

CHAPTER 10

Light Reflection and Refraction

1. ONE MARK QUESTIONS

1. Write down four important characteristics of image formed by a plane mirror.

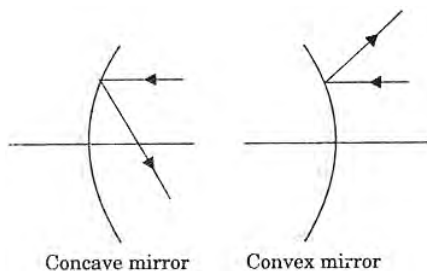
Ans : [CBSE 2014]

Image is virtual, erect, laterally inverted and of same size as object.

2. Describe a spherical mirror.

Ans : [CBSE 2014]

Spherical mirror is a part of a sphere. If reflection takes place from inside, it is said to be concave mirror, and if the reflection takes place from outside surface it is a convex mirror.



3. Define the following terms in relation to concave spherical mirror:

- Pole
- Centre of curvature
- Radius of curvature
- Principal axis
- Principal focus
- Aperture
- Focal length (each one mark)

Ans : [CBSE2013, 2014, 2015]

- The mid point of mirror is known as pole.
- The centre of curvature of a spherical mirror is the centre of that sphere of which mirror is a part,
- The distance between pole and centre of curvature is called radius of curvature of the mirror.
- The straight line joining the pole and centre of curvature is called principal axis.
- The point on the principal axis through which parallel rays to the principal axis passes or appear to pass after reflection.
- The diameter of the mirror or size of the mirror is called aperture.
- The distance between focus and pole of a mirror is the focal length of the mirror.

4. What are the advantages and disadvantages of using a

convex mirror for seeing traffic at the rear?

Ans : [CBSE 2015]

Advantage of Convex Mirror: It provide wider view of the rear traffic.

Disadvantage: It does not give the correct distance of the vehicle at the rear.

5. What are the units of power of a lens?

Ans : [CBSE 2015]

If the focal length is measured in metre then the unit of power of a lens is dioptre.

6. Give two uses of a convex lens.

Ans : [All India 2016]

Convex lens are used in (i) spectacles, (ii) telescopes, (iii) microscopes, (iv) camera.

7. Give one use of a concave lens.

Ans :

Concave lenses are used in (i) shaving mirror, (ii) flash lights,

8. What is a prism?

Ans : [CBSE 2015,2016]

A prism is an optical device with two triangular bases along with three rectangular lateral surfaces commonly inclined at an angle of 60° .

9. Define the term reflection.

Ans : [CBSE 2016]

The bouncing back of a ray of light in the same medium after striking on a surface of an object.

10. Define the terms:

- Angle of incidence
- Angle of reflection
- Plane of incidence

Ans : [CBSE 2016]

- The angle between incident ray and normal at the point of incidence is called angle of incidence $\angle i$.
- The angle between the reflected ray and normal at the point of incidence is called angle of reflection $\angle r$.
- A plane containing, incident ray, normal, and reflected ray is known as plane of incidence.

11. State the laws of reflection.

Ans : [All India 2010]

Laws of Reflection

- The incident ray, the reflected ray and the normal at the point of incidence are always in the same plane.
- $\angle i = \angle r$

12. Explain why we see the sign AMBULANCE front of the some vehicles.

Ans : [CBSE 2015]

Because the image of laterally inverted written letter will once again laterally inverted in the rear view mirror of the vehicle going ahead and image so produced will be erect image of the word **AMBULANCE**.

13. What is the radius of curvature of a plane mirror?

Ans : [CBSE 2015]

The radius of curvature of a plane mirror is infinite.

14. How many images are formed by two parallel mirrors?

Ans : [CBSE 2015]

The images formed by two parallel plane mirrors will be infinite.

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

Ans : [CBSE 2011, 2012, 2013]

Concave mirror

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

Ans : [CBSE 2011]

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

17. Light enters from air to glass having refractive index 1.50. What is the speed of light in glass? Speed of light in air is 3×10^8 m/s.

Ans : [CBSE 2011]

Speed of light in glass

$$v = \frac{c}{n} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m/s}$$

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

Ans : [CBSE 2011]

The meaning of refractive index of diamond is 2.42 is that speed of light in diamond is $1/2.42$ times the speed of light in air/vacuum D,
i.e. speed of light in diamond

$$v = \frac{c}{n} = \frac{3 \times 10^8}{2.42} = 1.24 \times 10^8 \text{ m/s}$$

TWO MARKS QUESTIONS

19. If the image formed by a convex lens is of the same size as that of the object. What is the position and nature of the image with respect to the lens?

Ans : [CBSE 2012, 2013]

The image will be real, inverted and will be formed at centre of curvature of the lens.

20. How can you identify the three types of mirrors without touching them?

Ans : [CBSE 2011]

- If the image formed is erect, of same size, and at equal distance behind the mirror as object and is in front of the mirror, then mirror is plane.
- If the image is of larger size and erect and changes to inverted and smaller size by changing the position of mirror from the object it is concave mirror.
- If the image is smaller and erect for all positions of mirror from the object, it is a convex mirror.

