The image is always virtual and erect.

(iii) The size of image is always smaller than the object.

(iv) Magnification is always positive. ½+½+½+½

[CBSE Marking Scheme, 2015]

R Q. 8. **State two laws of reflection of light.**

[Delhi Comptt. 31/1/3 2017]

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

(ii) The angle of incidence is equal to the angle of reflection. 1 + 1

U Q. 9. **A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal ? Why ?**

Ans. The light ray bends towards the normal when a ray of light travels from an optically rarer medium to an optically denser medium. Since water is optically denser than air, a ray of light travelling from air into water will bend towards the normal. 2

R Q. 10. **State two positions in which a concave mirror produces a magnified image of a given object. List two differences between the two images.**

[Board Term II Delhi Set I, 2016]

OR

List two possible ways in which a concave mirror can produce a magnified image of an object placed in front of it. State the difference, if any, between these two images.

[Board Term II Outside Delhi Set I, 2014]

Ans. (i) When the object is placed in front of the mirror :

(a) between its pole and focus ½

(b) between the focus and centre of curvature ½

(ii) In case (a) the image is virtual and erect. ½

In case (b) the image is real and inverted. ½

[CBSE Marking Scheme, 2016]

U Q. 11. **Differentiate a real image from a virtual image giving two points of difference.**

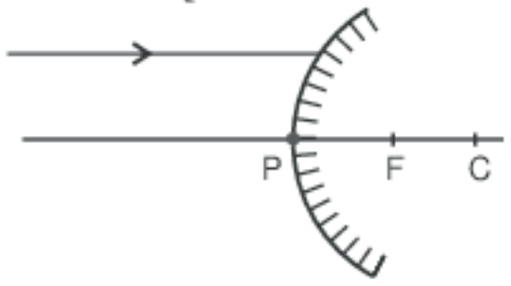
[Board Term II, Set (2021), 2012]

Ans.

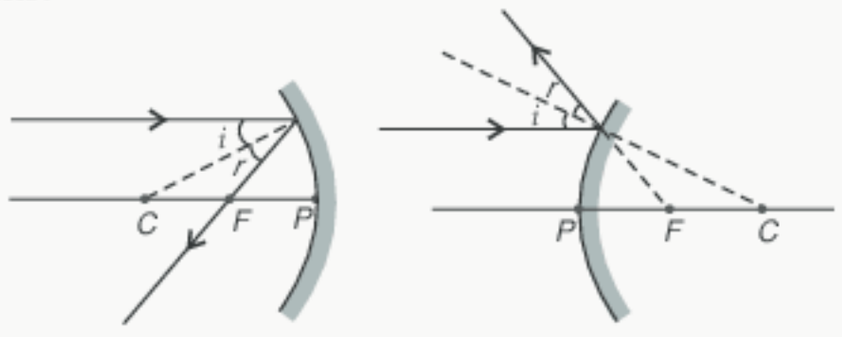
S. No.	Real Image	Virtual Image
(i)	Formed when reflected rays meet.	Formed at a point from which the reflected rays appear to diverge.
(ii)	Image is always inverted.	It is always erect.

[CBSE Marking Scheme, 2012] 1+1

A Q. 12. **A ray of light is incident on a convex mirror as shown. Redraw the diagram and complete the path of this ray after reflection from the mirror. Mark angle of incidence and angle of reflection on it.** **[Board Term II Delhi Set I, 2016]**



Ans.



Tracing the reflected ray 1

Marking $\angle i$ & $\angle r$ ½+½

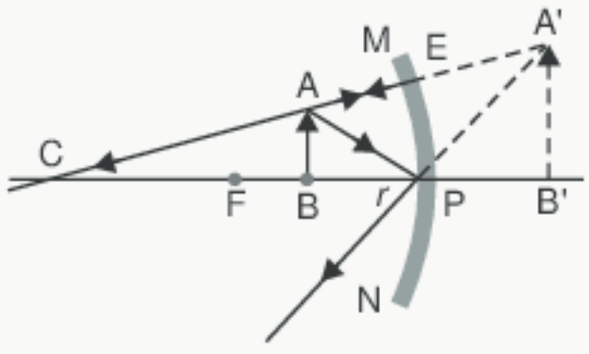
[CBSE Marking Scheme, 2016]

A Q. 13. **The linear magnification produced by a spherical mirror is +3. Analyse this value and state the (i) type of mirror and (ii) position of the object with respect to the pole of the mirror. Draw ray diagram to show the formation of image in this case.**

[Board Term II Foreign Set II, 2016]

Ans. (i) Concave mirror ½

(ii) Between the pole and focus. ½

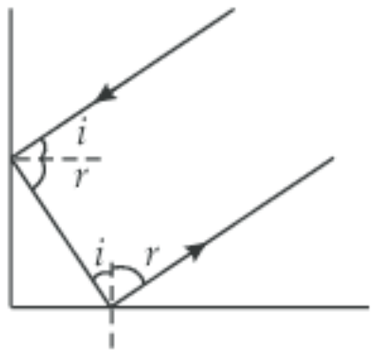


1

[CBSE Marking Scheme, 2016]

A Q. 14. **Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.** **[NCERT Exemplar 2017]**

Ans. When two plane mirrors are placed at right angle to each other then incident and reflected rays will always be parallel to each other.



1 + 1

A Q. 15. **"The magnification produced by a spherical mirror is – 3". List four informations you obtain from this statement about the mirror/image.**

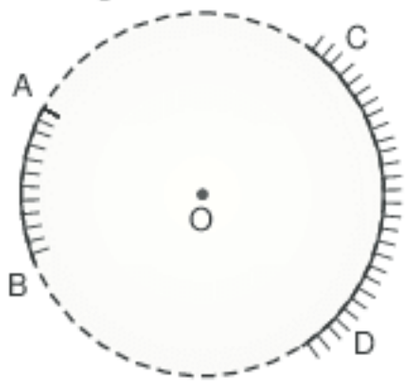
[Board Term II, O.D. Set I, 2016]

Ans. (i) Inverted image (ii) Magnified
(iii) Concave mirror (iv) Real image

[CBSE Marking Scheme, 2016] ½ × 4 = 2

A Q. 16. **AB and CD, two spherical mirrors, form parts of a hollow spherical ball with its centre at O as shown in the diagram. If arc AB = $\frac{1}{2}$ arc CD, what is the ratio of their focal lengths ? State which of the two mirrors will always form virtual image of an object placed in front of it and why.**

[Board Term II Foreign Set I, 2016]



Ans. Focal length of both the mirrors will be the same
1 : 1 1

Mirror AB will always form virtual image as it is a diverging / convex mirror. ½ + ½

[CBSE Marking Scheme, 2016]

R Q. 17. **Name the type of mirrors used in the design of solar furnaces. Explain how high temperature is achieved by this device.**

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

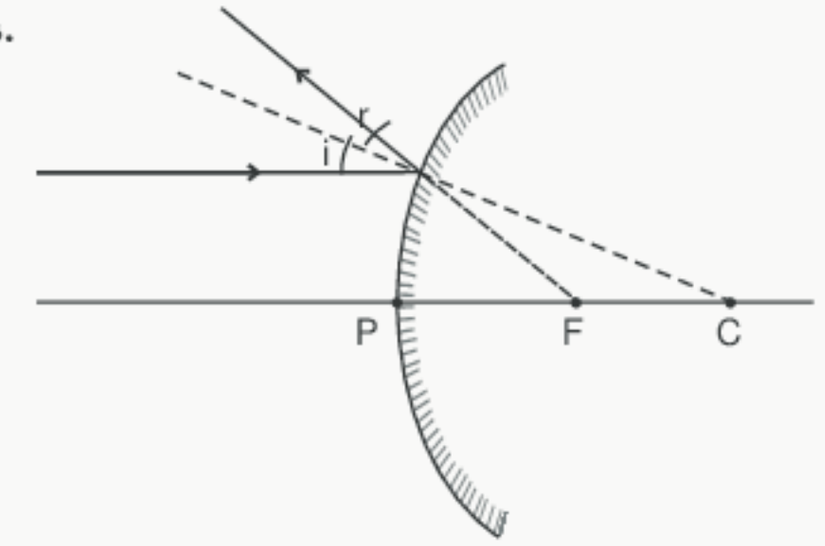
Ans. (i) Concave Mirrors / Converging Mirrors. ½
(ii) When a solar furnace is placed at the focus of a large concave mirror/ reflector, it focuses a parallel beam of light on the furnace, consequently a high temperature is achieved after some time.

[CBSE Marking Scheme, 2016] 3 × ½ = 1½

A Q. 18. **Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray of light parallel to the principal axis of a convex mirror and show the angle of incidence and angle of reflection on it.**

[Board Term II, O.D. II, 2015]

Ans.

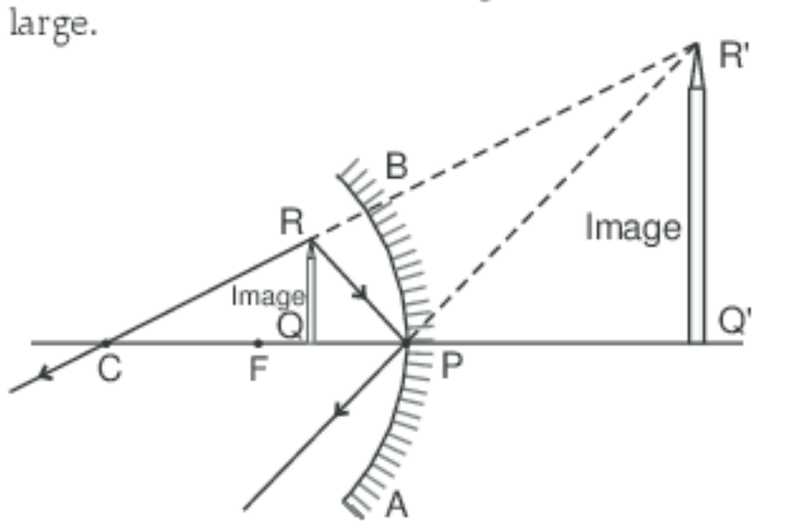


[CBSE Marking Scheme, 2015] 2

A Q. 19. **The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object relative to the mirror ? Draw ray diagram to justify your answer.**

[Board Term II, Outside Delhi Set II, III, 2014]

Ans. When the object is located between the focus (F) and the pole (P) of the mirror, the image is formed behind the mirror; this image is virtual, erect and large. 1

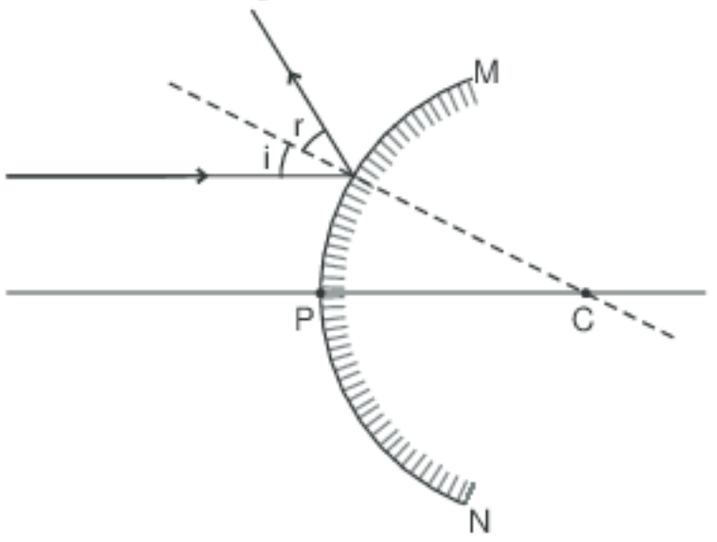


1

A Q. 20. **Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed parallel to the principal axis of a convex mirror. Mark on it the angle of incidence and the angle of reflection.**

[Board Term II, Delhi Set I, II, 2014]

Ans.

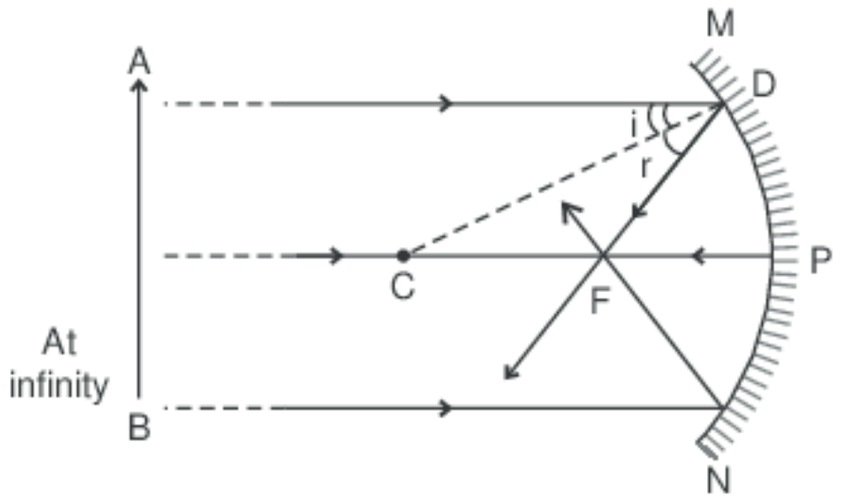


2

A Q. 21. **Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed parallel to the principal axis of a concave mirror. Mark on it the angle of incidence and the angle of reflection.**

[Board Term II, Delhi Set III, 2014]

Ans.



2

A **Q. 21. "A concave mirror of focal length 'f' can form a magnified erect as well as an inverted image of an object placed in front of it." Justify this statement stating the position of the object with respect to the mirror in each case for obtaining these images. [Board Term II O.D. Set I, 2013]**

Ans.

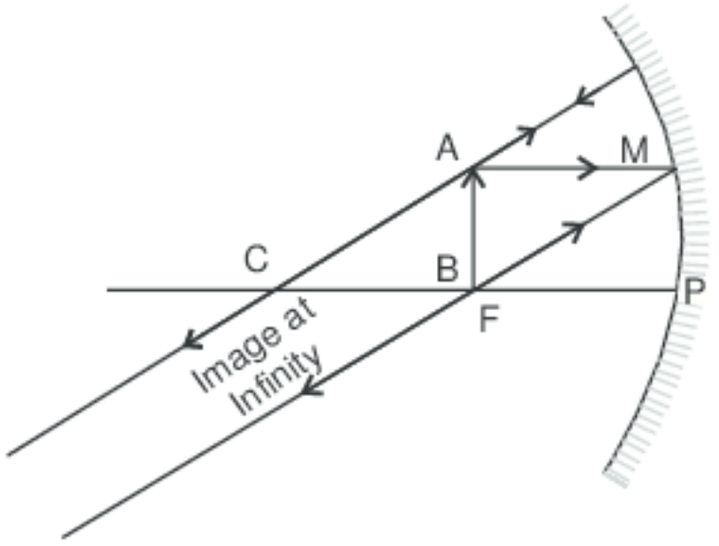


Image formed by a concave mirror with object placed at F **1**

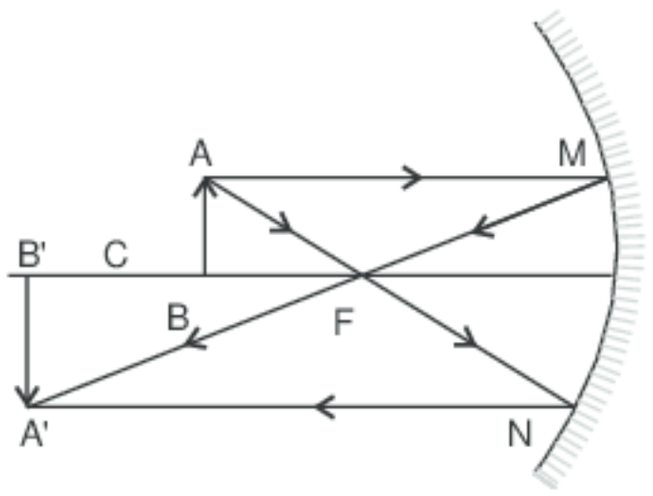


Image formed by a concave mirror with object placed between F and C. **1**

U **Q. 22. An object is placed at a distance of 20 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.**

[Board Term II, Set (2021), 2012]

Ans. $u = -20$ cm, $f = 15$ cm.

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

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

$$\frac{1}{v} = \frac{1}{15} - \frac{1}{20} = \frac{7}{60} \qquad 1\frac{1}{2}$$

$$v = 8{\cdot}57 \text{ cm} \qquad .$$

Nature of the image : Virtual. ½

[CBSE Marking Scheme, 2012]

A **Q. 23. The radius of curvature of a concave mirror is 50 cm. Where should an object be placed from the mirror so as to form its image at infinity ? Justify your answer. [Board Term II, Set (2025), 2012]**

Ans. Here R = 50 cm,

$$f = \frac{R}{2} = \frac{50}{2} = 25 \text{ cm} \qquad 1$$

The object held at focus, that is 25 cm from the mirror, will have its image at infinity. **1**

[CBSE Marking Scheme, 2012]

A **Q. 24. An object is kept at a distance of 5 cm in front of a convex mirror of focal length 10 cm. Calculate the position and nature of the image formed.**

[Board Term II, Set (2013), 2012]

Ans. $u = -5$ cm, $f = 10$ cm, $v = ?$ ½

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

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{(-5)} = \frac{3}{10}$$

or $$v = \frac{10}{3} = 3{\cdot}33 \text{ cm} \qquad ½$$

Nature of image : Virtual and erect. ½

[CBSE Marking Scheme, 2012]

A **Q. 25. An object is placed at a distance of 20 cm in front of convex mirror of radius of curvature 30 cm. Find the position and nature of the image.**

[Board Term II, Set (2025), 2012]

Ans. Here, $u = -20$ cm, $r = 30$ cm

$$f = \frac{R}{2} = \frac{30}{2} = 15 \text{ cm} \qquad ½$$

Using mirror formula and substituting the above values, we get $v = \frac{60}{7}$ cm ½

∴ The image will be formed at a distance of $\frac{60}{7}$ cm behind the mirror. ½

Nature of image : Virtual and erect. ½

[CBSE Marking Scheme, 2012]

Short Answer Type Questions-II

(3 marks each)

A **Q. 1. An object 4 cm in height, is placed at 15 cm in front of a concave mirror of focal length 10 cm. At what distance from the mirror should a screen be placed to obtain a sharp image of the object Calculate the height of the image.**

[Delhi 31/1/1 2017]

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

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

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

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

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

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

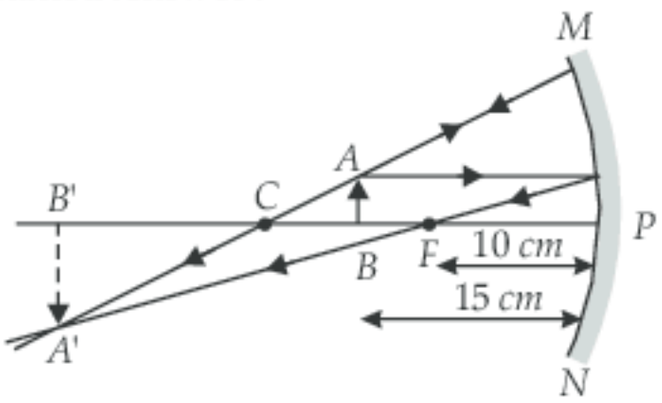
$$\therefore \quad h_2 = -\frac{v}{u} \times h_1$$

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

$$= -8\,cm \quad ½$$

[CBSE Marking Scheme] 1+1

Detailed Answer :



Using the mirror equation,

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

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

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

$$\Rightarrow \quad \frac{1}{v} = \frac{(-15+10)}{150}$$

$$= \frac{-5}{150}$$

$$v = -30\,cm$$

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,

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

$$m = \frac{-30}{-15} = -2$$

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

$$h_i = -8\,cm \quad 3$$

The image height will be 8 cm.