21. (a) What happens to a ray of light when it travels from one medium to another having equal refractive indices?

(b) State the cause of refraction of light.

Ans : [CBSE 2011]

- If a ray travels from one medium to another medium of same refractive indices then it will not bend and travels in a straight line.
- Change in speed of light is the cause of refraction.

22. (a) What should be the position of the object, when a concave mirror is to be used:

- as a shaving mirror, and
- in torches producing parallel beam of light?

(b) A man standing in front of a mirror finds his image having a very small head and legs of normal size. What type of mirror are used in designing such a mirror?

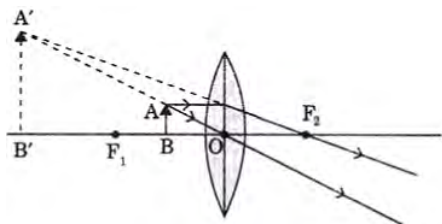
Ans : [CBSE 2011]

- (i) Face must be placed in between the pole and focus of the mirror so that enlarged, erect image of face can be formed.
 - (ii) At focus, because rays coming from the focus after reflection will become parallel.
- (b) It is a combination of convex mirror (small head) and plane mirror (legs of normal size).

23. Name the type of lens that can be used as magnifying glass. Give reason(s) and draw a ray diagram to support your answer.

Ans : [CBSE 2011]

A convex lens of smaller focal length can be used as magnifying glass. When an object is placed in between the pole and focus of the convex lens then enlarged, erect and same size of object image is formed.



24. An object is placed at the following distances from a concave mirror of focal length 15 cm.

- 10 cm
- 20 cm
- 30 cm
- 40 cm

Which position of the object will produce:

- Virtual image
- A diminished real image
- An enlarged real image
- An image of same size.

Ans : [CBSE 2011]

Given, concave mirror of $f = 15$ cm.

- When object is placed at a distance 10 cm from mirror (between P and f) image is virtual, enlarged and erected.
- For object in between $2F$ and ∞ i.e. 40 cm image is inverted, diminished and real.
- For object in between F and C (20 cm), image is inverted, enlarged and real beyond $2F(C)$.
- For object at $2F$ (30 cm), the image is of same size.

25. (a) What is meant by refraction of light?
 (b) If on applying Cartesian sign convention for spherical lenses, the image distance obtained is negative, state the significance of the negative sign.

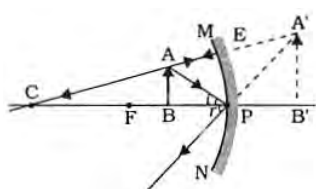
Ans : [CBSE 2011]

- When a ray of light passes from one medium to another it bends from its path. The phenomenon of bending a ray of light when it passes from one medium to another is called refraction of light.
- In a lens if the image distance is negative then its meaning is that image formed is at the same side of object, virtual and erect. The lens is concave lens.

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

Ans : [CBSE 2011]

We require minimum two rays for locating the image formed by a concave



27. (a) Name the spherical mirror used as:
 1. Shaving mirror,
 2. Rearview mirror in vehicles,
 3. Reflector in search – lights.
 (b) Write any three differences between a real and virtual image.

Ans : [CBSE 2012]

1. Concave mirror,
 2. Convex mirror,
 3. Concave parabolic
- Differences between a real and virtual image :

Real Image	Virtual Image
It can be taken on a screen	It can not be taken on a screen
It is always inverted	It is always erected
When reflected or refracted rays actually meet at a point, then real image is formed.	When reflected or refracted rays appear to meet at a point then virtual image is formed

28. What is meant by power of a lens? Give its SI unit. When two or more lenses are placed in contact, what will their combined power?

Ans : [CBSE 2012]

Power of a lens is the ability of the lens to converge or diverge a ray of light incident on it. It is the reciprocal of the focal length of the lens, i.e. $P = \frac{1}{f}$. The SI unit of power is D(dioptre) if f is measured in metre.

29. 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.

Ans : [CBSE 2012]

$$\text{As } n = \frac{c}{v} = \frac{\sin i}{\sin r} \Rightarrow v = \frac{c \sin r}{\sin i}$$

for same incident angle, v will be minimum for minimum value of angle r i.e. medium R.

30. Define absolute refractive index. Absolute refractive indices of medium A and medium B are n_a and n_b respectively, what is the refractive index of medium B with respect to medium A? How does the velocity of light vary with change in the optical density of the media?

Ans : [CBSE 2012]

Absolute refractive index of a given medium, w.r.t. air/vacuum is known as absolute refractive index of the medium

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

$$n = \frac{c}{v} \text{ as } c > v$$

$$n > 1$$

$${}_a n_b = \frac{\text{Velocity of light in B}}{\text{Velocity of light in A}} = \frac{v_b}{v_a} = \frac{n_a}{n_b}$$

Higher the optical density, lesser is the velocity of light in the medium

31. As the velocity of light increases, the refractive index of the medium decreases. Light enters from air to water having refractive index $4/3$. Find the speed of light in water. The speed of light in vacuum is 3×10^8 m/s.

Ans : [CBSE 2012]

Given: ${}_w^a n = \frac{4}{3}$, $c = 3 \times 10^8$ m/s

${}_w^a v = ?$

As ${}_w^a n = \frac{c}{v_w} \Rightarrow v = \frac{c}{{}_w^a n}$

$$v_w = \frac{3 \times 10^8 \times 3}{4} \\ = 2.25 \times 10^8 \text{ ms}^{-1}$$

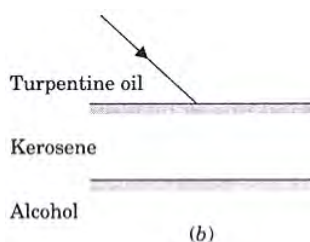
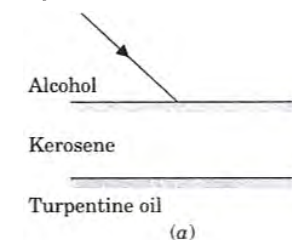
32. What is meant by radius of curvature of a spherical mirror? How is it related to the focal length of the mirror?

Ans : [CBSE 2013]

Radius of curvature of a spherical mirror is the radius of the sphere of which mirror is a part. It is the distance between pole and centre of curvature of a mirror. The radius of curvature is equal to the twice the focal length

$$R = 2f$$

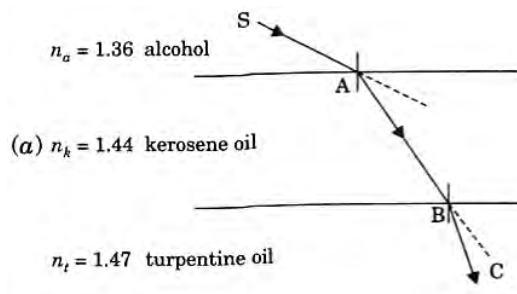
33. Refractive index of turpentine oil, kerosene and alcohol are 1.47, 1.44 and 1.36 respectively. On the basis of this information, complete the following ray diagram to show path of ray of light through each medium. Give reason for your answer.



Ans : [CBSE 2014]

When a ray passes from optically rarer to denser medium it bends towards the normal.

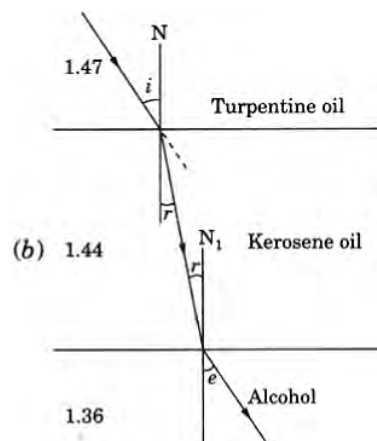
$$n_a = 1.36 \text{ alcohol}$$



a. $n_h = 1.44$ kerosene oil

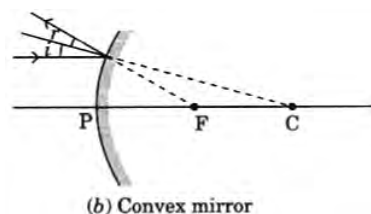
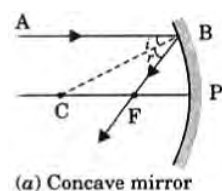
$$n_t = 1.47 \text{ turpentine oil}$$

b. 1.44



34. With the help of ray diagram show that angle of incidence is equal to the angle of reflection when a ray is incident on the concave/convex mirror.

Ans : [CBSE 2014]



35. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Ans : [CBSE 2011]

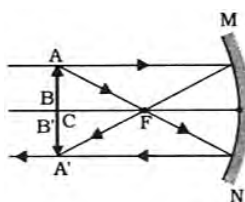
$$f = \frac{1}{P} m = \frac{1}{+1.5} m = +\frac{10}{15} m \\ = +\frac{2}{3} m$$

$$f = +66.7 \text{ cm}$$

$+f$ means the lens is convex (converging) lens.

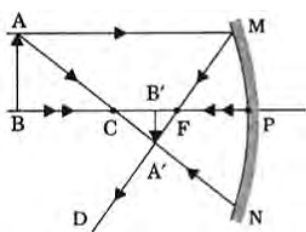
36. With the help of a ray diagram, show that the formation of the image of an object by a concave mirror when it is placed at the centre of curvature.

Ans : [CBSE 2012]



37. Draw a ray diagram for the image formed by a concave mirror when the object is placed beyond its centre of curvature.

Ans : [CBSE 2011]



38. Differentiate between reflection and refraction of light.

Ans : [CBSE 2012]

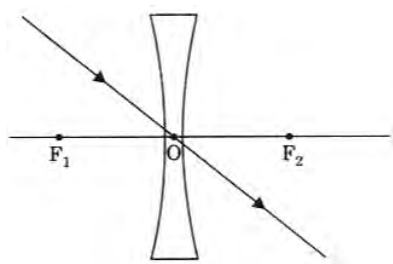
Reflection	Refraction
It is the phenomenon of bouncing back of ray of light in the same medium after striking with a surface	It is the phenomenon of bending a ray of light when it travels from one another medium.
$\angle i = \angle r$ (angle of reflection)	$\angle i \neq \angle r$ (angle of refraction)
Reflection can take place from any surface.	Refraction can take place from a transparent interface..