A Q. 2. 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. [Delhi 31/1/2 2017]

Ans. Given, $u = -18, f = -12, u = ?$

Using the mirror equation,

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

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

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

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

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

$$v = -36\,cm$$

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

Also, $m = \frac{h_i}{h_o}$

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

$$-2 = \frac{h_i}{3}$$

$$h_i = -6\,cm$$

The image height will be 6 cm. **3**

A Q. 3. 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. [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 equation,

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

$$\frac{1}{f} = \frac{1}{60} - \left(\frac{1}{-30}\right)$$

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

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

Therefore $f = 20\,cm$

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

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

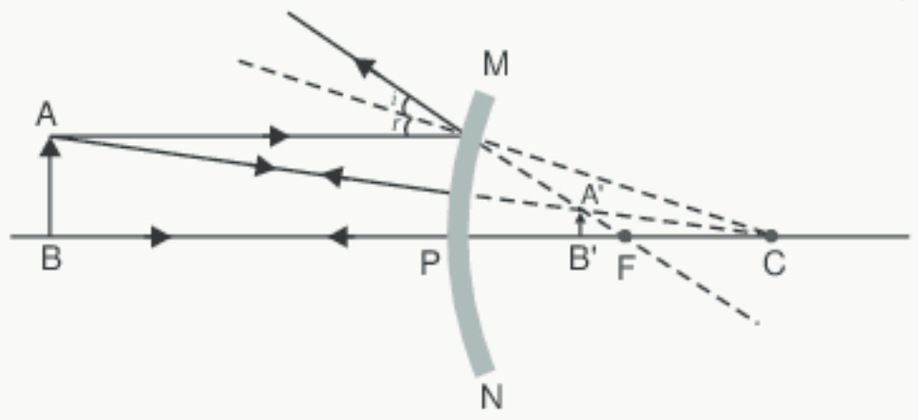
$$h' = \frac{60}{-30} \times 2.4 = -4.8 \text{ cm}$$

The required height of the image is – 4.8 cm

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

A **Q. 4. 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 ? [Board Term II O.D. Set I, 2016]**

Ans. Convex mirror ½



1

Use of convex mirror—as rear view mirror in vehicles. ½

Why—always gives erect image with large field of view. **[CBSE Marking Scheme, 2016]** 1

A **Q. 5. 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. [Board Term II O.D. Set I, 2016]**

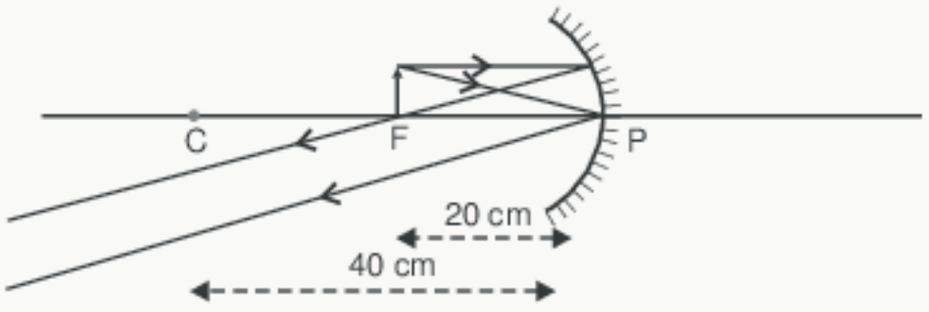
Ans. Object position : At C (Centre of curvature) ½

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)

[CBSE Marking Scheme, 2016]

A **Q. 6. 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 m 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. [Board Term II Foreign Set I, 2015]

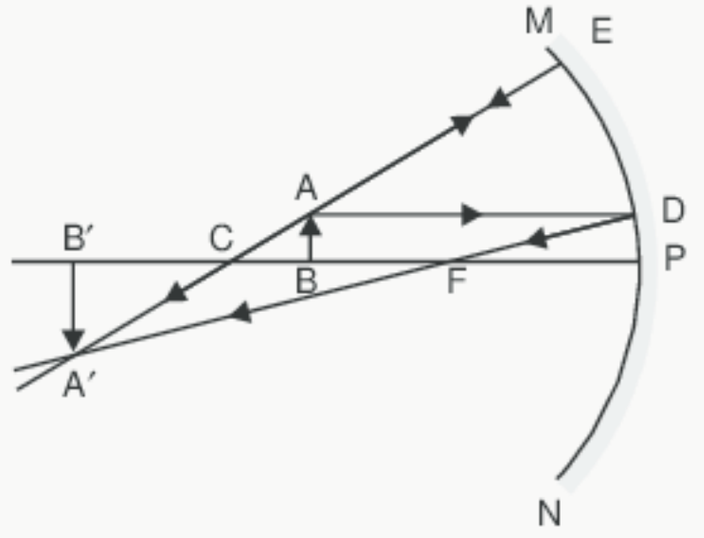
Ans. (i) Concave mirror ½

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

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

(iii) $v - u = 60$ cm ½

(iv)



1

[CBSE Marking Scheme, 2015]

A **Q. 7. 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**

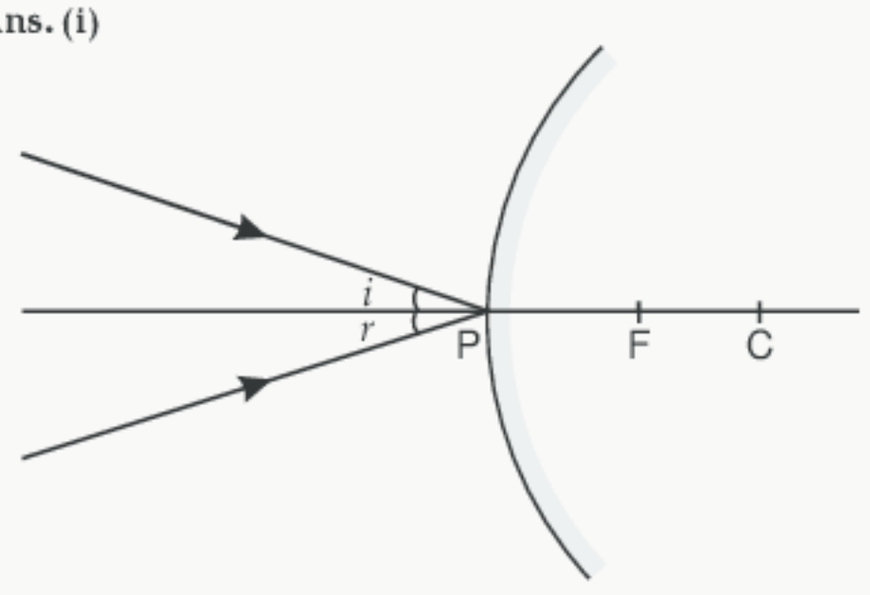
(i) Strikes at its pole making an angle θ from the principal axis.

(ii) Is directed towards its principal focus.

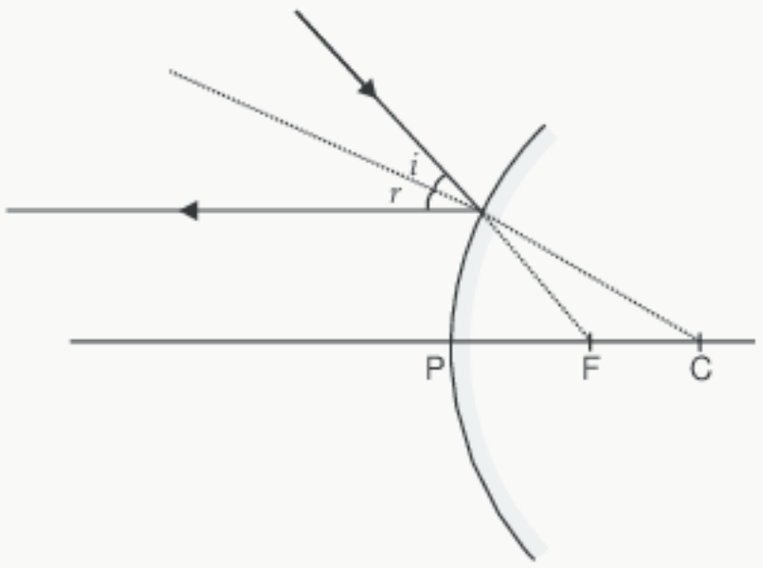
(iii) Is parallel to its principal axis.

[Board Term II, Foreign Set I, 2015]

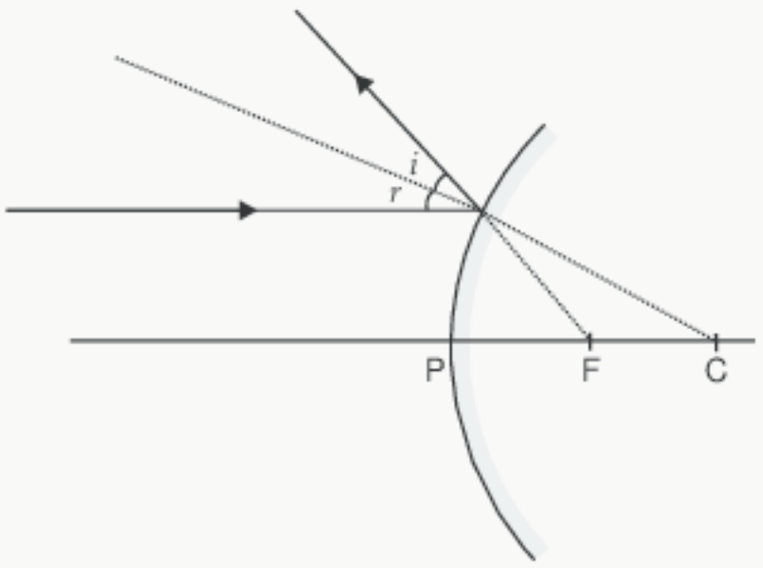
Ans. (i)



(ii)



(iii)



[CBSE Marking Scheme, 2015] 3

A Q. 8. **To construct ray diagrams, two rays of light are generally so chosen that it is easy to determine their directions after reflection from a mirror. Choose two such rays and state the path / direction of these rays after reflection from a concave mirror. Use these two rays to find the position and nature of the image of an object placed at a distance of 8 cm from concave mirror of focal length 12 cm.**

[Board Term II, Delhi Set I, 2015]

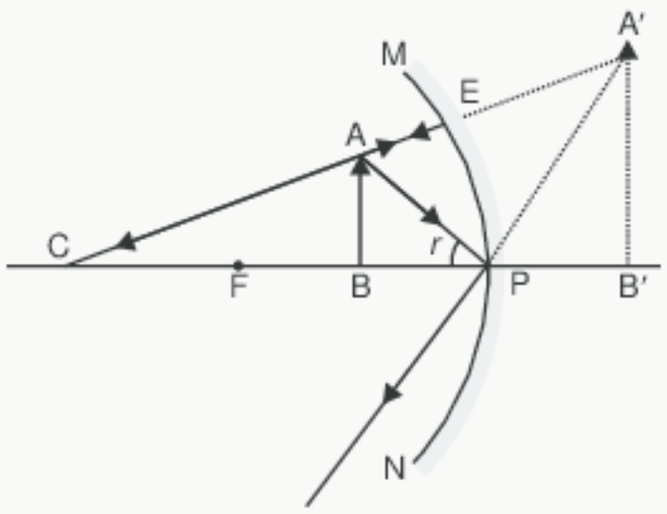
Ans. The candidate may choose any two of the following rays :

(i) A ray parallel to the principle axis, after reflection, will pass through the principle focus of concave mirror.

(ii) A ray passing through the principle focus of a concave mirror after reflection will emerge parallel to the principle axis.

(iii) A ray passing through the centre of curvature of a concave mirror after reflection is reflected back along the same path.

(iv) A ray incident obliquely to the principle axis towards the pole of a concave mirror is reflected obliquely, making equal angles with the principal axis. **(Any two) 1 × 2**



1

[CBSE Marking Scheme, 2015]

Detailed Answer :

Rays which are choose to construct ray diagram for reflection are :

(i) A ray parallel to the principal axis and

(ii) A ray passing through the centre of curvature of a concave mirror or appear to pass through the centre of curvature of convex mirror.

Path of these rays after reflection :

(i) After reflection, it will pass through the principal focus of a concave mirror or appear to diverge in case of a convex mirror.

(ii) After reflection, it is reflected back along the same path.

$f = -12$ cm, $u = -8$ cm

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

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-12} - \frac{1}{(-8)}$$

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

$$= \frac{3-2}{24}$$

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

$v = +ve$, So image is virtual and is formed at a distance of 24 cm behind the mirror. **1+1+1**

U Q. 9. **A student wants to project the image of a candle flame on a screen 60 cm in front of a mirror by keeping the flame at a distance of 15 cm from its pole.**

(i) Write the type of mirror he should use.

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

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

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

[Board Term II, Outside Delhi Set I, 2014]

Ans. (i) He should use a concave mirror, as it forms a real image on the same side of the mirror.

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

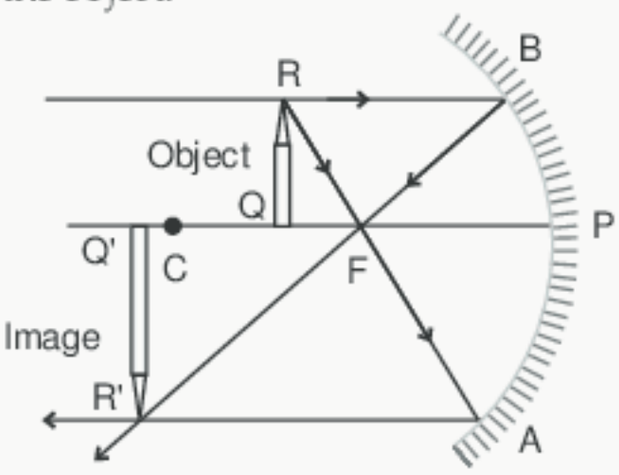
Image distance, $v = -60$ cm

Magnification, $m = -v/u = -(-60)/(-15) = -4$ cm,

The minus sign in magnification shows that the image formed is real and inverted.

(iii) The image is formed at a distance of 45 cm from the object.

(iv)



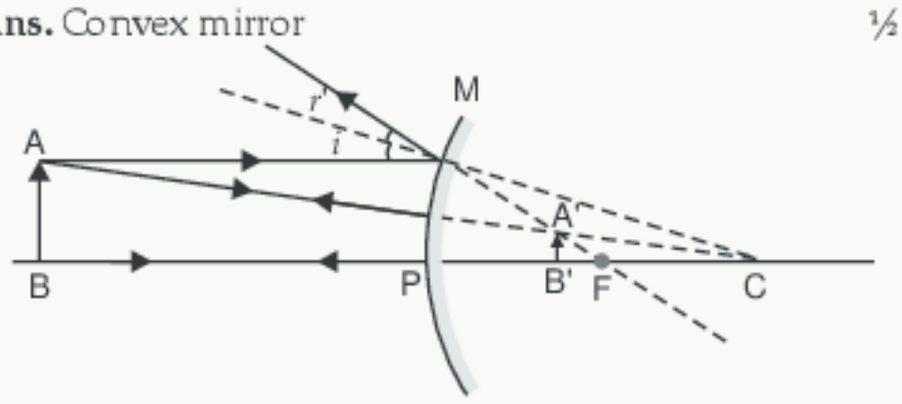
In this case, the image is formed beyond the centre of curvature. This image is real, inverted and enlarged.

[CBSE Marking Scheme, 2014] 1+1+1

A **Q. 10. If the image formed by a mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it ? Draw a ray diagram to justify your answer. Where and why do we generally use this type of mirror ?**

[Board Term II O.D. Set I, 2015]

Ans. Convex mirror ½



N 1

Use : As rear view mirror in vehicles / Also in Malls, Hotels, Airports for security reasons. ½

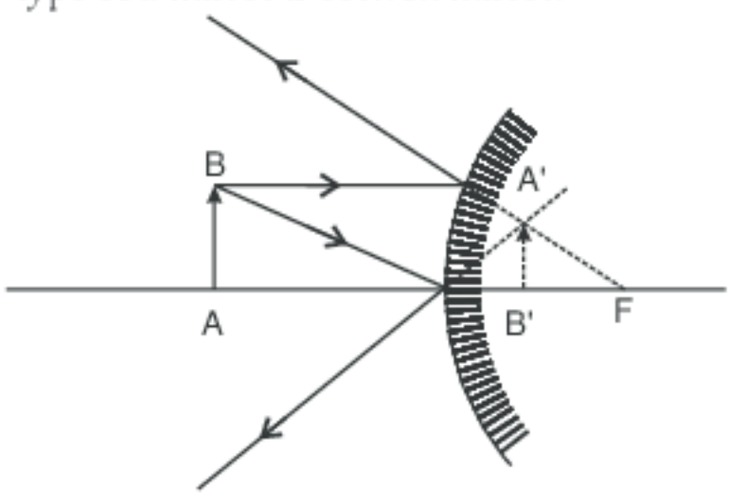
Why : (i) Forms erect image, ½

(ii) Wider field of view. ½

[CBSE Marking Scheme, 2015]

Detailed Answer :

The type of a mirror is convex mirror.



Convex mirror can be used as rear–view mirrors in automobiles because it gives a wider field of view as the mirror is curved outward. It produces erect and diminished image of the traffic behind the driver of the vehicle. **1+2**

U **Q. 11. A student wants to project the image of a candle flame on a screen 48 cm in front of a mirror by keeping the flame at a distance of 12 cm from its pole.**

(i) Suggest the type of mirror he should use.

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

(iii) How far is the image from its object ?

(iv) Draw ray diagram to show the image formation in this case. [Board Term II, O.D. Set II, III, 2014]

Ans. (i) He should use a concave mirror, as it forms a real image on the same side of the mirror.

(ii) Object distance, $u = -12$ cm

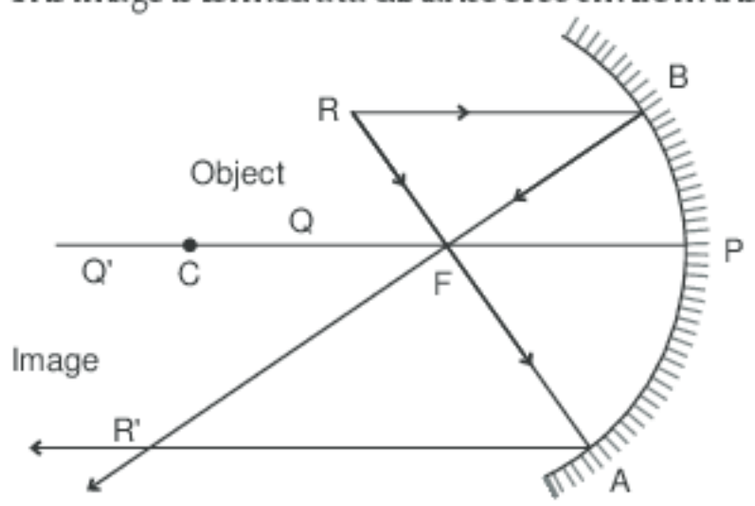
Image distance, $v = -48$ cm

Magnification, $m = -v/u = -(-48)/(-12) = -4$

The minus sign in magnification shows that the image formed is real and inverted.

(iii) The image is formed at a distance of 36 cm from the object.

(iv)



In this case, the image is formed beyond the centre of curvature. This image is real, inverted and enlarged. ½+1+½+1

A **Q. 12. (i) A concave mirror produces three times enlarged image of an object placed at 10 cm in front of it. Calculate the focal length of the mirror.**

(ii) Show the formation of the image with the help of a ray diagram when object is placed 6 cm away from the pole of a convex mirror.

[Board Term II, Set (2007), 2012]

Ans. (i) $m = -\frac{v}{u}$; $u = -10$ cm

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

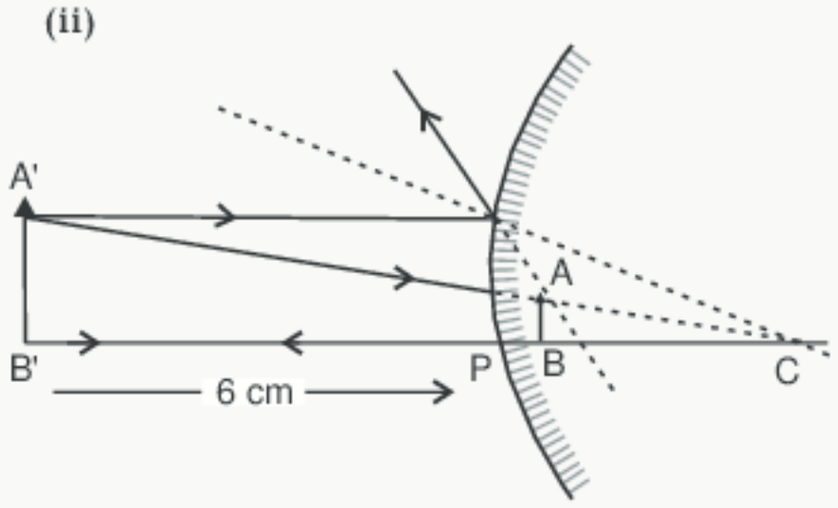
$v = +30$ ½

$= +3 \times -10 = -30$ cm

$$-\frac{1}{30} - \frac{1}{10} = \frac{1}{f}$$ 1

$f = -7{\cdot}5$ cm ½

(ii)



[CBSE Marking Scheme, 2012] 1

U **Q. 13. A spherical mirror produces an image of magnification – 1 on a screen placed at a distance of 50 cm from the mirror.**

(i) Write the type of mirror.

(ii) Find the distance of the image from the object.

(iii) What is the focal length of the mirror?

(iv) Draw the ray diagram to show the image formation in this case. [Board Term II Delhi Set I, II, III, 2014]

Ans. (i) As magnification is negative, the image formed is real.

Hence, it is a concave mirror.

(ii) $m = -v/u = -1$

$\therefore$ $u = v = -50$ cm

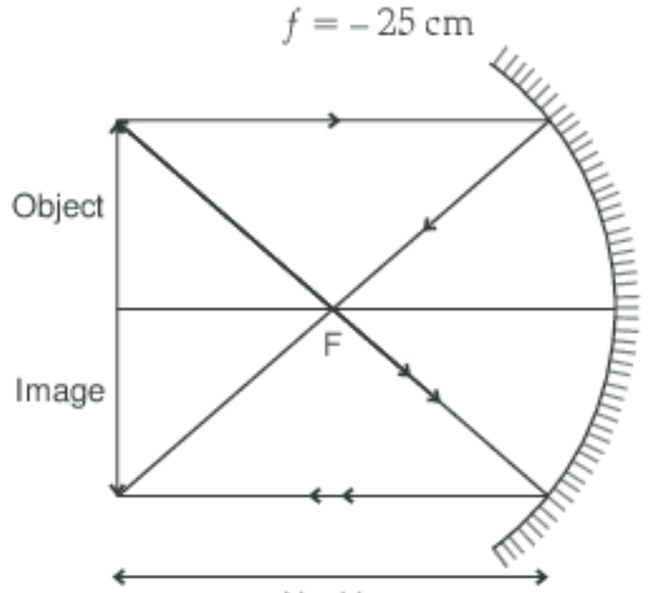
Distance of the image from the object

$$v - u = -50 - (-50) = 0 \text{ cm}$$

(iii) By using mirror formula :

$$1/f = 1/v + 1/u$$
$$= 1/(-50) + 1/(-50) = -1/25$$
$$\therefore \quad f = -25 \text{ cm}$$

(iv)



N = V 1+1+1

U **Q. 14. Rohit wants to have an erect image of an object, using a converging mirror of focal length 40 cm.**

(i) Specify the range of distance where the object can be placed in front of mirror. Give reason for your answer.

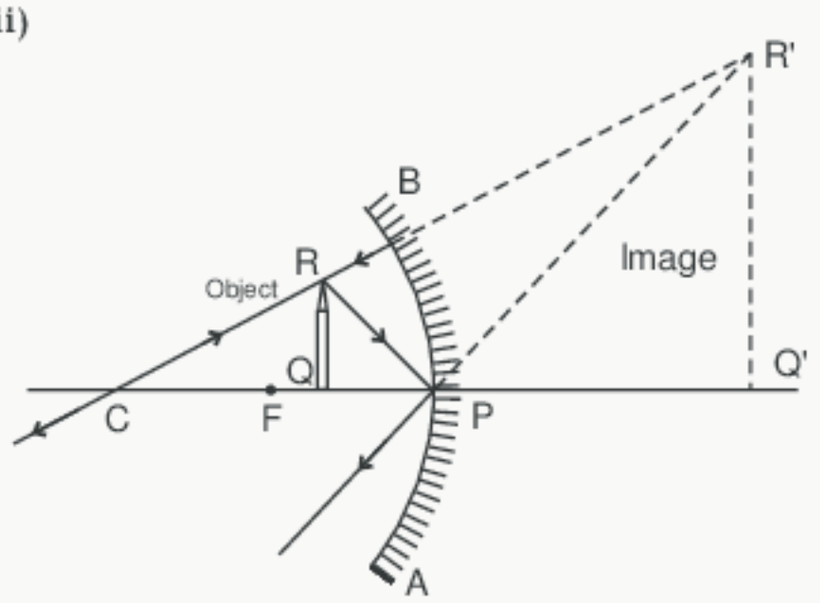
(ii) Will the image be bigger or smaller than the object ?

(iii) Draw a ray diagram to show the image formation in this case. [Board Term II, Set 8XSVHLC, 2014]

Ans. (i) Object should be placed at <40 cm (Less than 40 cm) in front of the mirror, *i.e.* between focus and pole, as concave mirror forms a virtual, erect and magnified image when object is placed between focus and pole.

(ii) Image will be bigger than the object.

(iii)



[CBSE Marking Scheme, 2014] 1+1+1

U **Q. 15. Name the type of mirror used in the following situations :**

(i) Headlights of a car

(ii) Rear–view mirror of vehicles

(iii) Solar furnace

Support your answer with reasons.

[Board Term II Foreign 2013]

Ans. Type of mirror used in :

(i) Headlights of a car : Concave mirror

Concave mirror is used because light from the bulb placed at the focus of it gets reflected and produces a powerful parallel beam of light to illuminate the road.

(ii) Rear view mirror of vehicles : Convex mirror

Convex mirror is used because it always produces a virtual and erect image whose size is smaller than the object. Therefore, it enables the driver to see wider field of view and traffic behind the vehicle in a small mirror.

(iii) Solar furnace : Concave mirror

Concave mirror has the property to concentrate the sunlight coming from sun along with heat radiation at its focus. As a result, temperature at its focus increases and the substance placed at the focal point gets heated to a high temperature. **1+1+1**

A **Q. 16. Mention the types of mirrors used as (i) rear view mirrors (ii) shaving mirrors. List two reasons to justify your answers in each case.**

[Board Term II Delhi Set I, 2013]

Ans. (i) A convex mirror always forms an erect, virtual and diminished image of an object placed anywhere in front of it. Thus, convex mirrors enable the driver to view much larger traffic behind him that would not be possible with a plane mirror.

(ii) A concave mirror is used as a shaving or make-up mirror because it forms an erect and enlarged image of the face when it is held closer to the face.

1½ + 1½

A **Q. 17. (i) Name the spherical mirror used as :**

(a) Shaving mirror

(b) Rear view mirror in vehicles

(c) Reflector in search-lights.

(ii) Write any three differences between a real and a virtual image. [Board Term II, Set (2017), 2012]

Ans. (i) (a) Shaving mirror– Concave mirror ½

(b) Rear view mirror – Convex mirror ½

(c) Reflector in search-lights – Concave mirror ½

(ii)(a) Real image can be obtained on screen but virtual image cannot be obtained. ½

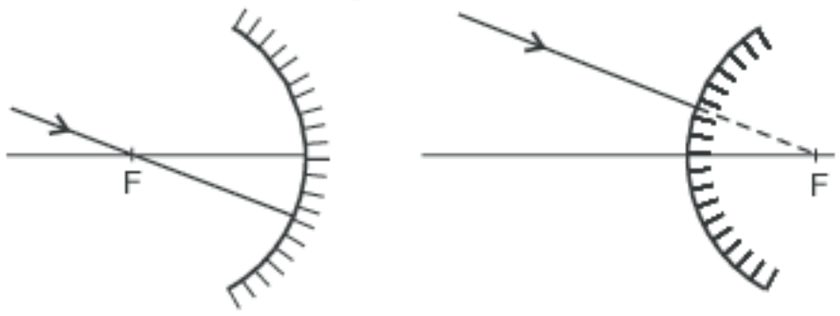
(b) Reflected / Refracted rays actually meet where real image is formed while for virtual they only appear to meet. ½

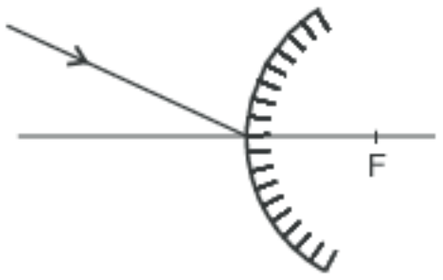
(c) Real image is always inverted while virtual image is always erect. ½

[CBSE Marking Scheme, 2012]

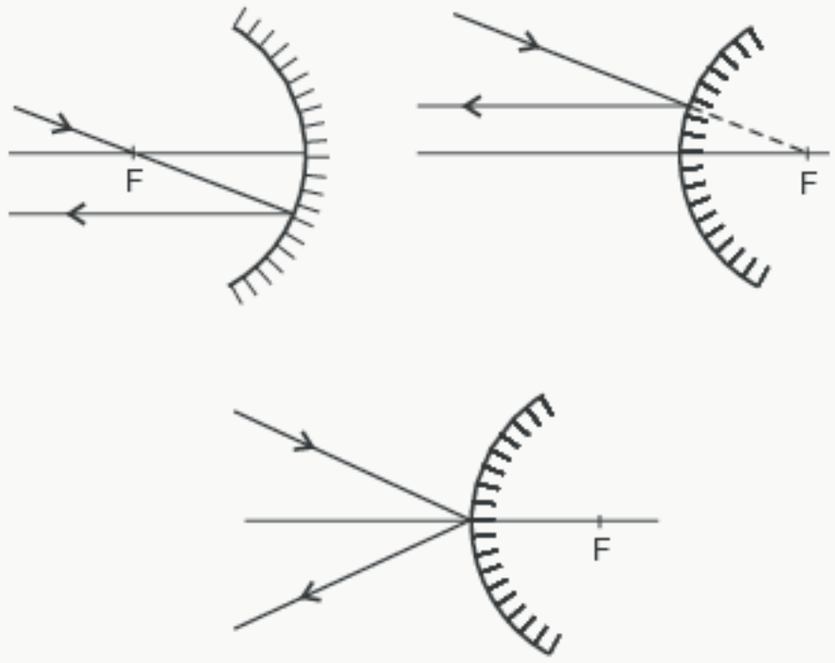
U **Q. 18. Draw the following diagram, in which a ray of light is incident on a concave/convex mirror, on your answer sheet. Show the path of this ray, after reflection, in each case.**

[Board Term II Delhi Set I, 2016]





Ans.



[CBSE Marking Scheme, 2016] 3 × 1 = 3

R **Q. 19. 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 length of the mirror. [Delhi Comptt. 31/1/1 2017]**

Ans. (a) 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]

Long Answer Type Questions

(5 marks each)

R **Q. 1. (a) Define the following terms in the context of spherical mirrors :**

(i) Pole (ii) Centre of curvature

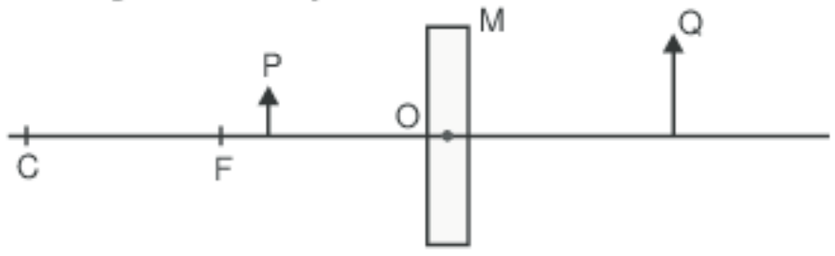
(iii) Principal axis (iv) Principal focus

(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.

[Board Term II Delhi Set I, 2016]

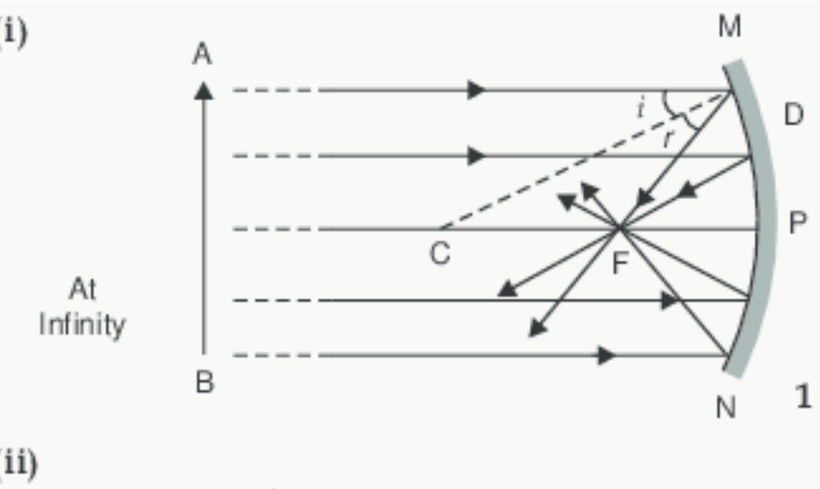
Ans. (a) (i) Pole – Centre of the reflecting surface of the mirror.

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

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

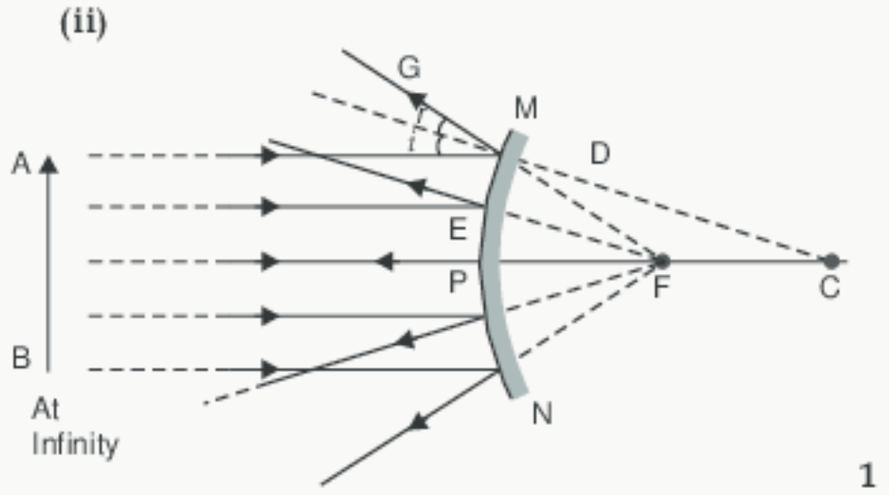
(iv) Principal focus – Incident rays parallel to principal axis, after reflection, either converge to or appear to diverge from a fixed point on the principal axis called principal focus of the spherical mirror. 4×½

(b) (i)



1

(ii)



1

(iii) Concave mirror ½

Image formed is virtual. ½

[CBSE Marking Scheme, 2016]

A **Q. 2. (a) To construct a ray diagram we use two 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? [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 $= -3$

$$m = \frac{v}{-u} \qquad ½$$

$$\therefore \quad v = -m^*(-u) \qquad ½$$

$$= -(-3)^*(-20\text{ cm}) = -60\text{ cm} \qquad ½$$

Distance between the object and the screen is 40 cm

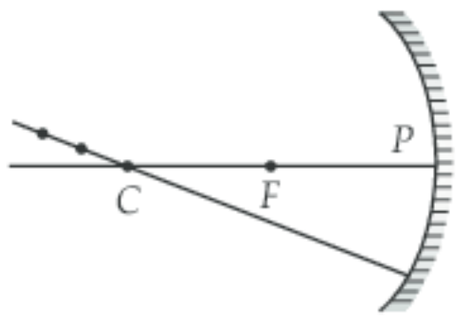
$= -60$ cm $-(-20$ cm$) = -40$ cm ½

[CBSE Marking Scheme, 2017]

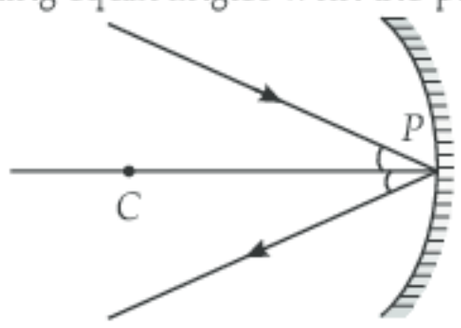
Detailed Answer :

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

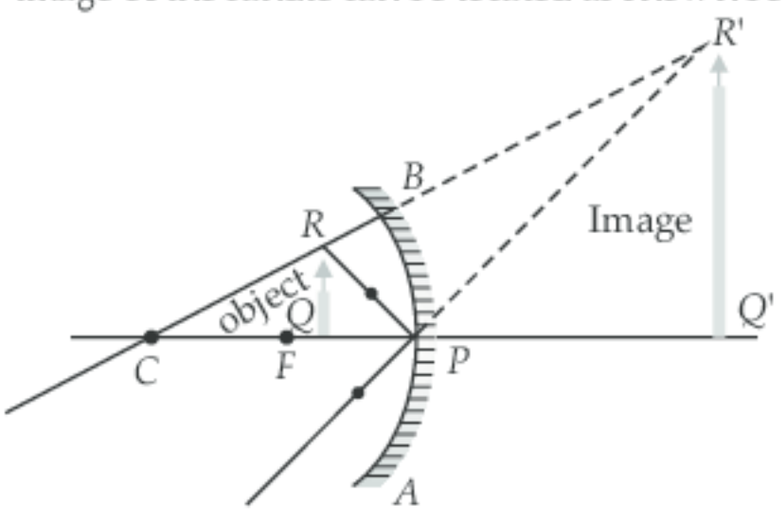
(a) The incident ray passes through the centre of curvature : In this case, light after reflecting from the concave mirror moves back in the same path. This happens because light is incident perpendicular on the mirror surface.



(b) 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 angles 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**

(iii) 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 mirrors at a distance of 60 cm from the pole of the mirror. Thus, the screen is placed 40 cm away from the object. 2

A Q. 3. 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 distance 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.

[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

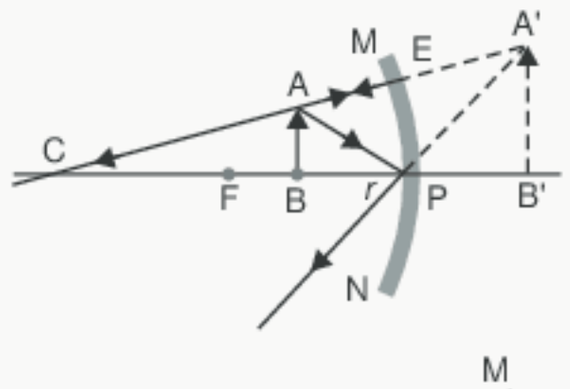
(i) $m = -1$ means $u = 2f$, for A $\rightarrow u_2$, for B $\rightarrow u_3$

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)



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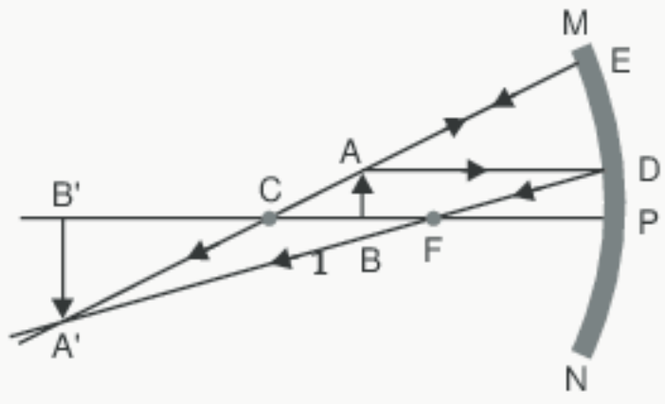


1

[CBSE Marking Scheme, 2016]

A 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 such mirrors are put to and why.

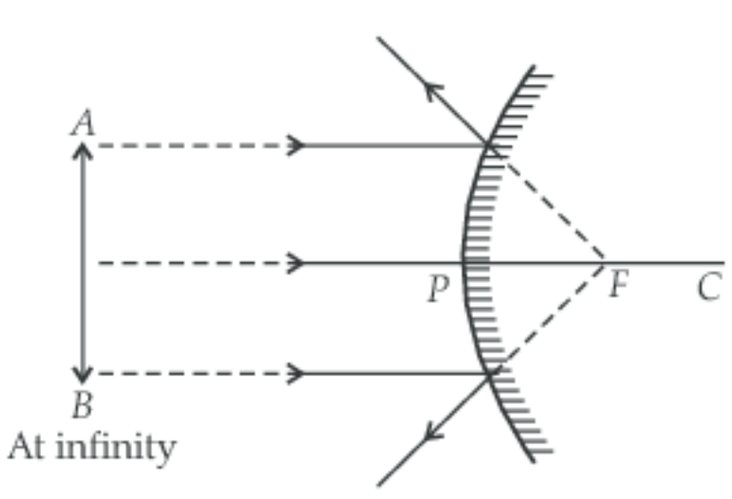
(b) Define the radius of curvature of spherical mirrors. Find the nature and focal length of a spherical mirror whose radius of curvature is + 24 cm. [OD 31/1 2017]

Ans.

(Topper Answer,2017)

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, though 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, $R = 24\,\text{cm}$

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

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

U **Q. 5. 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.

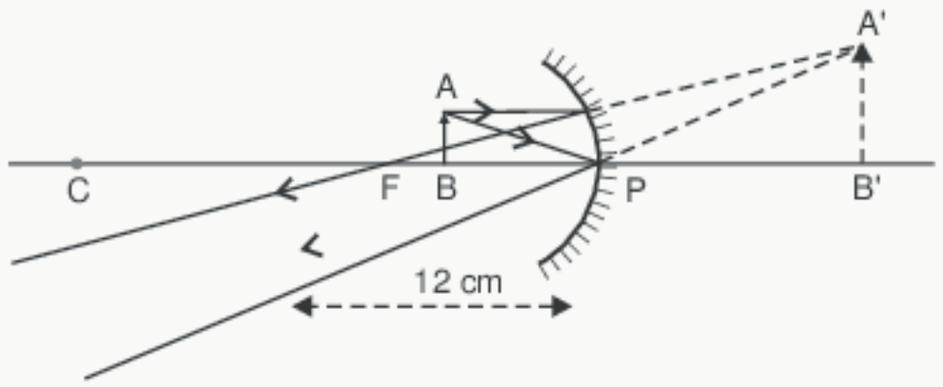
(iii) Where will the image of this object be, if it is placed 24 cm in front of the mirror ? Draw ray diagram for this situation also to justify your answer.

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

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

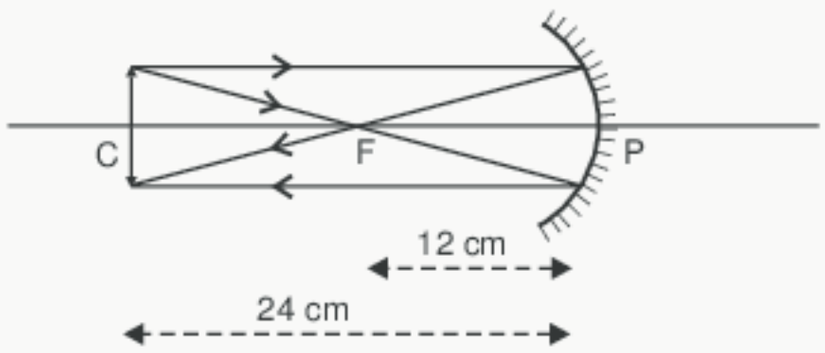
Ans. (i) Range of distance – between 0 cm - < 12 cm **1**

(ii) larger than the object ½



1½

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



[CBSE Marking Scheme, 2016] 1½

OR

[Topper Answer, 2016]

A **Q. 6. A student has focused 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

(ii) Length of the image

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

[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

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

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

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

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

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

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

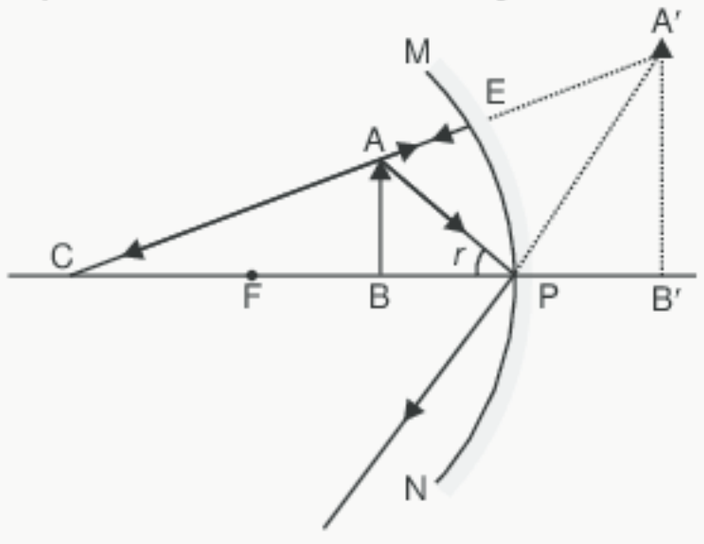
$= \frac{-36\text{cm}}{-18\text{ cm}} \times 1.5 = -3$ cm

(Magnified Inverted image)

(ii) If $u = -10$ cm **1**

No distinct image would be formed on the screen In this case the image formed will be virtual (object will be within focal length) **1**

(iii)



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[CBSE Marking Scheme, 2015]

A **Q. 7. A student wants to project the image of a candle flame on the walls of the school laboratory by using a mirror.**

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

(ii) 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 ?