39. Define optical centre and principal axis of a lens. Show the path of the refracted ray when a ray of light is incident towards the optical centre of concave lens.

Ans : [CBSE 2012]

Mid point of a lens through which a ray of light passes undeviated is known as optical centre.

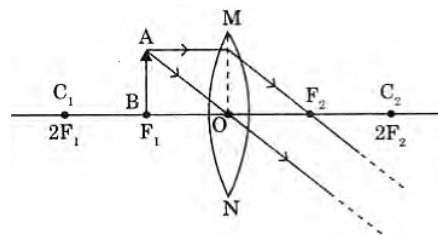
A straight line joining two centre of curvatures of the lens is called principal axis of lens.



40. An object is placed at the focus of a convex lens. Draw a ray diagram to locate the position of the image formed, if any. State its position and nature.

Ans :

Image is formed at ∞ , image will be real, inverted and enlarged.



41. Define the term magnification. Write its formula also.

Ans : [CBSE 2013]

Magnification m of a mirror gives the relative extent to which the size of image of an object is magnified w.r.t. size of object. It is the ratio of size of image (h_2) to size of an object (h_1).

$$m = \frac{\text{Size of image}}{\text{Size of object}} = \frac{h_2}{h_1} = -\frac{v}{u}$$

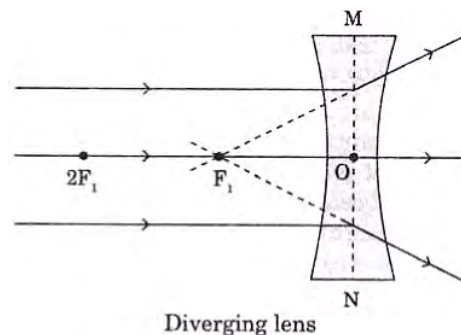
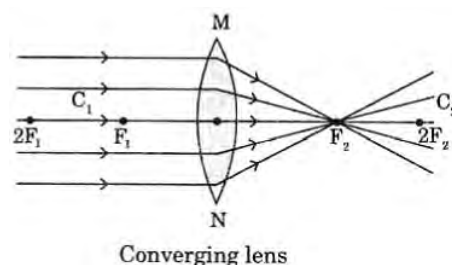
42. Write the relation between object distance and image distance from a lens and focal length of a lens.

Ans : [CBSE 2013]

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

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

Ans : [CBSE 2013]

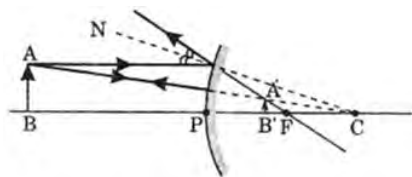


44. If the image formed by a spherical mirror for all positions of the object placed in front of it, is always erected and diminished, what type of mirror is it? Draw a labelled ray diagram to support your answer.

Ans : [CBSE 2018]

It is a convex mirror. Ray diagram for any position

of object



45. 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.

Ans :

[CBSE 2018]

Laws of refraction:

- The incident ray, refracted ray and normal to the point of incidence all lie in the same plane.
- The ratio of sin of incident angle to sin of angle of refraction for a given pair of medium is constant.

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

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

Absolute refractive index

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

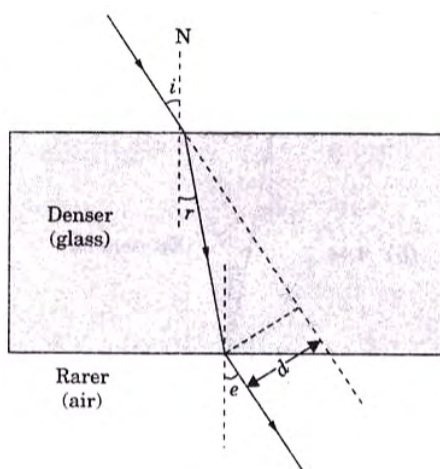
THREE MARKS QUESTIONS

46. A ray of light is incident obliquely on a glass slab. Draw a ray diagram showing the path of the light ray. Clearly, mark angle of incidence, angle of refraction, angle of emergence and lateral displacement of the ray. Give a formula to find refractive index of glass slab in terms of angle of incidence and angle of refraction.

Ans :

[All India 2011]

When a ray passes from optical rarer to denser medium, it bends towards the normal and vice versa.



$\angle i$ = angle of incidence

$\angle r$ = angle of refraction

$\angle e$ = angle of emergence

d = lateral displacement.