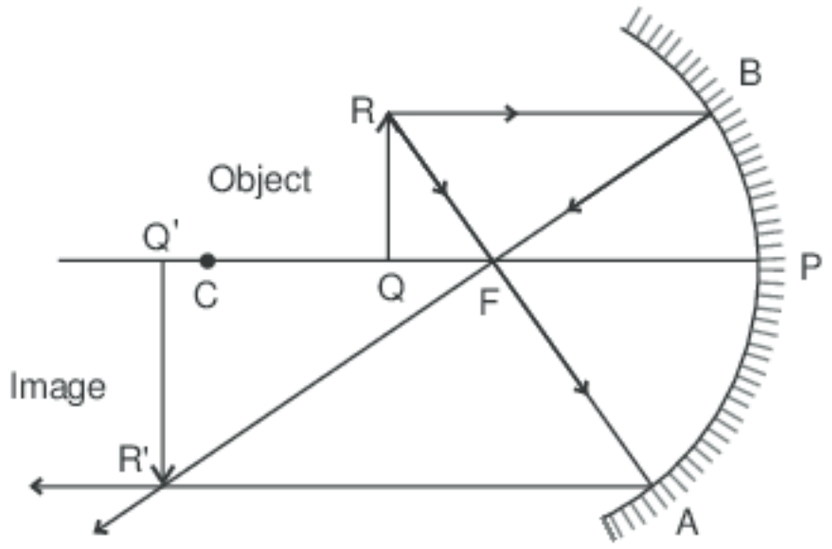
(iii) Draw a ray diagram to show the formation of the image in this case.

(iv) Can he use this mirror to project a diminished image of the candle flame on the same wall ? State 'how' if your answer is 'yes' and 'why not' if your answer is 'no.' [Board Term II, Delhi Set II, 2014]

Ans. (i) He should use a concave mirror as it forms real images.

(ii) He should place the candle flame between the focus and centre of curvature of the mirror to get the magnified image on the wall.

(iii) The ray diagram for the formation of the image is shown below :



(iv) Yes, he can get a diminished image of the candle flame when the object is located at bayonets.

2+1+1+1

A **Q. 8. (i) 4·5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.**

(ii) What kind of mirror is used in a solar furnace ? Give reason for using this mirror.

(iii) One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object ? Justify your answer.

[Board Term II, Set (2022), 2012]

Ans. (i) $u = -12$ cm

$f = +15$ cm

using mirror formula

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

$\Rightarrow \quad \frac{1}{v} = \frac{1}{15} - \frac{1}{-12}$

$\Rightarrow \quad v = \frac{60}{9} = 6{\cdot}7$ cm ½+½

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

$= -6{\cdot}7 / -12 = 0{\cdot}558$

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

$$h_2 = h_1 \times m$$
$$h_2 = 0{\cdot}558 \times 4{\cdot}5$$
$$h_2 = 2{\cdot}5 \text{ cm} \qquad ½+½$$

As the needle is moved farther from the mirror, image moves to the focus and the size of image goes on decreasing. ½+½

(ii) Concave mirrors are used in solar furnaces as they concentrate solar energy in the focal plane and help in attaining high temperatures. **1**

(iii) When one half of a convex lens is covered with a black paper, the lens will produce a complete image of the object but the intensity of the image is reduced because rays from the top portion of the lens only are refracted and forms the image. **1**

[CBSE Marking Scheme, 2012]

A **Q. 9. (i) An object is placed at a distance of 60 cm from a convex mirror where the magnification produced is $\frac{1}{2}$. Where should the object be placed to get a magnification of $\frac{1}{3}$?**

(ii) A small electric lamp is placed at the focus of a convex lens. State the nature of beam of light produced by the lens. Draw a diagram to show this. [Board Term II, Set (2023), 2012]

Ans.(i) $u = -60$ cm, **1**

$$M = +\frac{1}{2}$$

$$m = -\frac{v}{u} - \frac{1}{2}$$

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

$v = 30$ cm **1**

Using mirror formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{60}$$

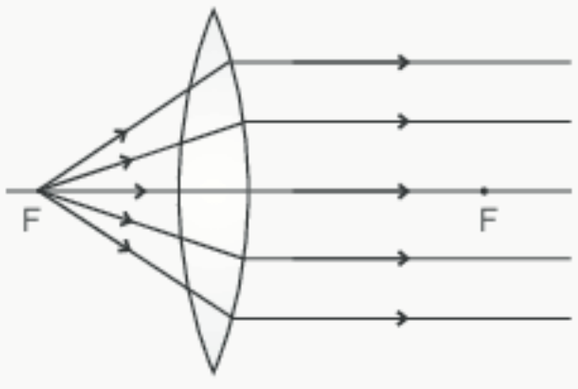
$f = 60$ cm **1**

Now $m = \frac{1}{3} \therefore \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \Rightarrow \frac{1}{-u} + \frac{1}{v} = \frac{1}{60}$

$\therefore \quad u = -60$ cm

(ii) When a small electric lamp is placed at the focus of a convex lens, a parallel beam of light is produced by the lens. **1**

Ray diagram.



1

[CBSE Marking Scheme, 2012]

R **Q. 10. Draw a ray diagram in each of the following cases to show the position and nature of image formed when the object is placed :**

(i) Between pole and focus of a concave mirror.

(ii) Between focus and centre of curvature of a concave mirror.

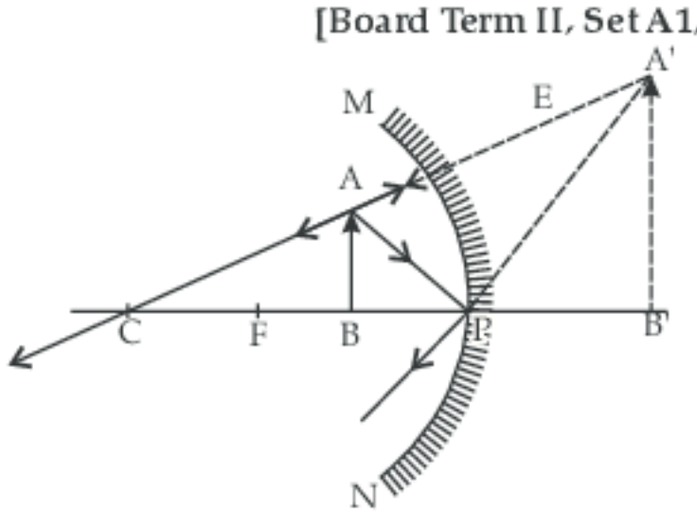
(iii) At the centre of curvature of a concave mirror.

(iv) Between infinity and pole of a convex mirror.

(v) At infinity from a convex mirror.

[Board Term II, Set A1, 2011]

Ans. (i)



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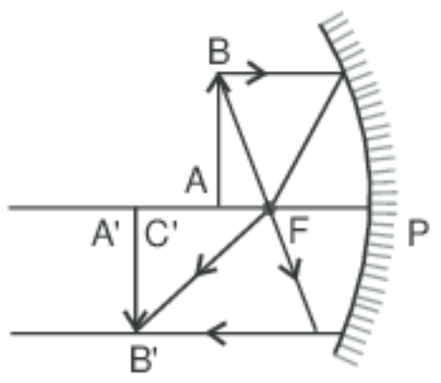
(ii)



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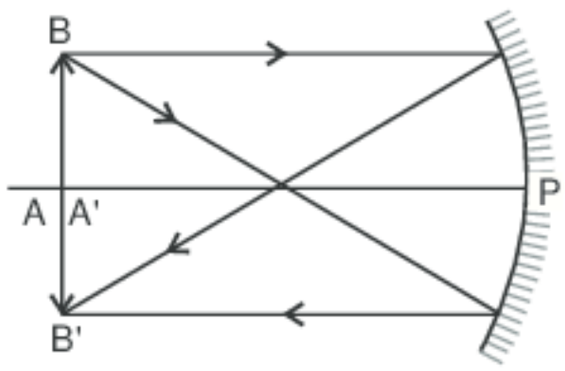
(iii)



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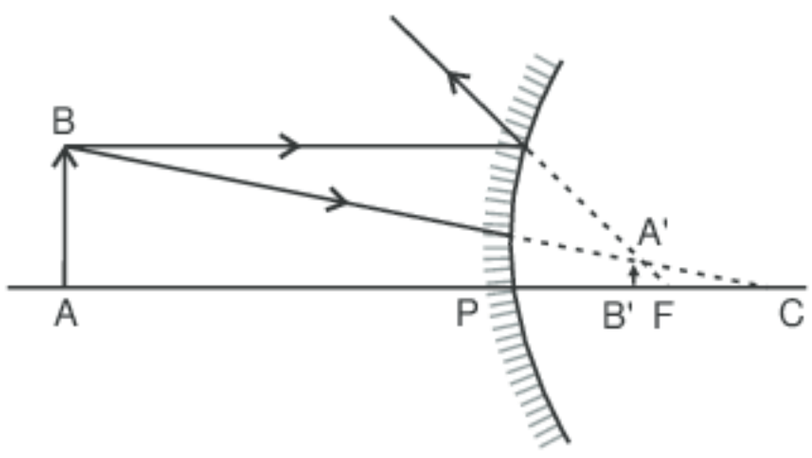
(iv)



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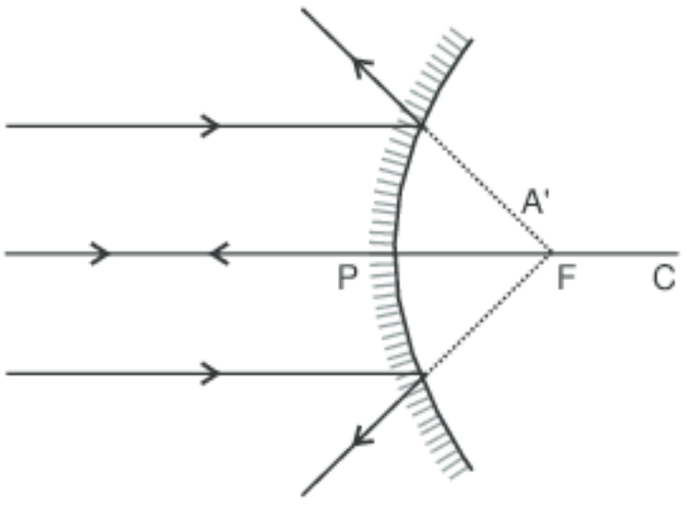
(v)



1

TOPIC-2
Refraction, Lenses, Power of Lens

Very Short Answer Type Questions (1 mark each)

R Q. 1 **What is meant by power of a lens ?**
[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 lens. It is equal to the reciprocal of the focal length (*i.e.*, $P = \frac{1}{f}$)
[CBSE Marking Scheme, 2015] 1

R Q. 2. **Define angle of incidence and angle of refraction.**

Ans. Angle of incidence is the angle i made by the incident ray with the normal. Angle of refraction is the angle r made by the refracted ray in the second medium with the normal. **1**

R Q. 3. **What is the unit of refractive index ?**

Ans. Refractive index being a ratio of two similar quantities and has no unit. **1**

R Q. 4. **Define 1 dioptre of power of a lens.**

Ans. 1 dioptre is defined as the power of a lens of focal length 1 metre.

$$1\,D = 1\,m^{-1}$$

$$P = \frac{1}{f(m)}$$ **1**

R Q. 5. **State a condition for no refraction of light entering from one medium to another.**

Ans. (i) Light incident normally. ½

(ii) Equal refractive index of two media. ½

R Q. 6. **What is the change in image observed as the object is moved from infinity towards the concave lens?**

Ans. The size of the image increases slightly, though it remains diminished in comparison to the size of the object. **1**

U Q. 7. **Why is refractive index of atmosphere different at different altitudes ?**
[Board Term II, Set A1, 2011]

Ans. Refractive index of atmosphere is different at different altitudes because the air density changes with altitudes. **1**

U Q. 8. **How does the size of the image change as the object is brought closer from infinity towards the convex lens ?**

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

A Q. 9. **Do, all cartesian sign conventions are applicable in each case of spherical lens as in mirrors ?**

Ans. Yes, all distances are measured from the optical centre of the lens. Conventionally, the object is placed on the left side of the lens. **1**

R Q. 10. **Why does light change its path as the medium changes during the transit ?**

Ans. Speed of light is different in different media. As the medium changes, the light has to choose a path of minimum time. Hence, the direction of the light changes. This phenomenon is know as refraction of light. **1**

A Q. 11. **Arrange the following common substances in the increasing order of refractive indices, Ice, Kerosene, Glass, Diamond, Alcohol, Water.**

Ans. Order of increasing refractive indices :
Ice, Water, Alcohol, Kerosene, Glass, Diamond. **1**

U Q. 12. **The refractive index of diamond is 2·42. What is the meaning of this statement ?**

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 to its speed in air. **1**

Short Answer Type Questions-I (2 marks each)

R Q. 1. **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 ?**
[Board Term II Delhi Set III, 2016]
[OD Comptt. 31/1 2017] [DDE 2017]

Ans. (i) Ability of lens to converge or diverge the light rays.
(ii) +ve sign ⟶ converging lens/ convex lens ½
−ve sign ⟶ diverging lens/ concave lens ½
(iii) S.I. unit – dioptre ½
1 dioptre = 1/ focal length (m) ½
[CBSE Marking Scheme, 2016]

R Q. 2. **What is meant by power of a lens ? Define its SI unit.** **[Board Term II, Foreign Set I, 2014]**
[Board Term II O.D. Set III, 2013]

Ans. The power of a lens is defined as the reciprocal of its focal length (f) expressed in metres. SI unit of power is dioptre.

One dioptre is defined as the power of a lens whose focal length is 1 metre. 1+½+½

R **Q. 3. State two laws of refraction.[NCERT Exemplar] [Delhi Comptt. 31/1/1 2017]**

Ans. (i) The incident ray, the refracted ray and the normal all lie in the same plane.

(ii) The ratio of sine of angle of incidence in the first medium to the sine of angle of refraction in the second medium is a constant and is known as refractive index of the second medium with respect to the first medium. 1+1

A **Q. 4. An object is placed at a distance of 30 cm from a concave lens of focal length 15 cm. List four characteristics ((nature, positions, etc.) of the image formed by the lens. [OD 31/1 2017]**

Ans. The four characteristics of the image formed by the lens are :

(i) Image will be in between lens and focus

(ii) Formed behind the lens

(iii) Smaller than object

(iv) Virtual Image 2

A **Q. 5. An object is placed at a distance of 15 cm from a convex lens of focal length 20 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. [OD 31/2 2017]**

Ans. Four characteristics will be virtual, magnified, erect and image is formed behind the lens. 2

R **Q. 6. State four characteristics of the image formed by plane mirror.**

Ans. (i) Image distance = Object distance ½

(ii) Size of the image = Size of the object ½

(iii) Image is laterally inverted ½

(iv) Image is always virtual and erect. ½

U **Q. 7. What is meant by the power of a lens ? Give its SI unit. When two or more lenses are placed in contact what will be their combined power ? [Board Term II, Set (2021), 2012]**

Ans. The reciprocal of the focal length of a lens is termed as power of lens. It is expressed in metres. SI unit is dioptre. ½+½

The combined power will be equal to the algebraic sum of their individual powers. 1

[CBSE Marking Scheme, 2012]

A **Q. 8. Mention the kind of lens that can form :**

(i) Real, inverted and magnified image

(ii) Virtual, erect and magnified image

(iii) Real, inverted and diminished image

(iv) Virtual, erect and diminished image.

[Board Term II, Set 8XSVHLC, 2014]

Ans. (i) Convex lens

(ii) Convex lens

(iii) Convex lens

(iv) Concave lens. ½ × 4 = 2

[CBSE Marking Scheme, 2014]

U **Q. 9. Briefly describe an activity to find approximate focal length of a convex lens. [Board Term II, Set GFUTB 86, 2015]**

Ans. The lens is placed along the path of light–either sun rays or through electric lamp.

The rays converge at a point. The distance between converging point and lens is measured which gives the rough focal length of the convex lens. 2

[CBSE Marking Scheme, 2015]

A **Q.10. The absolute refractive indices of glass and water are 4/3 and 3/2 respectively. If the speed of light in glass is 2×10^8 m/s, calculate the speed of light in (i) vacuum, (ii) water. [Board Term II O.D. Set I, 2015]**

Ans. Since, refractive index of glass

$$= \frac{\text{Speed of light in vacuum } (v)}{\text{Speed of light in glass } (o)}$$

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

$$\frac{4}{3} = \frac{v}{2\times10^8}$$

$$v = \frac{4}{3} \times 2 \times 10^8$$

$$= \frac{8}{3} \times 10^8 = 2.6 \times 10^8 \text{ m/s}$$

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

Refractive index of water

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

$$n = \frac{u}{w}$$

$$w = \frac{v}{n} = \frac{3\times10^8}{\frac{3}{2}}$$

$$= \frac{\cancel{3}\times10^8\times2}{\cancel{3}} = 2\times10^8 \text{ m/s} \qquad 2$$

[CBSE Marking Scheme, 2015]

A **Q. 11. 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. [Board Term II O.D. Set III, 2016]**

Ans. $$\text{Refractive index of a medium} = \frac{\text{Speed of light in air}}{\text{Speed of light in the medium}}$$

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

1

$$\text{Speed of light in air} = 3 \times 10^8 \text{ m/s}$$

$$\text{Speed of light in water} = \frac{3 \times 10^8 \text{ m/s}}{4/3} = 2.25 \times 10^8 \text{ m/s} \qquad 1$$

[CBSE Marking Scheme, 2016]

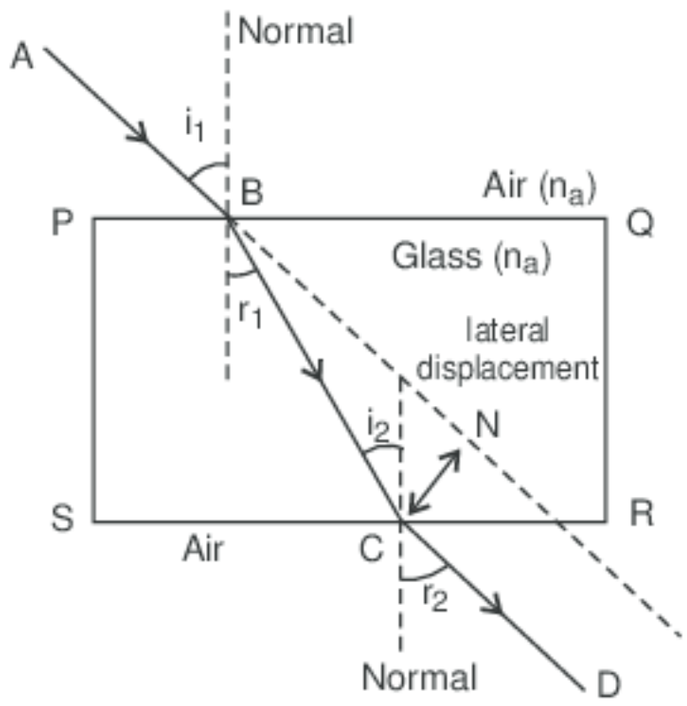
OR

[Topper Answer, 2016]

A **Q. 12. "A ray of light incident on a rectangular glass slab immersed in any medium emerges parallel to itself." Draw a diagram to justify the statement.**

[Board Term II Delhi Set I, 2013]

Ans.



Refraction through a glass slab

The emergent ray CD is parallel to the incident ray AB, but it has been laterally displaced by a perpendicular distance CN with respect to the incident ray. 2

A **Q. 13. For the same angle of incidence in media P, Q and R, the angles of refraction are 45°, 35° and 15° respectively. In which medium will the velocity of light be minimum ? Give reason for your answer. [Board Term II, Set (2022), 2012]**

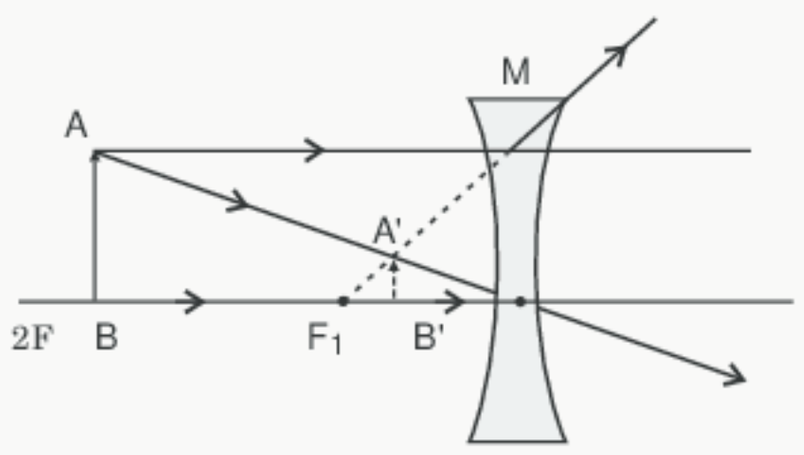
Ans. For the same angle of incidence in media P, Q and R, the angles of refraction is minimum for the medium R. Hence velocity of light would be minimum in R as $\frac{c}{v} = \frac{\sin i}{\sin r}$. **1+1**

[CBSE Marking Scheme, 2012]

A **Q. 14. Draw the ray diagram for the formation of image by a concave lens when the object is placed in between infinity and optical centre of the lens. State the nature of the image formed.**

[Board Term II, Set (2018), 2012]

Ans.