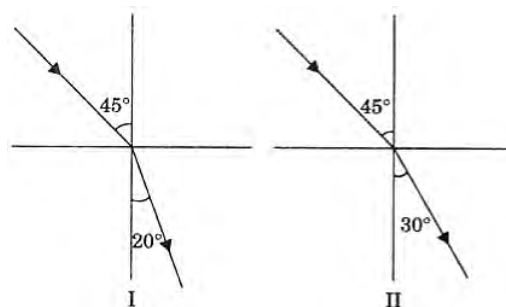
$${}_g n = \frac{\sin i}{\sin r}$$

47. (a) For the same angle of incidence 45° , the angle of refraction in two transparent media; I and II is 20° and 30° respectively. Out of I and II, which medium is optically denser and why?
- (b) Light enters from air to diamond which has refractive index of 2.42. Calculate the speed of light in diamond, if speed of light in air is $3 \times 10^8 \text{ ms}^{-1}$.

Ans :

[All India 2011]

- a. For the same angle of incidence. The refracted ray in medium I deviates less than in medium II. Hence medium I is more denser than medium II.



- b. Refractive index of diamond = 2.42
Speed of light in air = $3 \times 10^8 \text{ m/s}$
Speed of light in diamond = ?

$$n = \frac{\text{Speed of light in air}}{\text{Speed of light in diamond}} = \frac{c}{v}$$

$$v = \frac{c}{n} = \frac{3 \times 10^8}{2.42}$$

$$v = 1.24 \times 10^8 \text{ m/s}$$

48. 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:

Distance of flame from the lens (cm)	Distance of screen from the lens (cm)
60	20
40	24
30	30
24	40
15	70

- From the above table, find the focal length of lens without using lens formula.
- Which set of observations is incorrect and why?
- In which case the size of object and image will be same? Give reason for your answer.

Ans :

[CBSE 2012]

- a. In observation (iii) of the table given $u = 30 \text{ cm}$, $v = 30 \text{ cm}$, which is only possible when $u = v = 2f$ (at C)

$$2f = 30 \text{ or } f = 15 \text{ cm}$$

49. (a) Define power of a lens and write its SI unit.
- (b) A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the lens, if image size is equal to the object size? Also, find the power of

the lens.

Ans : [CBSE 2012]

- a. Power of a lens is the ability of a lens to bend a ray of light incident upon it. It is equal to the reciprocal of the focal length of the lens.

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

If f is measured in m then unit of power is dioptre (D).

- (b) $v = +50 \text{ cm}$
 $m = 1$
 $P = ?$

Since, $m = 1$, $m = \frac{v}{u} = 1$

or $u = v = 50 \text{ cm}$

i.e. v and u both are at centre of curvatures
 $C = 2f = 50$ or $f = 25 \text{ cm}$

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

$$P = +\frac{100}{25} D \text{ or } P = +4D$$

50. (a) 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?
 (b) Light enters from air to a medium X. Its speed in medium X becomes $1.5 \times 10^8 \text{ ms}^{-1}$. Find the refractive index of medium X.

Ans : [All India 2012]

- a. When a ray of light falls normally on a glass slab then $i = 0$, and $r = 0$
 b. $v_m = 1.5 \times 10^8 \text{ m/s}$

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

We know Refractive index

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

$$\text{or } n = \frac{3 \times 10^8}{1.5 \times 10^8} = 2$$

$$n = 2$$

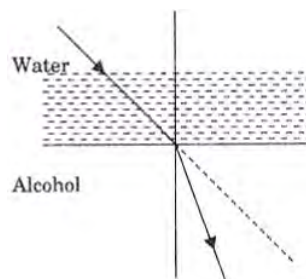
51. (a) Water has refractive index 1.33 and alcohol has refractive index 1.36. Which of the two medium is optically denser? Give reason for your answer. Draw a ray diagram to show the path of a ray of

light passing obliquely from water to alcohol.

- (b) 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.

Ans : [CBSE 2013]

- a. More refractive index means more optical denser medium. Here refractive index of water is 1.33 and of alcohol is 1.36 $n_{Al} > n_w$. Hence alcohol is more optical denser than water.



- b. ${}_d^a n = 2.42$
 ${}_g^a n = 1.50$
 ${}_d^g n = ?$
 ${}_d^g n = {}_d^a n \times {}_a^g n = \frac{{}_d^a n}{{}_a^g n}$
 ${}_d^g n = \frac{2.42}{1.50} = 1.61$

52. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of image and magnification. Describe what happens to the image as the needle is moved farther from the mirror.

Ans : [All India 2014]

Given: $u = -12 \text{ cm}$
 $f = +15 \text{ cm}$
 $h_1 = 4.5 \text{ cm}$
 $v = ?, m = ?$

Mirror formula,

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

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} - \frac{1}{-12} = \frac{1}{15} + \frac{1}{12}$$

$$v = +6.6 \text{ cm}$$

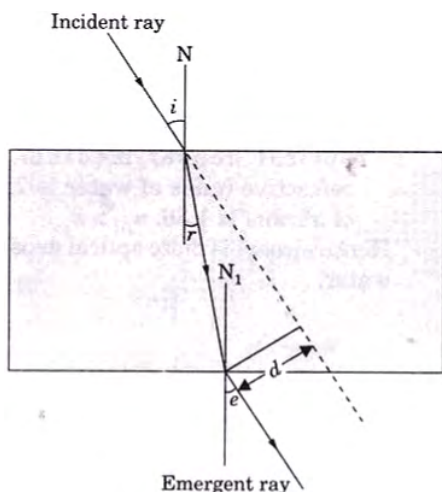
$$m = -\frac{v}{u} = -\frac{6.6}{-12} = 0.55$$

Size of image is smaller than size of object.