1½

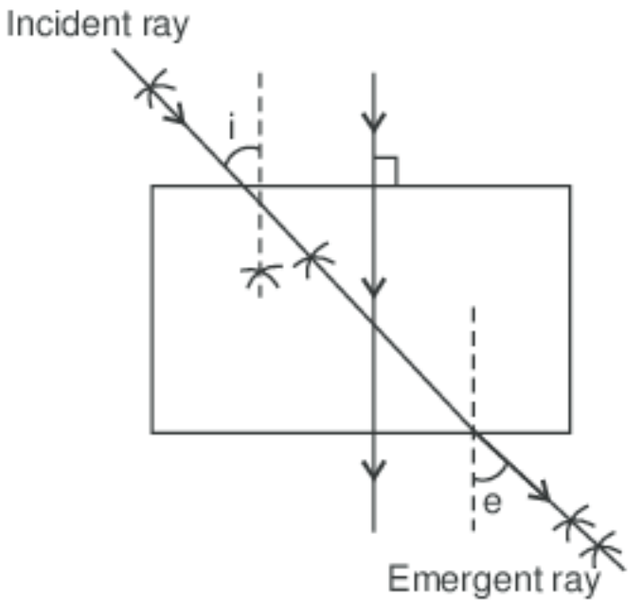
Nature of the image : Virtual and erect. **½**

[CBSE Marking Scheme, 2012]

A **Q. 15. A ray of light falls normally on the surface of a transparent glass slab. Draw a ray diagram to show its path and also mark angle of incidence and angle of emergence.**

[Board Term II Delhi Set I, 2013]

Ans.



$\angle i$ = Angle of incidence = 0° , $\angle e$ = Angle of emergence = 0° 2

A **Q. 16. Light enters from air into glass plate which has refractive index 1·5. Calculate the speed of light in glass (velocity of light in air is 3×10^8 m/s).**

[Board Term II, Set (2016), 2012]

Ans.

$$v_g = \frac{c}{{}_a\mu_g} \quad 1$$

$$= \frac{3\times10^8}{1.5}$$

$$= 2 \times 10^8 \text{ m/sec} \quad 1$$

[CBSE Marking Scheme, 2012]

A **Q. 17. Define absolute refractive index of a medium. Light enters from air to water having refractive index $\frac{4}{3}$. Find the absolute refractive index of a medium if the speed of light in vacuum is 3×10^8 m/s.** **[Board Term II, Set (2026), 2012]**

Ans. Absolute refractive index of a medium

$$= \frac{\text{Velocity of light in vaccum}}{\text{Velocity of light in medium}} \quad 1$$

$$v = \frac{c}{n} = \frac{3\times10^8}{\frac{4}{3}} = 2{\cdot}25 \times 10^8 \text{ m/s} \quad 1$$

[CBSE Marking Scheme, 2012]

A **Q. 18. A convex lens of focal length 10 cm is placed at a distance of 12 cm from a wall. Calculate the distance from the lens where an object can be placed so as to form its distinct real image on the wall.**

Ans. $v = +12$ cm, $f = +10$ cm.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{12} - \frac{1}{u} = \frac{1}{10}$$

$u = -60$ cm. 2

A **Q. 19.** The refractive index of a dense flint glass is 1·65 and for alcohol it is 1·36 with respect to air. Find the refractive index of dense flint glass with respect to alcohol.

[Board Term II, Set (2023), 2012]

Ans.

$${}_{al}\mu_{fl} = \frac{{}_a\mu_{fl}}{{}_a\mu_{al}}$$

$$= \frac{1.65}{1.36} = 1{\cdot}21$$

Refractive index of dense flint glass with respect to alcohol is 1·21. **[CBSE Marking Scheme, 2012]** 2

Short Answer Type Questions-II

(3 marks each)

A **Q. 1. 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.**

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

[DDE 2017]

Ans. (i) There are two laws of refraction :

(a) The ratio of the sin of the angle of incidence to the sin of the angle of refraction is constant. This is known as Snell's law. Mathematically, it can be expressed as :

$$\sin i / \sin r = n_{12}$$

Here, n_{12} is the relative refractive index of medium 1 with respect to medium 2.

(b) The incident ray, the refracted ray and the normal to the interface of two media at the point of incidence lie on the same plane. **1 × 2**

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

$v = 1.4 \times 10^8$ m/s

(ii) Absolute refractive index

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

$$= \frac{3\times10^8 \text{ m/s}}{1.4\times10^8 \text{ m/s}} = 2.14 \quad ½$$

[CBSE Marking Scheme, 2015]

A **Q. 2. State the laws of refraction of light. If the speed of light in vacuum is 3×10^8 m/s, find the speed of light in a medium of absolute refractive index 1·5.** **[Board Term II, Delhi Set I, II, III, 2014]**

Ans. There are two laws of refraction :

Refer S.A.Q. II Q.1.

Given :

Speed of light in vacuum = 3×10^8 m/s

Refractive index of the medium

= Speed of light in vacuum/Speed of light in medium

$\Rightarrow$ $1{\cdot}5 = 3 \times 10^8/v$

$\Rightarrow$ $v = 3 \times 10^8/1{\cdot}5 = 2 \times 10^8$ m/s

Hence, the speed of light in the medium of refractive index 1·5 is 2×10^8 m/s 2+1

U Q. 3. **(i) Define the term magnification. Write the formula for magnification of mirror explaining the symbols used in the formula.**

(ii) The magnification produced by a convex lens is –2. What is meant by this statement and also write the information regarding image obtained from it. [Board Term II, Set QNA4XWT, 2012]

Ans. (i) Ratio of height of the image to height of the object is magnification.

$$M(\text{mirror}) = h^1/h = -v/u$$

M = Magnification

h = Height of object

h^1 = Height of image

v = Image distance

u = Object distance.

(ii) It means image formed is two times the size of object and the image formed is inverted, formed in front of the lens. 2+1

[CBSE Marking Scheme, 2014]

U Q. 4. **Define the power of lens. The power of lens is + 2·0 D.**

(i) Find the focal length of lens in m.

(ii) Name the kind of this lens. Explain with the help of figure whether this lens would converge or diverge a beam of lens.

[Board Term II, Set QNA4XWT, 2014]

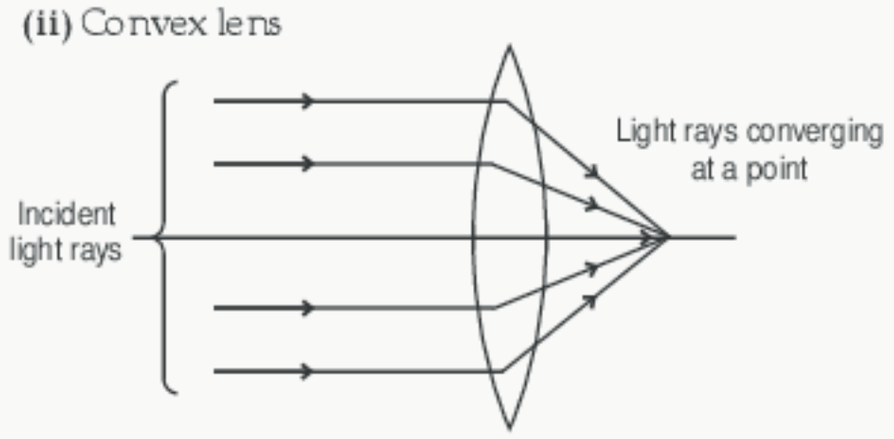
Ans. (i) The ability of a lens to converge/diverge a beam of light rays is expressed in terms of its power (P). It is the inverse of focal length, f (in meters).

Hence, power of a lens is given by the relation

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

$F = 1/P = +1/2 = + 0{\cdot}5$ m

(ii) Convex lens



[CBSE Marking Scheme, 2014] 1+1+1

R Q. 5. **Draw a ray diagram to show that path of the refracted ray in each of the following cases :**

A ray of light incident on a concave lens is

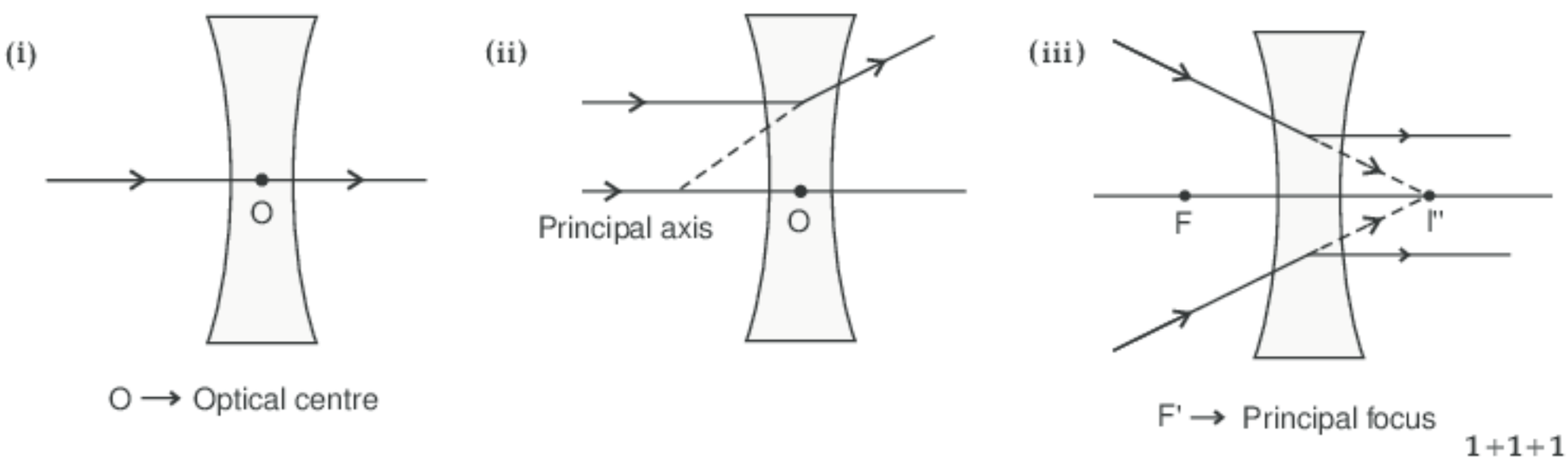
(i) passing through its optical centre.

(ii) parallel to its principal axis.

(iii) directed towards its principal focus.

[Board Term II, Outside Delhi Set I, III, 2014]

Ans.



1+1+1

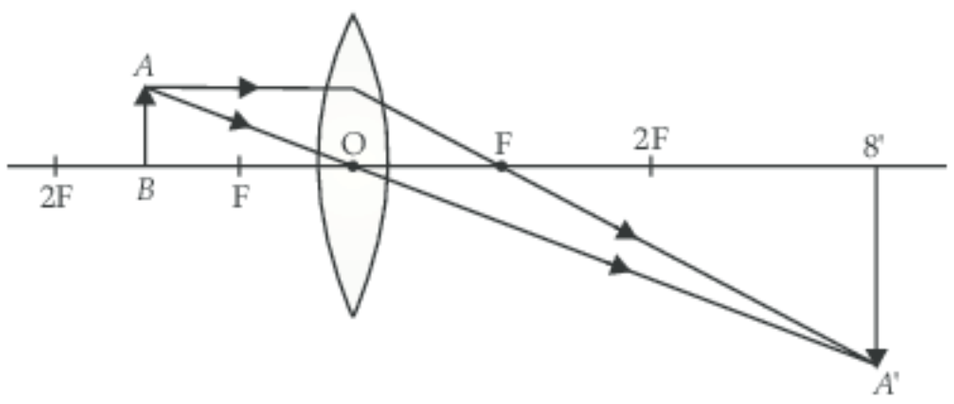
A Q. 6. **If the image formed by a lens for all positions of an object placed in front of it is always erect and diminished, what is the nature of this lens ? Draw a ray diagram to justify your answer. If the numerical value of the power of this lens of 10 D, what is its focal length in the Cartesian system ?** [OD 31/1 2017] 3

Ans.

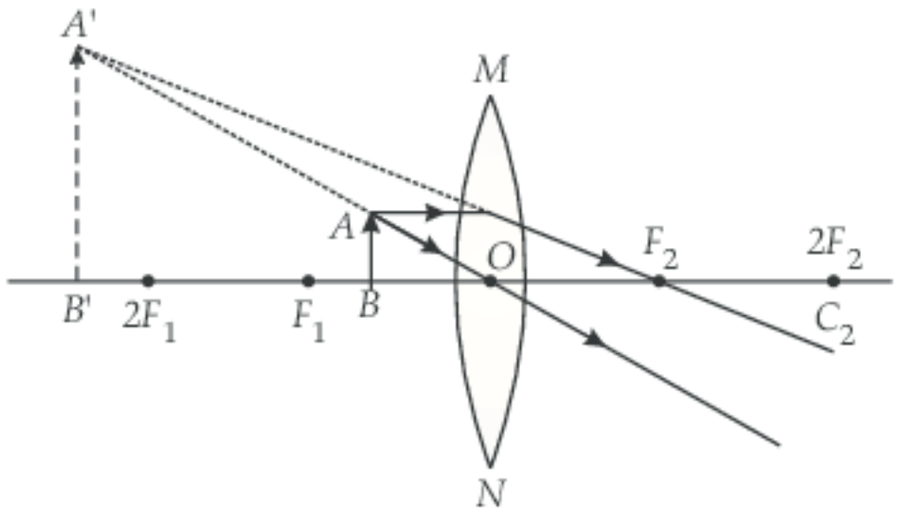
(Topper Answer,2017)

U Q. 7. **Draw ray diagrams to show the formation of three times magnified (a) real, and (b) virtual image of an object by a converging lens. Mark the positions of O, F and 2F in each diagrams.** [OD 31/2 2017]

Ans.



Labelling O, F and 2F



A Q. 8. **An object is placed perpendicular to the principal axis of a convex lens of focal length 8 cm. The distance of the object from the lens is 12 cm. Find the position and nature of the image.** [Delhi Comptt. 31/1/1 2017]

Ans. $u = -12\,\text{cm}, f = +8\,\text{cm}, v = ?$

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

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

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

Image is real and inverted **2 + 1**

A Q. 9. **The image formed by a spherical mirror is real inverted and is of magnification -2. If the image is at 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.** [Board Term II, O.D. Set III, 2016]

Ans.

[Topper Answer, 2016] 3

U Q. 10. (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.

[NCERT Exemplar]

(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)

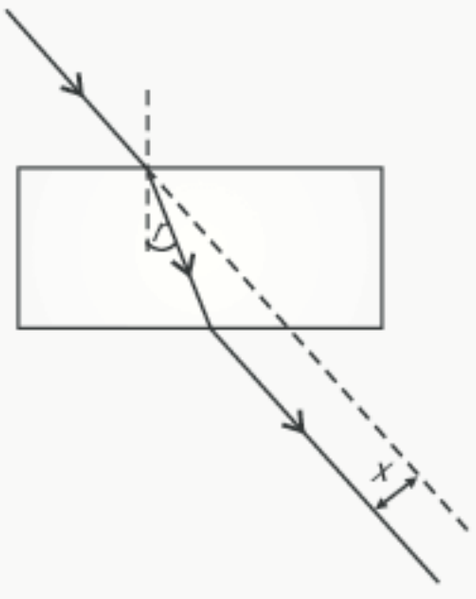


Diagram 1

Marking $\angle r$ and x ½+½

(ii) $${}_{a}n_{g} = \frac{3}{2}$$

$$\therefore \quad {}_{a}n_{g} = \frac{1}{{}_{a}n_{g}} = \frac{1}{3/2} = \frac{2}{3}$$

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

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

[CBSE Marking Scheme, 2016]

A Q. 11. An object of height 5 cm is placed perpendicular to the principal axis of a concave lens of 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.

[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

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

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

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

$$v = \frac{-20}{3} \text{ cm}$$

$$m = \frac{h_1}{h_0} = \frac{v}{u}$$

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

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

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

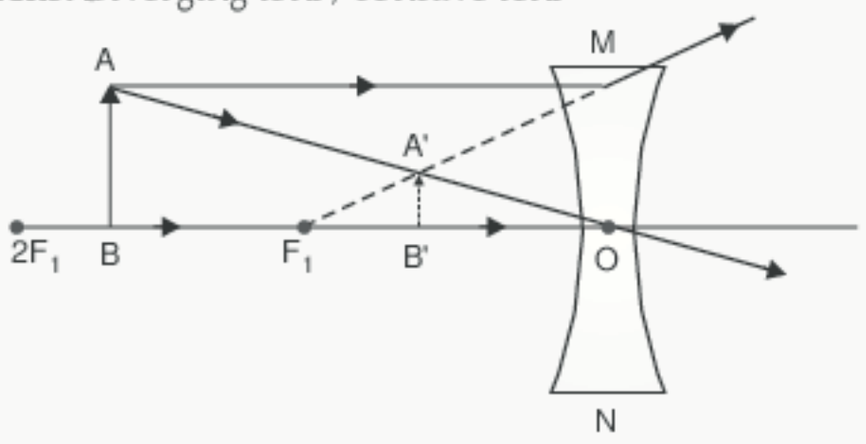
Image is virtual and diminished. 3

[CBSE Marking Scheme, 2015]

A **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.**

[Board Term II Foreign Set I, 2016]

Ans. Diverging lens / concave lens ½



1

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

Power = P
= $1/f$
= $100/-20$ cm
= –5D ½ + ½

[CBSE Marking Scheme, 2016]

A **Q. 13. 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.**

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

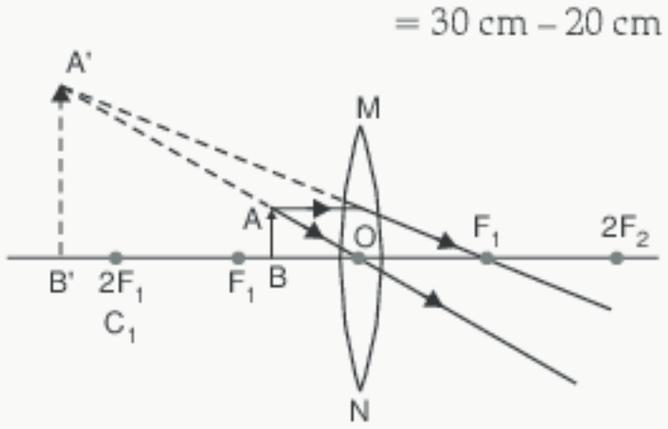
Ans. Image with magnification –1 means image is inverted and of the same size.

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

$\Rightarrow$ $f = 15$ cm

Object distance $2f = 30$ cm, if the object is shifted towards the lens by 20 cm, the new object distance = 30 cm – 20 cm = 10 cm.



1

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

[CBSE Marking Scheme, 2016]

A **Q. 14. An object of height 6 cm is placed perpendicular to the principal axis of a concave lens of focal length 5 cm. Use lens formula to determine the position, size and nature of the image if the distance of the object from the lens is 10 cm.**

[Board Term II Delhi Set I, 2013]

Ans. A concave lens always forms a virtual and erect image on the same side of the object.

Image distance, v = ?

Focal length, f = – 5 cm

Object distance u = – 10 cm

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

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

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

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

$$= \frac{-3}{10} = 3{\cdot}3 \text{ cm.}$$

v = – 3·3 cm

$$\frac{\text{Size of the image}}{\text{Size of the object}} = + \frac{v}{u}$$

$$\frac{h'}{h} = \frac{-3.3}{-10}$$

$$\frac{h'}{6} = \frac{3.3}{10}$$

$$h_1 = \frac{6 \times 3.3}{10}$$

$$= \frac{19.8}{10} = 1{\cdot}98 \text{ cm.}$$

Size of the image is 1·98 cm. 2 + 1

A **Q. 15. The image of candle flame placed at a distance of 40 cm from a spherical lens is formed on a screen placed on the other side of the lens at a distance of 40 cm from the lens. Identify the types of lens and write its focal length. What will be the nature of the image formed if the candle flame is shifted 25 cm towards the lens ? Draw ray diagram to justify. [Board Term II, Foreign Set I, II, III, 2014]**

Ans. Given,

Object distance, u = – 40 cm

Image distance, v = 40 cm

Using lens formula,

$$\frac{1}{f} = 1/v - 1/u = 1/40 - 1/(-40)$$

or Focal length,

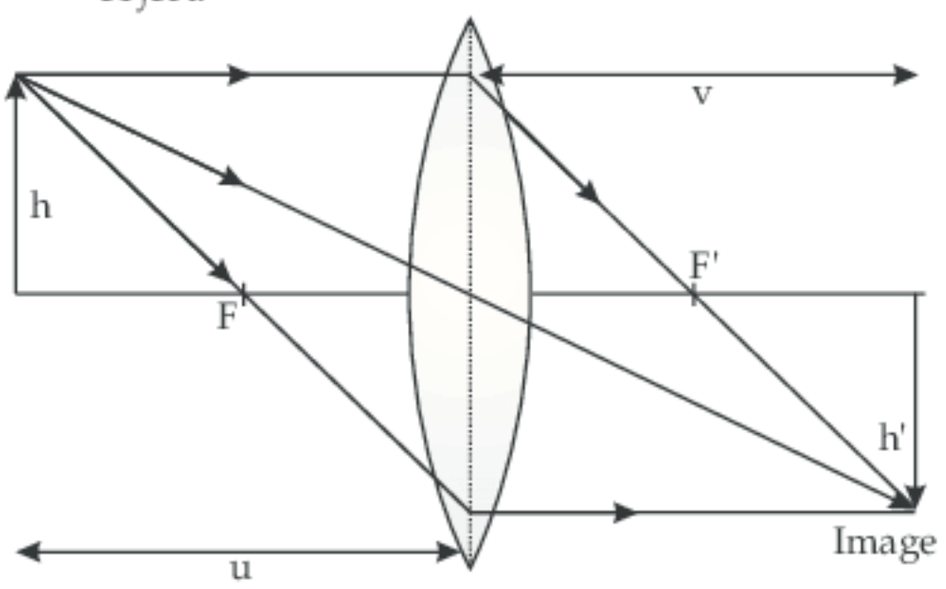
$$f = +20 \text{ cm}$$

The positive sign of focal length shows that it is a convex lens.

Now,

Magnification, $m = v/u = 40/(-40) = -1$

Thus, the image is real, inverted and same size as object.



If candle flame is shifted 25 cm towards the lens, then

$$u = -(40 - 25) = -15 \text{ cm}$$

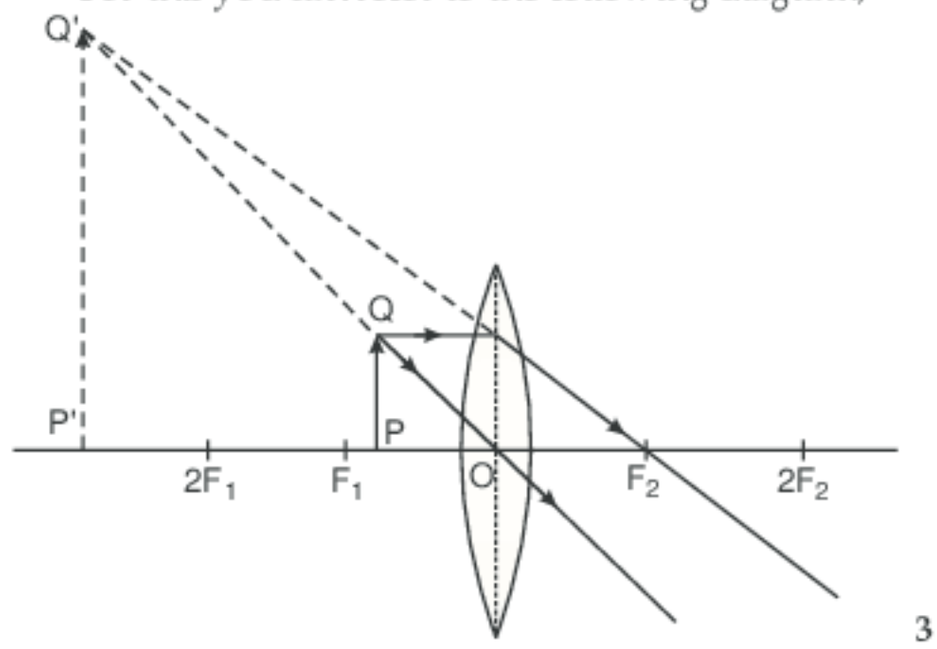
then, $1/20 = 1/v - 1/(-15) = 1/v + 1/15$

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

$$m = v/u = -60/-15 = 4$$

Thus the image will be virtual, erect and enlarged.

For this you can refer to the following diagram,



3

A Q. 16. (a) An object is kept at a distance of 18 cm, 20 cm, 22 cm and 30 cm, from a lens of power + 5D.

(i) In which case or cases would you get a magnified image ?

(ii) Which of the magnified image can we get on a screen ?

(b) List two widely used applications of a convex lens. [Board Term II, Set (2020), 2012]

Ans. (a) (i) $P = \frac{1}{f}, f = \frac{100}{5} = 20 \text{ cm}$

Object at 18 cm, 22 cm, and 30 cm, image can be magnified. 1

(ii) At 22 cm and 30 cm, image can be obtained on a screen. 1

(b) Film projectors and telescopes. 1

[CBSE Marking Scheme, 2012]

A Q. 17. Calculate the distance at which an object should be placed in front of a convex lens of focal length 100 cm to obtain an erect image of double its size. [Board Term II SQP 2013]

Ans. $f = 100 \text{ cm}$

$$m = \frac{v}{u} = 2$$

$$v = 2u$$

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

$$\frac{1}{100} = \frac{1}{2u} - \frac{1}{u}$$

$$\frac{1}{100} = \frac{1-2}{24}$$

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

$\because \quad 2u = -100$

$\therefore \quad u = 50 \text{ cm}.$ 3

A Q. 18. An image $\frac{2}{3}$ of the size of the object is formed by a convex lens at a distance of 12 cm from it. Find the focal length of the lens. [Board Term II, Set (2020), 2012]

Ans. The image formed is real (convex lens forms diminished real image)

$m = -\frac{2}{3}, v = +12 \text{ cm}, m = \frac{v}{u} = -\frac{2}{3} = 12 \text{ u}.$ 1

$-2u = 36.$

$u = -18 \text{ cm}$ ½

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

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

$$= \frac{3+2}{36}$$

$$f = \frac{36}{5} = 7{\cdot}2 \text{ cm}$$ 1½

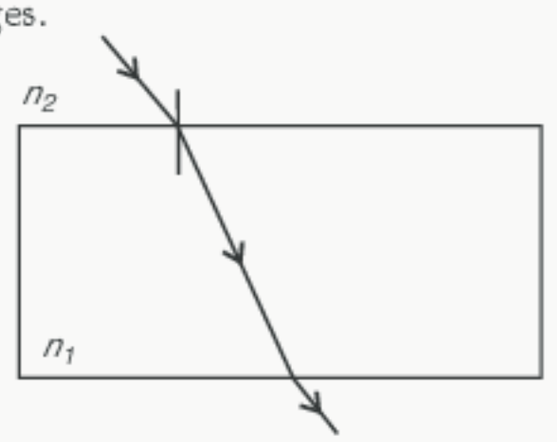
[CBSE Marking Scheme, 2012]

A Q. 19. 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. Complete the path of rays of light emerging from the glass slab, if : [Board Term II, Set (2008), 2012]

(i) $n_1 > n_2$, **(ii)** $n_1 = n_2$, **(iii)** $n_1 < n_2$.

Ans. (i) When $n_1 > n_2$

Light goes from rarer to denser medium $\therefore$ it diverges.



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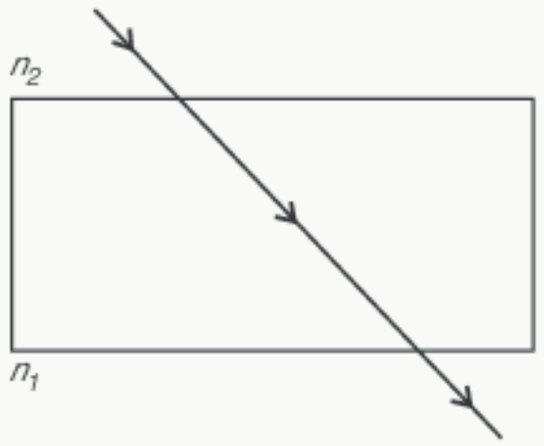
(ii) When $n_1 = n_2$

There is no change in the medium $\therefore$ no bending or refraction occurs.

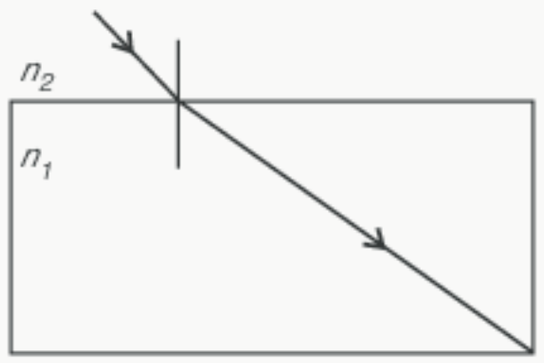


1

(iii) When $n_1 < n_2$

Light goes from denser to rarer medium

$\therefore$ It converges.



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[CBSE Marking Scheme, 2012]

A **Q. 20. (a) Two lenses have power of (i) + 2 D, (ii) – 4 D. What is the nature and focal length of each lens ?**

(b) An object is kept at a distance of 100 cm from lens of power – 4 D. Calculate the image distance.

[Board Term II, Set (2007), 2012]

Ans. (a) (i) Convex lens = + 50 cm ½

(ii) Concave lens = 25 cm ½

(b) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$f = \frac{1}{-4\text{D}} = -25 \text{ cm}$

$u = -100 \text{ cm}$ 1

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

$= -\frac{1}{25} - \frac{1}{100}$

$= \frac{-5}{100} = -\frac{1}{20}$

$v = -20 \text{ cm}$ 1

[CBSE Marking Scheme, 2012]

A **Q. 21. (i) A ray of light falls normally on a face of a glass slab. What are the values of angle of incidence and angle of refraction of this ray ?**

(ii) Light enters from air to a medium 'X'. Its speed in medium 'X' becomes $1{\cdot}5 \times 10^8$ m/s. Speed of light in air is 3×10^8 m/s. Find the refractive index of medium 'X'. [Board Term II, Set (2015), 2012]

Ans. (i) $\angle i = 0°$ and $\angle r = 0°$ ½+½

(ii) $n_x = \frac{c}{v_x} = \frac{3\times10^8}{1.5\times10^8} = 2$ 2

[CBSE Marking Scheme, 2012]

A **Q. 22. Where should an object be placed from a converging lens of focal length 20 cm, so as to obtain a real magnified image.**

[Board Term II, Set (2016), 2012]

Ans. $f = 20$ cm, $u = ?$, $m = 2$

$m = \frac{v}{u} \Rightarrow 2 = \frac{v}{u} \Rightarrow v = 2u$ 1

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

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

$\Rightarrow u = -10$ cm. 1

$v = -20$ cm 1

[CBSE Marking Scheme, 2012]

A **Q. 23. A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens ? Also find the magnification produced by the lens. [Board Term II, Set (2017), 2012]**

Ans. $f = -15$ cm, $v = -10$ cm, $u = ?$

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

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

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

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

$\Rightarrow u = -30$ cm. 2

Magnification, $m = \frac{v}{u} = \frac{-10}{-30}$

$= \frac{1}{3}$ 1

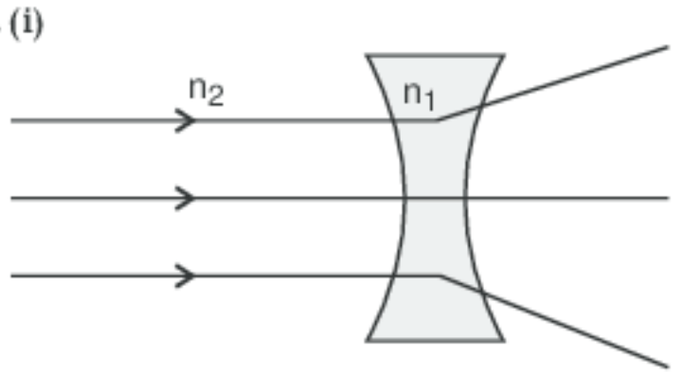
[CBSE Marking Scheme, 2012]

A **Q. 24. A concave lens made of a material of refractive index n_1 is kept in a medium of refractive index n_2. A parallel beam of light is incident on the lens. Trace the path of rays of light parallel to the principal axis incident on the concave lens after refraction when :**

(i) $n_1 > n_2$, **(ii)** $n_1 = n_2$.

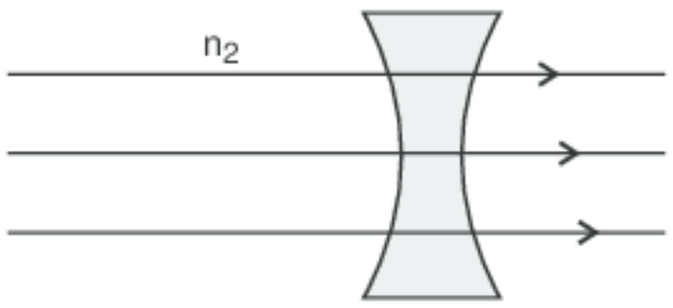
Give reason for each.

Ans. (i)



$n_1 > n_2$, lens behaves as diverging lens 1½

(ii)



$n_1 = n_2$, no refraction occurs. 1½

U Q. 25. **A student focused 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 :**

[Board Term II, Set (2008), 2012]

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.

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

(c) In which case, the size of the object and image will be same ? Give reason for your answer.

Ans. (a) $u = 30$ cm, $v = 30$ cm

This is possible if the object is placed at $2f$

$\therefore$ $2f = 30$ cm, $f = 15$ cm **1**

(b) $u = 15$ cm, $v = 70$ cm is incorrect. This is because if the object is at focus then image is formed at infinity. **1**

(c) In (iii) case, because object is at the centre of curvature. **[CBSE Marking Scheme, 2012] 1**

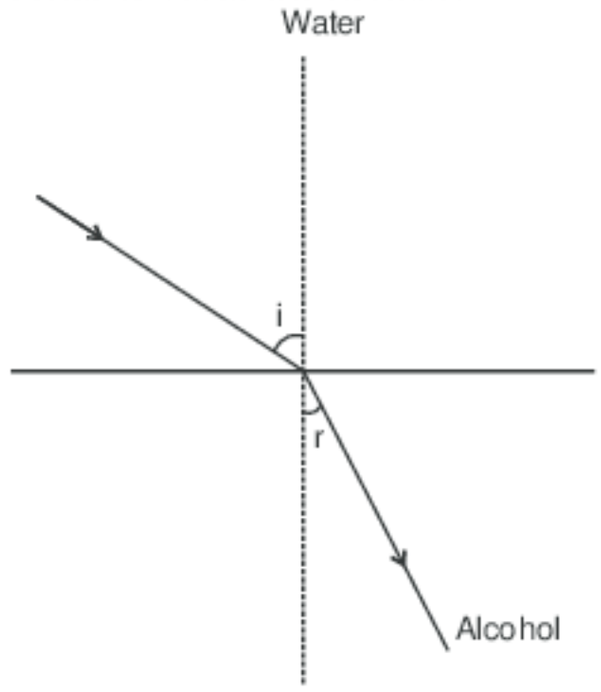
A Q. 26. **(i) Water has a refractive index 1·33 and alcohol has refractive index 1·36. Which of the two medium is optically denser ? Give reason for your answer. Draw a ray diagram to show the path of a ray of light passing obliquely from water to alcohol.**

(ii) The absolute refractive index of diamond is 2·42 and the absolute refractive index of glass is 1·50. Find the refractive index of diamond with respect to glass. [Board Term II SQP 2013]

Ans. (i) Refractive index of alcohol > refractive index of water.

So, alcohol is optically denser than water.

When a ray of light enters from water to alcohol, it bends towards the normal : 1½



(ii) $${}_g\mu_D = \frac{{}^a\mu_D}{{}^a\mu_g} = \frac{2.42}{1.5} = 1.61$$ 1½

Long Answer Type Questions (5 marks each)

A Q. 1. **(i) Define optical centre of a spherical lens.**

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

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

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

Ans. (i) Optical centre : the central point of a lens. **1**

(ii) $f = -20$ cm ½

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

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

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

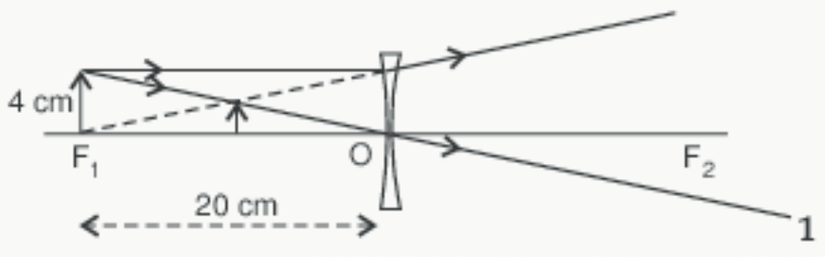
$$= \frac{-2+1}{20} = -\frac{1}{20}$$

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

$h_i = \frac{v}{u} h_0$ ½

$$= \frac{-10\,\text{cm}}{-20\,\text{cm}} \times 4 = 2\,\text{cm}$$ ½

(iii)



1

[CBSE Marking Scheme, 2016]

A **Q. 2. (i) Define focal length of a spherical lens.**

(ii) A divergent lens has a focal length of 30 cm. At what distance should an object of height 5 cm from the optical centre of the lens be placed so that its image is formed 15 cm away from the lens ? Find the size of the image also.

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

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

Ans. (i) Distance between optical centre and focus of the lens. **1**

(ii) $f = -30\text{ cm}$; $u = ?$; $h_1 = 5\text{ cm}$; $h_2 = ?$, $v = -15\text{ cm}$

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

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

$$\Rightarrow \quad u = \frac{vf}{f - v} = \frac{-15\text{ cm} \times -30\text{ cm}}{-30\text{ cm} - (-15\text{ cm})}$$

$$= -30\text{ cm} \qquad \text{1½}$$

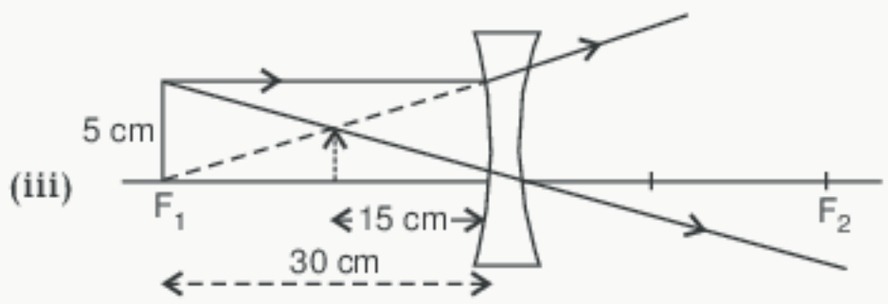
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$

$$\Rightarrow \quad h_2 = \frac{v}{u} \times h_1$$

$$= \frac{-15\text{ cm}}{-30\text{ cm}} \times 5\text{ cm} = 2.5\text{ cm}$$

1

(iii)



[CBSE Marking Scheme, 2016] 1

U **Q. 3. (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. [Board Term II O.D. Set II, 2016]

Ans.

[Topper Answer, 2016] 5

U **Q. 4. (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' **[Board Term II Delhi Set II, 2015]**

Ans. (a) Laws of refraction of light :

(i) The incident ray, the normal and the refracted ray at the point of incidence all lies in the same plane for the two given transparent medium.

(ii) The ratio of size of angle of incidence (*i.e.*, sin *i*) to the sine of angle of refraction (*i.e.*, sin *r*) is always constant for the light of given colour and for the given pair of media.

Mathematically, $\frac{\sin i}{\sin r} = \text{constant} = n_2$

The constant '*n*' is called refractive index of the second medium with respect to the first medium.

Absolute refractive index of the medium is given by

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

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

Speed of light in medium B $= 2 \times 10^8$ 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 $c = 2 \times 10^8 \times 1.5$

$= 3.0 \times 10^8$ m/s

Speed of light in medium 'A'

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

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

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

$= 1.5 \times 10^8$ m/s 2 + 3

[CBSE Marking Scheme, 2015]

A **Q. 5. 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.

[Delhi 31/1/1 2017]

Ans. **(a)** $f = +15$ cm ½

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

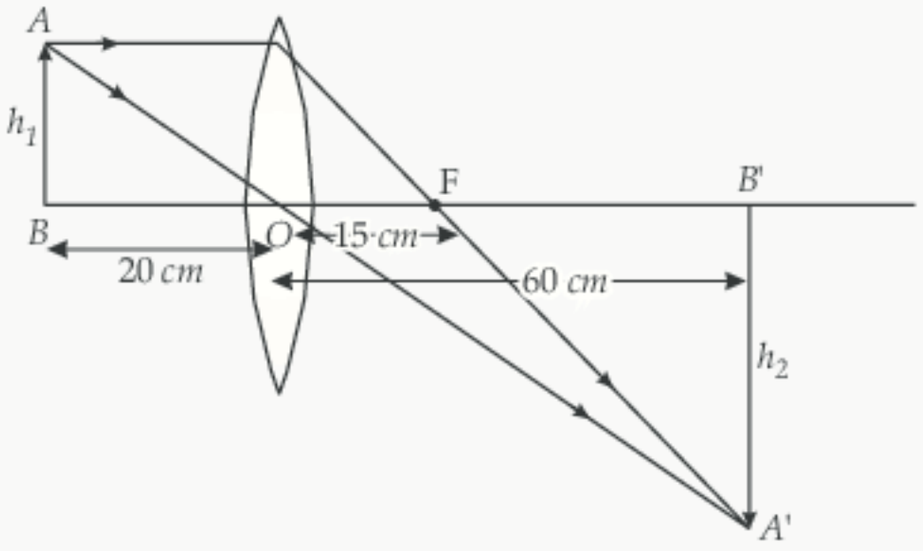
Thus, object is at 2F ($2f = 30$ cm)

$\therefore$ $f = 15$ 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

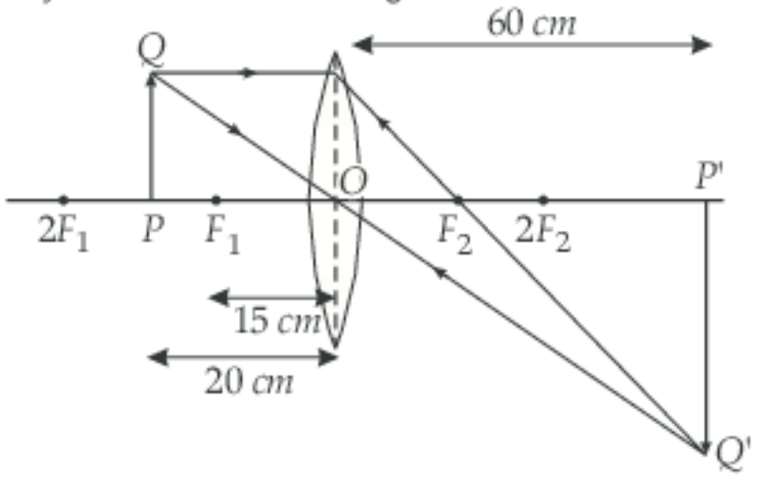
[CBSE Marking Scheme, 2017]

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) Approximate value magnification for distance object – 20 cm and image distance + 60 cm is 3.



A **Q. 6. 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 ?

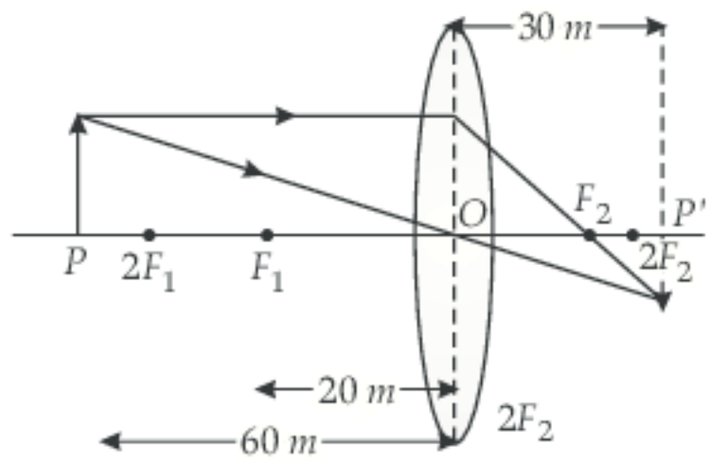
(c) Select an appropriate scale and draw a ray diagram for the observation at S. No. 2. Also find the approximate value of magnification.