53. (a) State Snell's law of refraction.
 (b) When a ray of light travelling in air enters obliquely into a glass slab, it is observed that the light ray emerges parallel to the incident ray but it is shifted sideways slightly. Draw a ray diagram to illustrate it.

Ans : [All India 2014]

- (a) Snell's law = $\frac{\sin i}{\sin r} = \text{constant}$
 (Refractive index of the medium)
 (b)



54. 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.

- Write the type of mirror he should use.
- Find the linear magnification of the image produced.
- What is the distance between the object and its image?
- Draw a ray diagram to show the image formation in this case.

Ans : [All India 2014]

Given: $v = -60$ cm

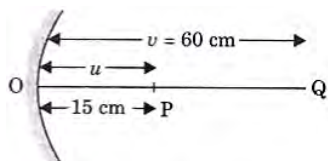
$u = -15$ cm

- Since the image is real the mirror is concave

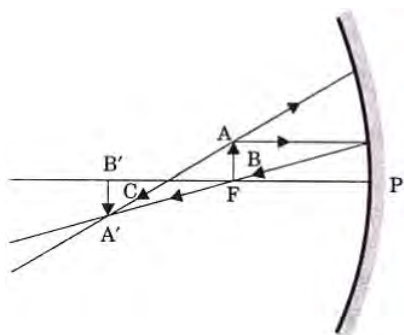
$$b. \quad m = -\frac{v}{u} = \frac{-(-60)}{(-15)} = -4$$

$$m = -4$$

- Distance between object position and image position = $60 - 15 = 45$ cm



d.



55. Discuss the position and nature of the image formed by a concave mirror when the object is moved from infinity towards the pole of the mirror.

Ans : [All India 2015]

When an object is moved from ∞ toward the pole of

a concave mirror then its image moves from focus to infinity.

56. State the laws of refraction.

Ans : [All India 2015]

Snell's laws of refraction

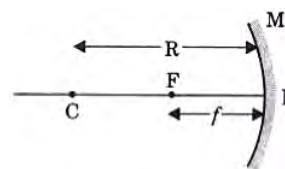
- Incident ray, refracted ray and normal to the point of incidence lie in the same plane.

$$b. \quad \frac{\sin i}{\sin r} = \frac{1}{2}n$$

57. (a) Define radius of curvature and focal length of a spherical mirror and show it on a figure.
(b) Write relation between radius of curvature and focal length of a spherical mirror.

Ans : [All India 2015]

- Distance between pole and centre of curvature is known as radius of curvature or the radius of the sphere of which mirror is a part is called radius of curvature.



$PC = \text{radius of curvature } (R)$

- Focal length of a mirror is half of the radius of curvature

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

58. An object of height 5 cm is placed perpendicular to the principal axis of a concave lens of focal length 10 cm. If the distance of the object from the optical centre of the lens is 20 cm, determine the position, nature and size of the image formed using the lens formula.

Ans : [All India 2015]

Given, object height $h = +5$ cm for a concave lens.

$$u = -20 \text{ cm}, f = -10 \text{ cm}$$

$$v = ?$$

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

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

$$\frac{1}{v} = \frac{1}{-10} + \frac{1}{-20} = -\frac{3}{20}$$

$$v = -\frac{20}{3} \text{ cm} = -6.66 \text{ cm}$$

Image formed is virtual, erect

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

$$h' = h \times \frac{v}{u} = 5 \times \left(-\frac{20}{3} \times \frac{1}{-20} \right) \text{ cm}$$

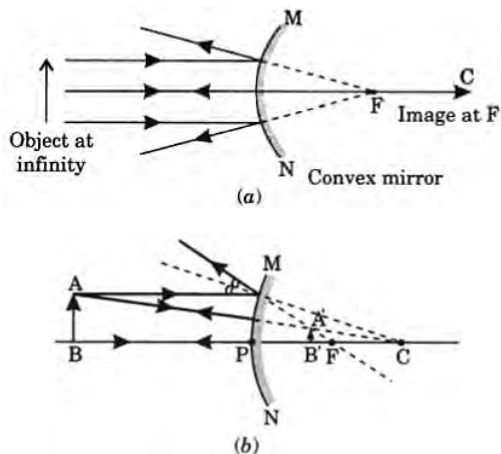
$$= 5 \times \frac{1}{3} \text{ cm} = \frac{5}{3} \text{ cm} = 1.66 \text{ cm}$$

59. 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?