[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 radius of curvature is i.e., + 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.

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

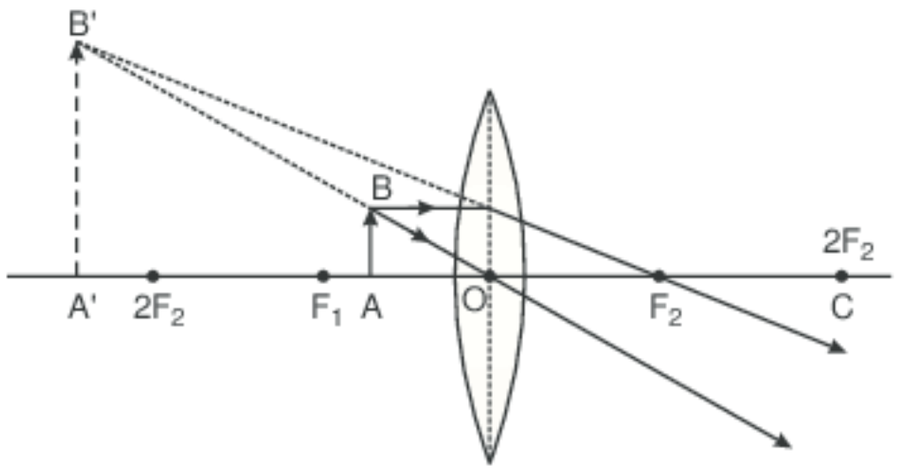


A **Q. 7. "A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it". Draw ray diagram to justify this by statement stating the position of the object with respect to the lens in each case.**

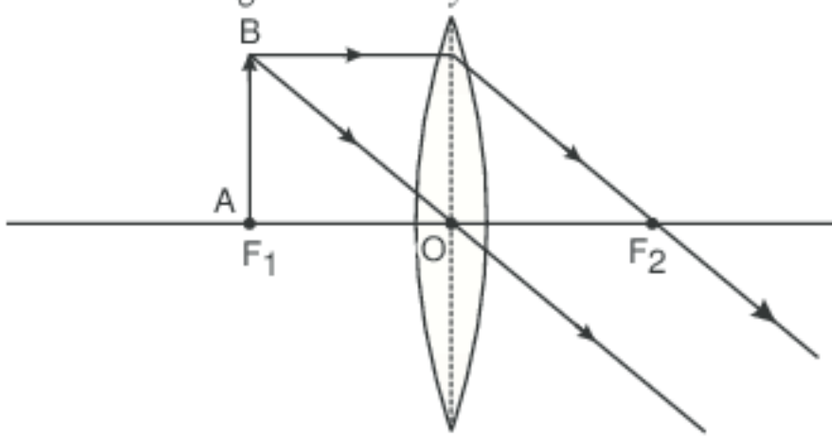
An object of height 4 cm is placed at a distance of 20 cm from a concave lens of focal length 10 cm. Use lens formula to determine the position of the image formed.

[Board Term II Delhi Set I, 2015]

Ans. Convex lens form magnified erect image when object is placed between F_1 and optical centre O. Image formed is virtual, erect and enlarged and on the same side of the lens as the object.



Convex lens form magnified inverted image when object is placed at F_1. Image formed is real, inverted and enlarged at infinity.



Given focal length $f = +10$ cm (concave)

Object distance $(u) = -20$ cm

For concave lens

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

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

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

$$\frac{2-1}{20} = \frac{1}{v} = \frac{-2-1}{20} = \frac{-3}{20}$$

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

$$m = \frac{h_1}{h_0} = \frac{v}{u}$$

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

$$= \frac{-20}{3 \times -20} \times 4 = \frac{4}{3} = 1.3 \text{ cm}$$

Image is diminished. 3 + 2

R **Q. 8. (a) Explain the following terms related to spherical lenses :**

(i) Optical centre
(ii) Centres of curvature
(iii) Principal axis
(iv) Aperture
(v) Principal focus
(vi) Focal length

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

[Board Term II, Outside Delhi Set I, III, 2014]

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

(ii) Centre of curvature : It is defined as the centre of the spheres of which the lens is originally a part of. Because the spherical lens consists of two spherical surfaces, the lens has two centres of curvature.

(iv) Aperture : This is the length or breadth of the lens through which refraction takes place.

(v) Principal focus : A light ray parallel to the principal axis of the lens meets at a point on the principal axis. This point is called the principal focus.

(vi) Focal length : The distance of the point from the centre of lens or mirror at which a parallel ray of beam converge (or diverge) is called focal-length and the point is called focus.

(b) Focal length of the converging lens, $f = 12$ cm

Image distance, $v = 48$ cm

Using the lens formula, we get :

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

$$\frac{1}{v} = \frac{1}{v} - \frac{1}{f} = \frac{1}{48} - \frac{1}{12}$$

$$= \frac{1-4}{48} = \frac{-3}{48}$$

$$\because \quad u = -\frac{48}{3} = -16 \text{ cm}$$

So, the distance of the object from the lens is 16 cm. ½×6+2=5

A **Q. 9. (i) Define power of a lens. Write its SI units.**

(ii) You are provided with two convex lenses of focal length 15 cm and 25 cm, respectively. Which of the two is of larger power ? Give reason for your answer.

(iii) A 20 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

[Board Term II, Set (2017), 2012]

Ans. (i) Ability of a lens to converge or diverge light rays is termed as power of a lens. ½+½

$$\text{Power} = \frac{1}{\text{Focal length}},$$

SI unit of power is Dioptre.

(ii) Lens of focal length 15 cm is of larger power because power is inversely proportional to the focal length. 1

(iii)

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

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

$$= \frac{1}{30} \quad \therefore v = 30 \text{ cm}$$

Image is real and inverted 3

$$\text{Magnification} = \frac{h'}{h} = \frac{v}{u}, m = -2$$

[CBSE Marking Scheme, 2012]

A **Q. 10. What is meant by the power of a lens ? What is its S.I. unit ? Name the type of lens whose power is positive.**

The image of an object formed by a lens is real, inverted and of the same size as the object. If the image is at a distance of 40 cm from the lens, what is the nature and power of the lens ? Draw ray diagram to justify your answer.

Ans. (i) Power of lens – Ability of a lens to converge or diverge light rays / Degree of convergence or divergence of light ray achieved by a lens / Reciprocal of focal length of the lens 1

(ii) S.I. unit is dioptre ½

(iii) Convex lens has positive power ½

(iv) $v = +40$ cm; $h' = h$

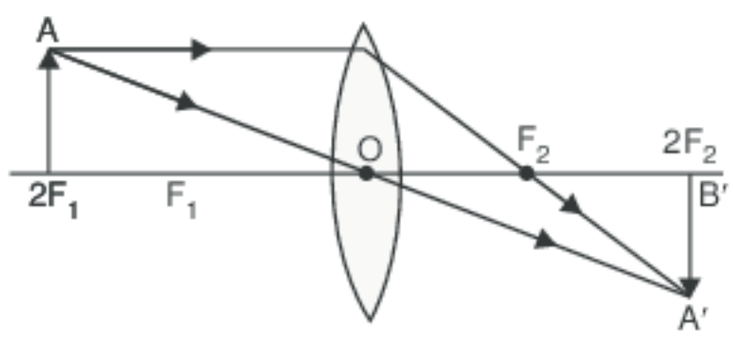
The lens is real, inverted and same sized 1

$\therefore$ object is at 2F ½

$$2f = 40 \therefore f = 20$$

$$P = \frac{1}{f} = \frac{100}{20\text{cm}} = 5 \text{ dioptre} \quad ½$$

(v)



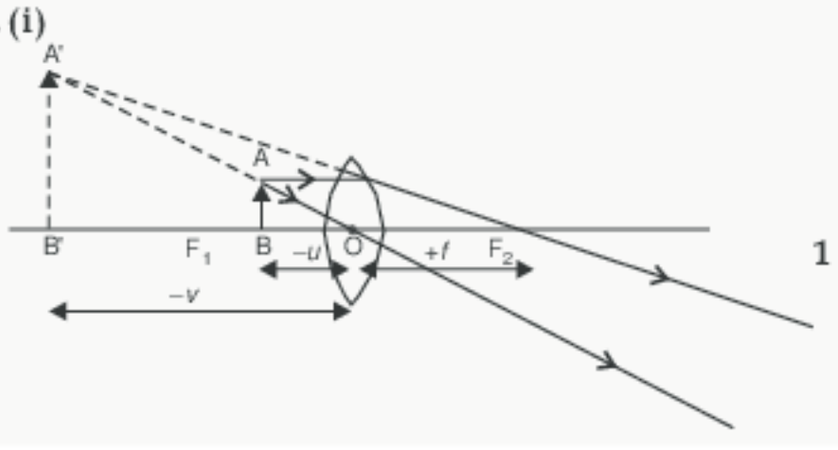
1

A **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. [Board Term II Delhi Set I, 2016]

Ans. (i)



1

(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

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

[CBSE Marking Scheme, 2016]

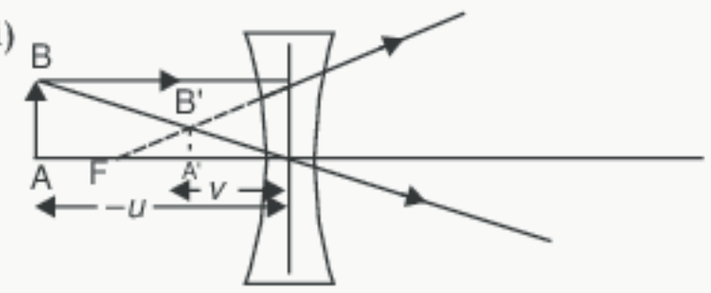
R **Q. 12. (i) Draw a ray diagram to show the formation of image by a concave lens when an object is placed in front of it.**

(ii) 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.

(iii) 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. 5

[Board Term II Foreign Set I, 2016]

Ans. (i)



1

(ii) Marking – u and – v ½ + ½

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

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

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

$\therefore$ $v = -u$ ½

Thus, object is at 2F

$2f = 40$ cm

$\therefore$ $f = 20$ cm $= 0.2$ m 1

$$p = \frac{1}{f} = \frac{1}{0.2} = +5\text{D}$$

(convex lens) 1

[CBSE Marking Scheme, 2016]

A **Q. 13. At what distance from a concave lens of focal length 20 cm a 6 cm tall object be placed so as to obtain its image at 15 cm from the lens ? Also calculate the size of the image formed.**

Draw a ray diagram to justify your answer for the above situation and label it.

[Board Term II Foreign Set I, 2016]

Ans. $f = -20$ cm; $h_1 = 6$ cm; $v = -15$ cm; $u = ?$

Lens formula : $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ ½

$\Rightarrow \quad u = \frac{vf}{f - v}$ ½

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

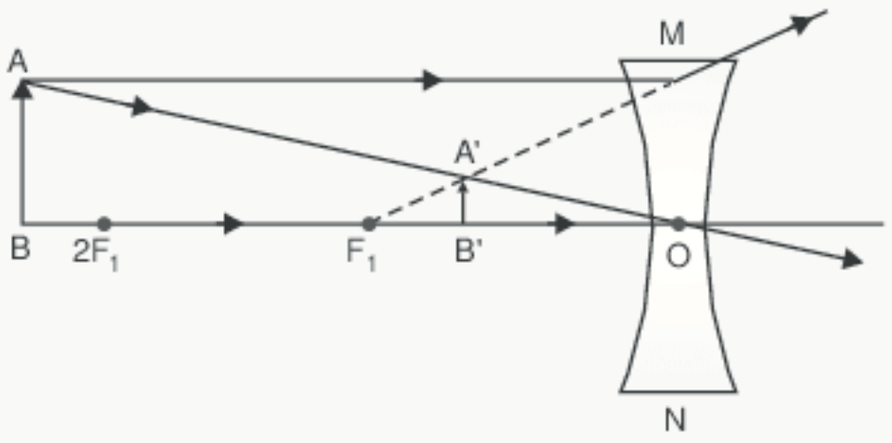
$= -60$ cm

object at 60 cm from the lens

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

$= \frac{-15\text{cm}}{-60\text{cm}} \times 6\text{ cm}$

= + 1.5 cm diminished, erect 1



2

[CBSE Marking Scheme, 2016]

A Q. 14. A student wants to project the image of a candle flame on the walls of school laboratory by using a lens :

(i) Which type of lens should he use and why ?

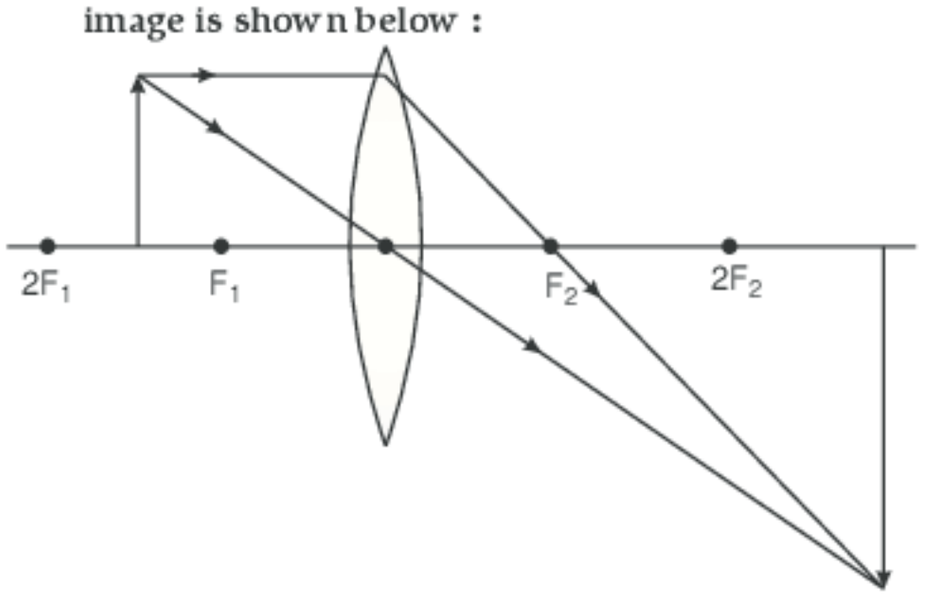
(ii) At what distance in terms of focal length 'F' of the lens should he place the candle flame so as to get (i) a magnified, and (ii) a diminished image respectively on the wall?

(iii) Draw ray diagram to show the formation of the image in each case ? [Board Term II, Delhi Set I, 2014]

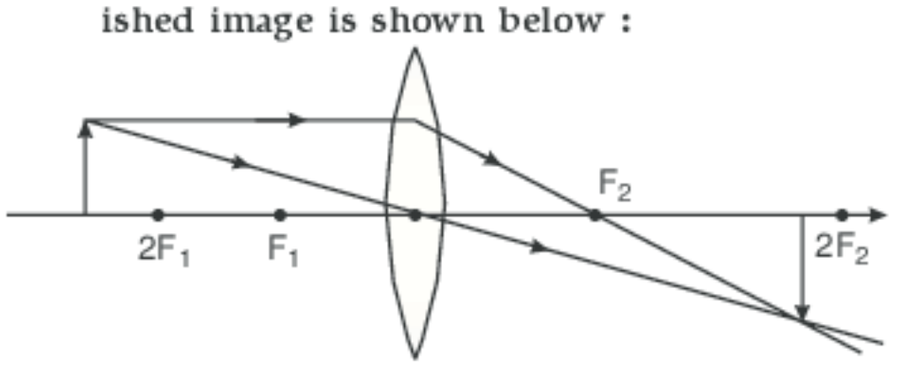
Ans. (i) He should use a convex lens as it forms real images.

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

(iii) **The ray diagram for the formation of the magnified image is shown below :**



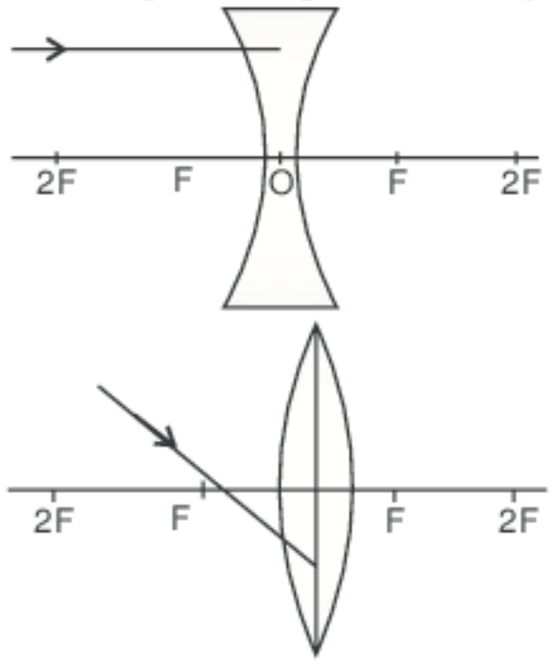
The ray diagram for the formation of the diminished image is shown below :



1+2+2

A Q. 15. (i) The refractive index of diamond is 2·42. What is the meaning of this statement ?

(ii) Redraw the diagram given below in your answer book and complete the path of the ray.

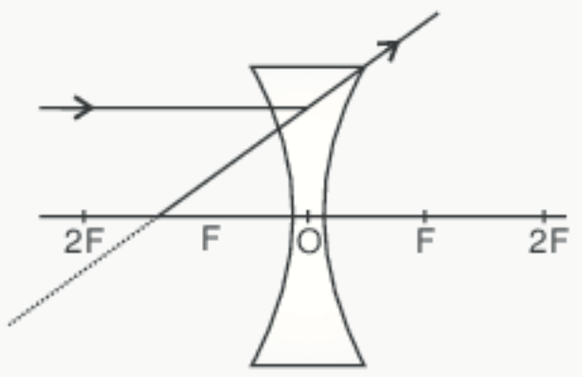


(iii) What is the difference between virtual images produced by concave, plane and convex mirrors ?

(iv) What does the negative sign in the value of magnification produced by a mirror indicates about a image ? [Board Term II, Set (2007), 2012]

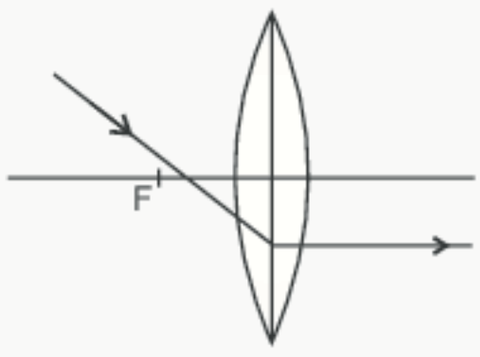
Ans. (i) This means that the ratio of speed of light in air and speed of light in diamond is 2.42. 1

(ii) (a)



1

(b)



1

(iii) Virtual image produced by concave mirror is magnified, that produced by plane mirror is of the same size and the virtual image produced by convex mirror is diminished. 1

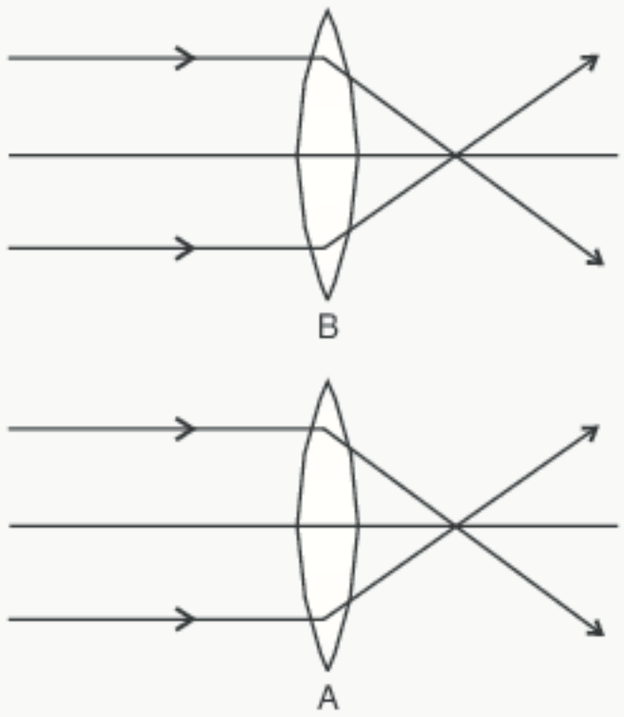
(iv) Real. [CBSE Marking Scheme, 2012] 1

A Q. 16. (i) Two convex lenses A and B have powers P_1 and P_2, respectively and P_2 is greater than P_1. Draw a ray diagram for each lens to show which one will be more converging. Give reason for your answer.

(ii) A 2·0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

[Board Term II, Set (2016), 2012]

Ans. (i) $P_2 > P_1 \therefore F_2 < F_1$ 2



B is more converging because rays are refracted more. **1**

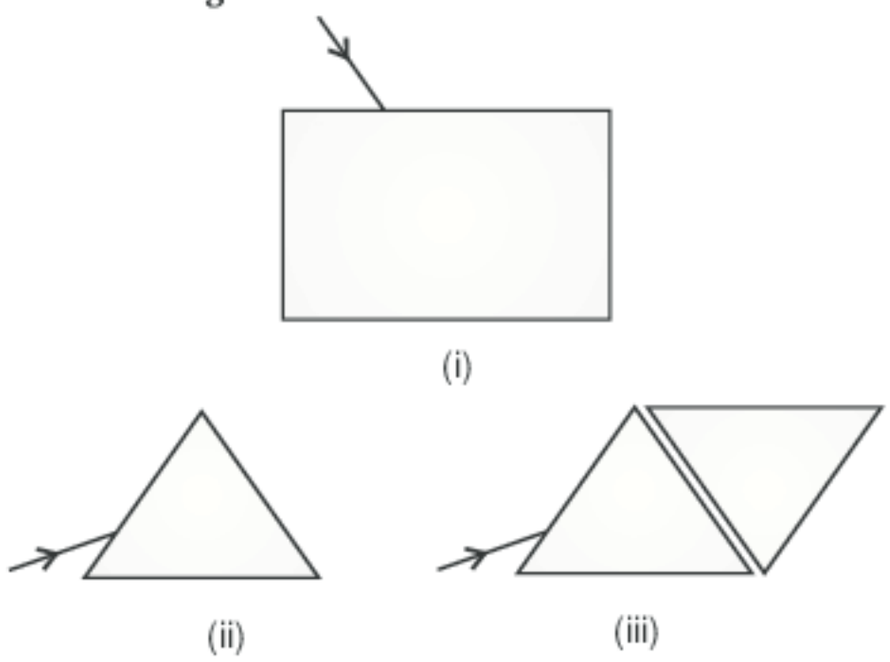
(ii) $$\frac{1}{u} = \frac{-1}{15} + \frac{1}{10} \Rightarrow \frac{1}{30} \Rightarrow v = +30 \text{ cm}$$ **1**

The image formed is real and inverted and on the other side of optical centre

$m = \frac{h'}{h} = \frac{v}{u} \Rightarrow m = -2$ inverted and 4 cm tall **1**

[CBSE Marking Scheme, 2012]

A Q. 17. **A very thin narrow beam of white light is made incident on three glass objects shown below. Comment on the nature and behaviour of the emergent beam in all the three cases.**



There is a similarity between two of the emergent beams. Identify the two.