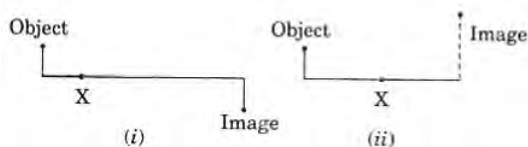
Ans : [All India 2015]

Only in convex mirror, for all positions of the object placed in front of it is always virtual, erected and diminished. Hence this mirror is convex mirror.



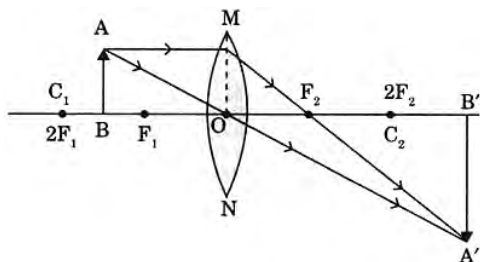
Convex mirrors are used in automobiles as a rear view mirror because of wider field of view and formation of erect image.

60. The nature, size and position of image of an object produced by a lens/ mirror are as shown below. Identify the lens/ mirror (X) used in each case and draw the corresponding complete ray diagram, (size of the object about half of the image).

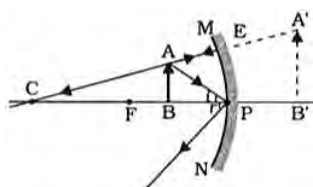


Ans : [CBSE 2016]

- a. Convex lens when object is in between F and C ($2F$).



- b. Concave mirror when object is in between P and F its enlarged, erect and virtual image is formed.



61. (a) Calculate the distance at which an object should be placed in front of a convex lens of focal length 10 cm to obtain a virtual image of double its size.
(b) In the above given case, find the magnification,

if image formed is real. Express it in terms of relation between v and u

Ans : [All India 2016]

Given $f = +10$ cm, $u = ?$

For virtual image

$$m = +2$$

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

$$v = 2u \quad \dots(1)$$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \dots(2)$$

Substituting (1) in (2)

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

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

$$u = -5 \text{ cm}$$

For real image, $f = 10$ cm, $m = -2$

$$\frac{v}{u} = -2, v = -2u$$

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

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

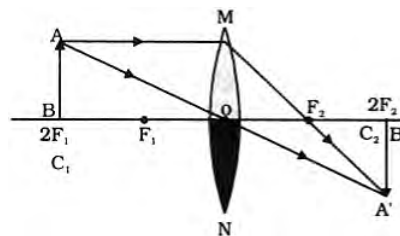
$$\frac{-3}{2u} = \frac{1}{10} \text{ or } u = -15 \text{ cm}$$

62. One half of a convex lens is covered with a black paper.

- a. Show the formation of image of an object placed at $2F_p$ of such covered lens with the help of ray diagram. Mention the position and nature of image.
b. Draw the ray diagram for same object at same position in front of the same lens, but now uncovered. Will there be any difference in the image obtained in the two cases? Give reason for your answer.

Ans : [Delhi 2016]

- a. If the lower half of the lens is covered even then it will form a complete real, inverted image of same size at $C_2(2F_2)$ with reduced intensity of image.



- b. There will be no change in the nature and position of the object except in later case the image will be brighter.

63. What is meant by power of a lens? Write its SI unit. A student uses a lens of focal length 40 cm and another of -20 cm. Write the nature and power of each lens.

Ans : [CBSE 2017,2018]

Power of lens is the ability of a lens to converge or diverge light rays passing through it. It is the reciprocal

of the focal length.

S.I. Unit: If focal length is measured in metre then unit of power of a lens is Dioptre (D)

$$P = \frac{1}{f}(D)$$

Power of first lens: Focal length = +40 cm. Focal length is positive hence it is a convex lens.

$$P_1 = +\frac{100}{f(\text{cm})} = +\frac{100}{40 \text{ cm}} = +2.5 \text{ D}$$

Power of second lens

Focal length = -20 cm

Its focal length is negative hence it is a concave lens.

$$f_2 = -\frac{20}{100} \text{ m} = -\frac{1}{5} \text{ m}$$

$$P_2 = \frac{1}{f_2} = -5 \text{ D}$$

64. 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.

Ans : [CBSE 2017]

Laws of refraction:

- The incident ray, refracted ray and normal to the point of incidence, all lie in the same plane.
- The ratio of sine of incident angle and sine of angle of refraction for a given pair of medium is constant.

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

Absolute refractive index of a medium is the ratio of speed of light in air or vacuum and speed of light in the medium.