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° = $\frac{1}{2}$)

Ans. In (i) emergent beam is white and laterally displaced. ½+½

In (ii) emergent beam is a spectrum of seven colours bent in different angles. ½+½

In (iii) emergent beam from the second prism is white only. ½

Similarity between (i) and (iii) as both emergent rays are white in colour. ½

$n_{gw} = \sin i / \sin r = \sin 45° / \sin 30°$ ½+½

$$= \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \sqrt{2}$$ ½+½

High Order Thinking Skills (HOTS) Questions

Q. 1. An object is placed between two plane mirrors inclined at an angle θ with each other. What is the total number of images formed ? 3

Ans. If θ is a submultiple of 180°, then the number of images formed.

$$n = \frac{360°}{\theta} - 1$$ 1½

If θ is not a submultiple of 180°, then the number of images formed is the integer next higher than

$$\frac{360°}{\theta} - 1$$ 1½

Q. 2. Lemon kept in water in a glass tumbler appears to be larger in size than its actual size. Give reason. 3

Ans. This is due to refraction of light. Ray of light travelling from air to water, undergoes bending and then reflection at the lemon's surface. As a result it appears larger to the observer. 3

Q. 3. An object is placed at a distance of 30 cm from a convex mirror; the magnification produced is $\frac{1}{2}$. Where should the object be placed to get a magnification of $\frac{1}{3}$. 5

Ans. Given : $u = 30$ cm, $m = \frac{1}{2}$

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

(For convex spherical mirror)

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

Also for spherical mirror **1**

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

$$= \frac{2-1}{30} = \frac{1}{30} \qquad \textbf{1}$$

$$f = +30\text{ cm}$$

Again $m' = \frac{v^1}{u^1}$

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

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

$$\frac{1}{30} = \frac{-3}{u^1} + \frac{1}{u^1} = \frac{-2}{u^1}$$

$$u = 30 \times -2$$

$$= -60\text{ cm.} \qquad \textbf{1 + 1}$$

Hence, object should be placed at a distance of 60 cm in front of convex mirror to get a magnification of $\frac{1}{3}$.

Q. 4. How will you distinguish between a plane, concave and convex mirrors without touching them? 5

Ans. We will look our face in each mirror, turn by turn.

(i) If the image formed is of same size as our face but laterally inverted for all positions, then it is a plane mirror. **2**

(ii) If the image formed is erect and enlarged initially but gets inverted as the face is moved away, then it is a concave mirror. **2**

(iii) If the image formed is erect and smaller in size for all positions, then it is a convex mirror. **1**

Q. 5. (i) What is the angle of incidence, when a ray of light falls on a spherical mirror from its centre of curvature ?

(ii) Two concave mirror have the same focal length but the aperture of one is larger than the other. Which mirror forms the sharper image and why ?

(iii) A convex mirror is held in water. What change you will observe in its focal length ? 5

Ans. (i) Such a ray falls normally on the mirror. So its angle of incidence is 0°. **2**

(ii) The concave mirror with smaller aperture forms the sharper image because it is free from spherical aberration. **2**

(iii) No change. The focal length of a convex mirror does not depend on the nature of the medium. **1**

Q. 6. On what factors does the refractive index of medium depend ? 3

Ans. The refractive index of a medium depends on :

(i) Nature of the medium.

(ii) Nature of the surrounding medium.

(iii) Wavelength of light used.

(iv) Temperature. **(Any three) 3**

Q. 7. Two thin lenses of power + 3.5 D and –2.5D are placed in contact. Find the power and focal length of the lens combination. 3

Ans. $P_1 = +3.5\text{ D}, P_2 = -2.5\text{ D}$

Total Power (P) $= P_1 + P_2$

$= 3.5 - 2.5 = 1$ dioptre.

Focal length of combination

$$= \frac{1}{P} = \frac{100}{P}\text{ cm}$$

$$= \frac{100}{1} = 100\text{ cm}$$

Focal length (f) = 100 cm **3**

Q. 8. The image of a candle flame placed at a distance of 45 cm from a spherical lens is formed on a screen placed at a distance of 90 cm from the lens. Identify the type of lens and calculate its focal length. If the height of the flame is 2 cm, find the height of the image.

Ans. Nature of Spherical lens = Convex **3**

Given $u = -45$ cm, $v = +90$ cm, $h_1 = +2$ cm

Using lens formula

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

$$= \frac{1}{90} - \frac{1}{-45}$$

$$= \frac{1}{90} + \frac{1}{45} = \frac{1+2}{90}$$

$$= \frac{3}{90} = \frac{1}{30}$$

$$f = +30\text{ cm}$$

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

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

$$= \frac{90}{-45} \times 2 = -4\text{ cm}$$

So, height of image is –4 cm. Negative sign indicates that it is formed below the principal axis. **3**

Value Based Questions

Q. 1. Nature of image formed by mirrors depends on the nature of the mirror and the position of the object in some cases. In a single array, one can make mirrors of various nature. A universal mirror, an object that reflects all light waves back at their source, has been created by scientists in Europe and Asia. Unlike an ordinary mirror, which reflects object at 90 degrees, a universal mirror reflects object back

at any angle. A mirror may be flat or curved. Flat mirrors are the most common types of mirror that we have while curved mirrors either magnify or minimize an object on focus.

(i) How reflection takes place in mirrors ? 1

(ii) Estimate the values or importance of mirrors used by people around you. 2

Ans. (i) When light falls on a surface and gets back into the same medium, it is called reflection. A highly polished surface or mirror reflects the light. 1

(ii) (a) Concave mirrors are used as shaving mirrors and in headlights of automobiles.

(b) Convex mirror are used as rear-view mirrors in vehicles.

(c) Plane mirrors are used to see our virtual image. 2

Q. 2. A girl was playing with a thin beam of light from her 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.

(i) State the reason for this observation. 1

(ii) If white light source is used with (a) parallel, (b) non-parallel sides, record your observations. 2

Ans. (i) Reason is lateral displacement.

Lateral displacement depends upon thickness of the slab, the incident and refraction angles. 1

(ii) (a) If white light source is used with parallel side the ray will pass through the focus 1

(b) Light rays will not pass through the non-parallel side. 1

Q. 3. An aeroplane was flying over the Sahara desert. It was around 10 am, when the pilot noticed some fire in the engine of the plane and then he decided to land the plane in the desert. On landing, all the passengers de-boarded the plane and then within few seconds the whole plane was in fire. Now, the passengers are left with no help as there were no mobile signal to call for help too. After about 2 hrs, they saw a plane passing over. They all shouted but was of no use because of the sound of plane. Then one person got an idea. He asked for a mirror. Then a young lady said that she had a mirror. He took it and with the help of the light coming from the search and rescue plane, he reflected them back so as to get revealed their position and thus, saved the life of all the co-passengers.

(i) State the laws of phenomenon, he used to save the lives of all the co-passengers ? 1

(ii) What moral values do we get from this passage ? Write any two only. 2

Ans. (i) Phenomenon used by the person is reflection of light. Laws of reflection are :

(a) The angle of incidence is equal to the angle of reflection.

(b) The incident ray, the normal at the point of incidence on the mirror and the reflected ray, all lie on the same plane. ½+½

(ii) (a) Presence of mind

(b) High degree of general awareness

(c) Ability to take prompt decision

(d) Concern for other passengers. 2

Q. 4. Two fast friends named Sita and Gita spend most of the time with each other. One day Gita observed that Sita is having pain in gums while eating her school lunch. Gita's father is a dentist so she advised, Sita to come with her to her father's clinic. Gita's father examines Sita's mouth and teeth with the help of a mirror and light and advises her not to eat too many chocolates and soft drinks. She also starts taking care of her mouth as she washed her mouth properly after having every food and also started taking a calcium rich diet.

(i) Which type of mirror is used by the dentist ? 1

(ii) Name the phenomenon of light by which doctor is able to examine Sita. 1

(iii) What values are shown by doctor, his daughter and his daughter's friend ? 1

Ans. (i) Concave mirror 1

(ii) Reflection of light 1

(iii) (a) Friendship

(b) Concern for each other

(c) Helping nature

(d) Right choices 1

Q. 5. When light enters from one medium into another, we say refraction takes place. Light bends on undergoing refraction, when light enters from rarer medium into denser medium, it will bend towards the normal. Similarly, when light gets into rarer medium from a denser medium, it will bend away from the normal.

(i) State the laws of Refraction. 1

(ii) 'Due to refraction, the original depth of a tank cannot be known'. Give any three examples of effects of refraction in support of the statement. 2

Ans. (i) **Laws of refraction :**

(a) The incident ray, the normal and the refracted ray, all lie in same plane.

(b) The ratio of sine of the angle of incidence and sine of the angle of refraction is constant. Which is called refractive index. ½ + ½

(ii) **Three examples of refraction :**

(a) A coin placed at the bottom of glass tumbler appears to be raised.

(b) Pencil immersed in water appears to be bent when viewed from sides.

(c) Lemon kept in water bowl appears to be larger.

1+1

Practical Based Questions

Experiment 1 :	**(i)** To determine the focal length of a concave mirror by obtaining image of a distant object.
	(ii) To determine the focal length of a convex lens by obtaining image of distant object.
Experiment 2 :	To trace the path of a ray of light passing through a rectangular slab for different angles of incidence, angle of refraction and angle of emergence and interpret the result.
Experiment 3 :	To trace the path of rays of light passing through a glass prism.
Experiment 4 :	To draw the images of an object formed by a convex lens when placed at various positions.

Q. 1. A student focuses the image of a well illuminated distant object on a screen using a convex lens. After that he gradually moves the object towards the lens and each time focuses its image on the screen by adjusting the lens.

[Board Term II, Delhi Set I, 2016]

(i) In which direction-towards the screen or away from the screen, does he move the lens ?

(ii) What happens to the size of the image-does it decrease or increase ?

(iii) What happens to the image on the screen when he moves the object very close to the lens ?

Ans. (i) Lens towards the screen/ screen away from the lens

(**Note :** One mark to be awarded for any other answer) **1**

(ii) Increase. ½

(iii) No image on the screen. ½

[CBSE Marking Scheme, 2016]

Q. 2. To find the image distance for varying object distances in case of a convex lens of focal length 15 cm, a student obtains on a screen a sharp image of a bright object by placing it at 20 cm distance from the lens. After that he gradually moves the object away from the lens and each time focuses the image on the screen.

(i) In which direction-towards or away from the lens does he move the screen to focus the object ?

(ii) How does the size of image change ?

(iii) Approximately at what distance does he obtain the image of magnification –1 ?

(iv) How does the intensity of image change as the object moves farther and farther away from the lens ?

[Board Term II, Foreign I, 2016]

Ans.(i) Towards the lens.

(ii) Size decreases gradually.

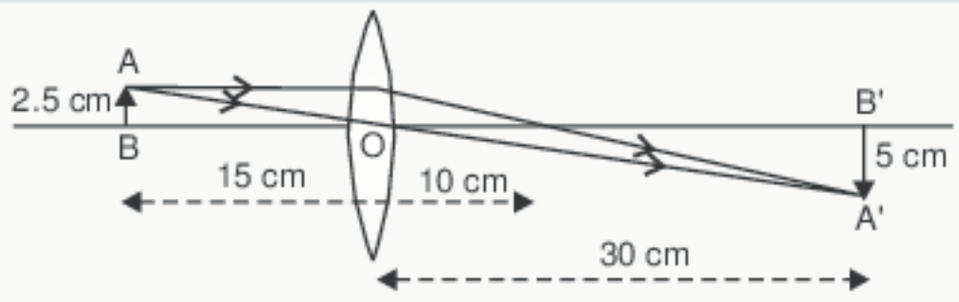
(iii) Nearly 30 cm from the lens.

(iv) Intensity of the image gradually increases. 4 × ½

[CBSE Marking Scheme, 2016]

Q. 3. 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. **[Board Term II, O.D. Set I, 2016]**

Ans.



Marking of O, F and size of the image. **2**

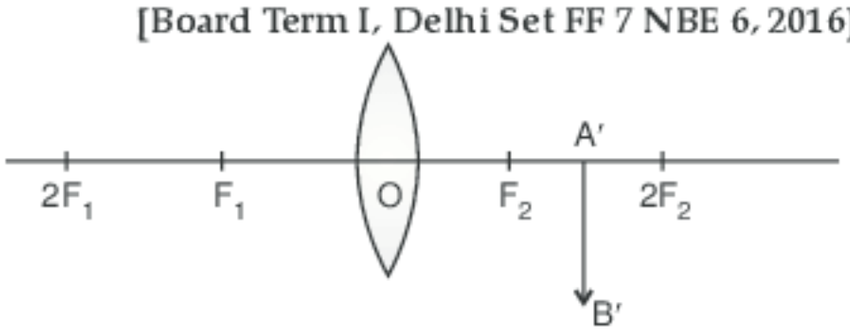
[CBSE Marking Scheme, 2016]

OR

[Topper Answer, 2016]

Q. 4. Observe the following incomplete ray diagram of an object where the image A'B' is formed after refraction of a convex lens.

[Board Term I, Delhi Set FF 7 NBE 6, 2016]



On the basis of above information fill in the blanks :

(i) The position of object AB would have been_____.

(ii) Size of the object would have been_____than the size of image.

Ans. (i) beyond $2F_1$ 1

(ii) greater. 1

Q. 5. A students place a candle flame at a distance of about 60 cm from a convex lens of focal length 10 cm focuses the image of the flame on a screen. After that he gradually moves the flame towards the lens and each time focuses the image on the screen.

(a) In which direction-toward or away from the lens, does he move the screen to focus the image?

(b) How does the size of the image change?

(c) How does the intensity of the image change as the flame moves towards the lens?

(d) Approximately for what distance between the flame and the lens, the image formed on the screen is inverted and of the same size ?

[Delhi 31/1/1 2017]

Ans. (a) Away from the lens

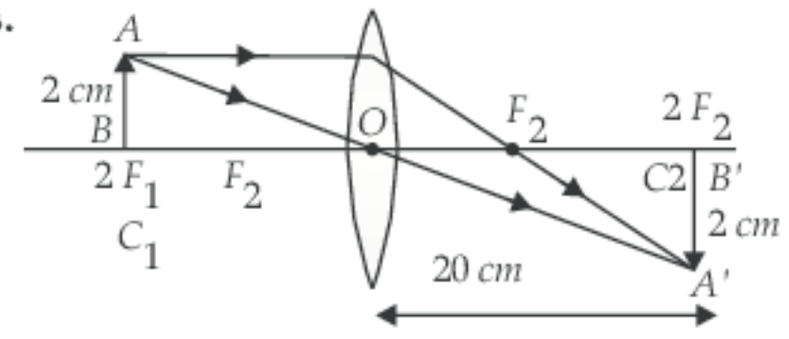
(b) Size increases

(c) Intensity decreases

(d) About 20 cm $4 \times ½$

Q. 6. An object of height 2.0 cm is placed on the principal axis of a convex lens of focal length 10 cm. The distance of the object from the optical centre (O) of the lens is 20 cm. Choose a proper scale and draw a ray diagram to find the position, nature and size of the image. Also measure and write the size of the image and its distance from the optical centre of the lens. [OD Comptt. 31/1 2017]

Ans.



Q. 7. A student performed an experiment with convex lens and found the virtual image of an object. Find

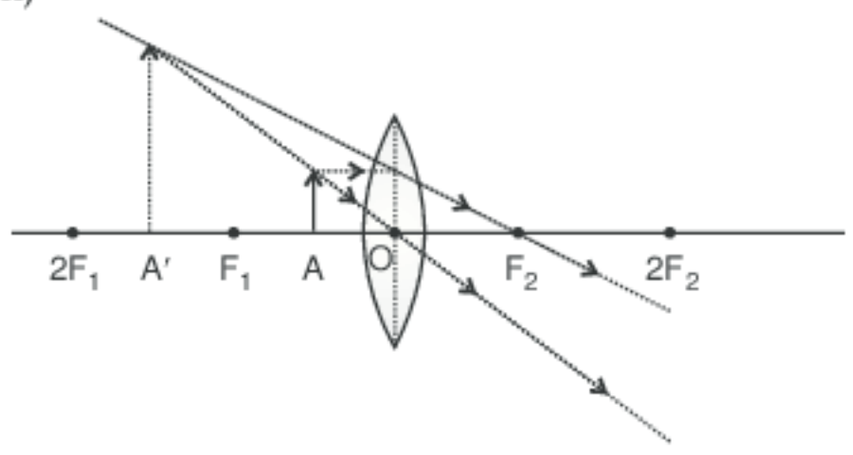
(i) Position of the object

(ii) Draw ray diagram for the above situation

[Board Term II, Set GFUTB86, 2015]

Ans. (i) Position of object is between lens and focal length of a convex lens. 1

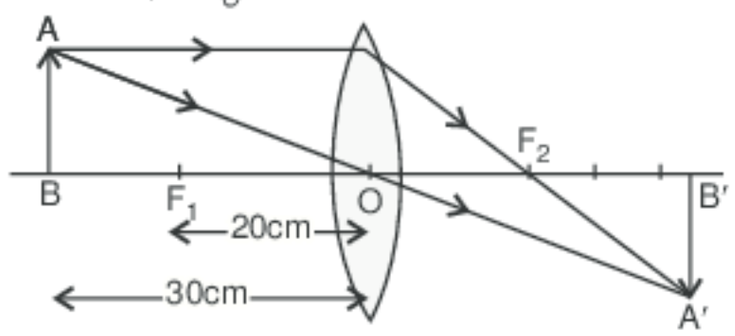
(ii)



1

Q. 8. A student places a 8.0 cm tall object perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30 cm. He obtains a sharp image of the object on a screen placed on the other side of the lens. What will be the nature (inverted, erect, magnified, diminished) of the image he obtains on a screen ? Drawn a ray diagram to justify your answer.

Ans. Inverted, magnified 1



1

Q. 9. Write two precautions to be taken while finding the image distance using a convex lens.

Ans. (i) Use a very sharp tipped pencil to draw thin lines to represent incident and refracted rays.

(ii) The convex lens drawn should be thin and of small aperture. (This is required for obtaining the distinct image.) 1+1

Q. 10. Write two precautions to be taken while tracing the path of a ray of light passing through a rectangular glass slab for different angles of incidence.

Ans. (i) The glass slab should be perfectly rectangular with all its faces smooth.

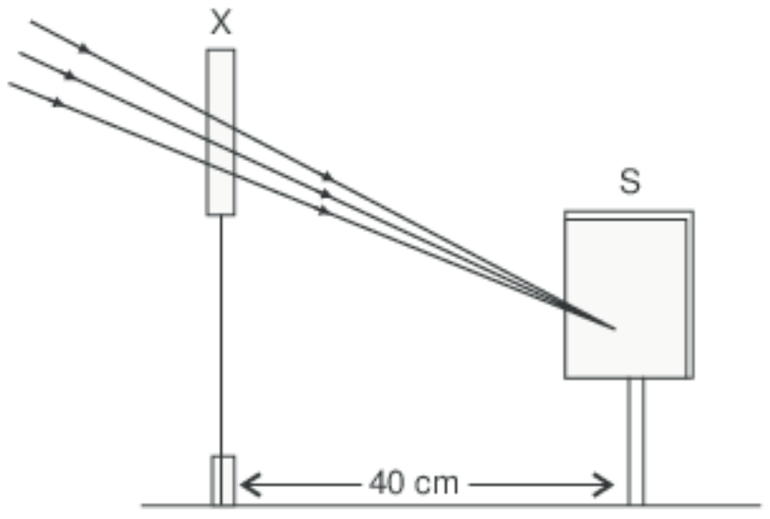
(ii) While fixing the pins P_1 and P_2 or the pins P_3 and P_4, care should be taken to maintain a distance of about 5 cm between the two pins. This would help in tracing the direction of incident ray and that of emergent ray with greater accuracy. **1+1**

Q. 11. Write two precautions to be taken while tracing the path of a ray of light passing through a rectangular glass prism.

Ans. (i) While viewing the collinearity of pins and images, the eye should be kept at a distance from the pins so that all of them can be seen simultaneously. The collinearity of pins fixed on one side of the glass prism and the images of pins on the other side could also be confirmed by moving the head slightly to either side while viewing them. All the pins and images of pins would appear to move together if they are collinear.

(ii) The pins P_1, P_2, P_3 and P_4 fixed on the paper may not be exactly perpendicular (or vertical) to the plane of paper. It is therefore desirable to look at the feet of the pins or their images while establishing their collinearity. That is why the position of each pin is marked with pointed tip of the pins on the paper. **1+1**

Q. 12. A student focussed the Sun rays using an optical device 'X' on a screen S as shown.



What conclusion can be drawn based on this about device X?

Ans. Light rays from infinity are converged at the focal point of the convex lens. Therefore, the focal length of the convex lens is 20 cm.

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