Absolute refractive index

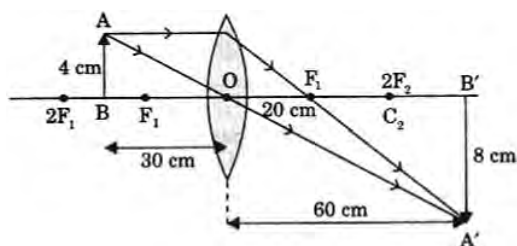
$$= \frac{\text{speed of light in air/vacuum}}{\text{speed of light in medium}}$$

FIVE MARKS QUESTIONS

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

Ans : [CBSE 2018]

Ray diagram: Position of O and F



$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{20} = \frac{1}{v} - \frac{1}{(-30)}$$

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

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

$$m = \frac{h_i}{h_o} = \frac{v}{u} \Rightarrow \frac{h_i}{4} = \frac{60}{(-30)}$$

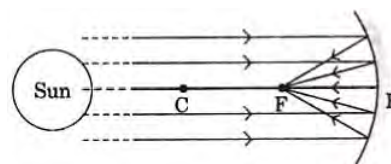
$$h_i = -8 \text{ cm}$$

Ratio = h_i/h_o is approximately 2:1

66. (a) Define real image of an object.
 (b) Name the mirror that:
- can give real as well as virtual image of an object.
 - will always give virtual image of same size of an object.
 - will always give virtual and diminished image of an object.
 - is used by a doctor in examining teeth,
- (b) With the help of a ray diagram explain the use of concave mirror as solar concentrators.

Ans : [All India 2011]

- When the reflected rays after reflection actually meet at a point then real image is formed.
- Concave mirror
Plane mirror
Convex mirror
Concave mirror
- The rays coming from the sun are parallel to principal axis and will concentrate at focus after reflection.



67. Name the type of mirror used in the following:

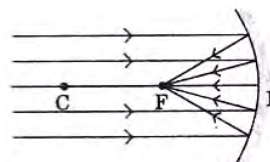
- Solar furnace
- Side/rear - view mirror of a vehicle.

Draw a labelled ray diagram to show the formation of image in each of the above two cases.

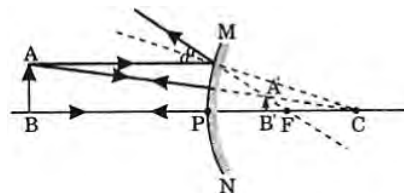
Which of these mirrors could also form a magnified and virtual image of an object? Illustrate with the help of a ray diagram.

Ans : [All India 2011, 2015]

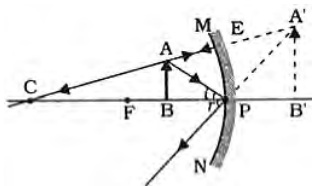
- Concave mirror



- Convex mirror



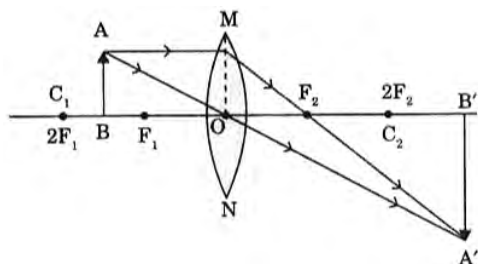
Concave mirror form magnified virtual image of an object.



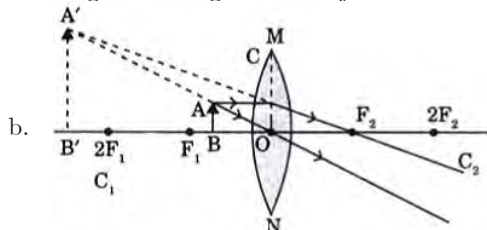
68. (a) A thin converging lens forms a
- Real magnified image.
 - Virtual magnified image of an object placed in front of it.
- Write the positions of the objects in each case.
- (b) Draw labelled ray diagrams to show the image formation in each case.
- (c) How will the following be affected on cutting this lens into two halves along the principal axis?
- Focal length
 - Intensity of the image formed by half lens.

Ans : [All India 2011,2015]

- a. When object is placed in between F and $2F(C)$ of a converging lens it will form a real magnified image.



When object is placed in between F_1 and optical centre O of a converging lens, it will form a virtual magnified image of the object.

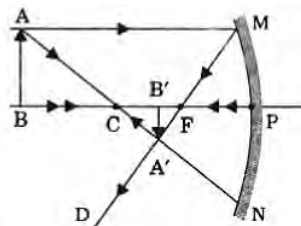


- b.
- c. When lens is cut along the principal axis its focal length remains same but intensity is reduced.

69. (a) Define principal focus of a spherical mirror.
- (b) For what position of the object does a concave mirror form a real, inverted and diminished image of the object? Draw the ray diagram.
- (c) An object 4 cm high is placed at a distance of 6 cm in front of a concave mirror of focal length 12 cm. Find the position of the image formed.

Ans : [All India 2011]

- a. The point on the principal axis at which the light rays parallel to principal axis after reflection from a concave mirror actually meet or appear to come from in convex mirror on the principal axis is called principal focus.
- b. In case of a concave mirror, when the object is placed beyond $2F(C)$ then image formed is real, inverted and diminished.

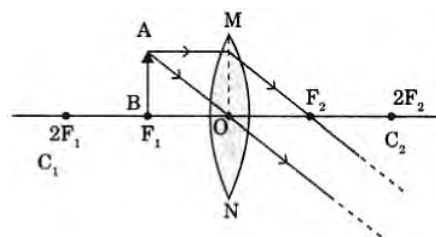


- c.
- $$f = -12 \text{ cm}$$
- $$u = -6 \text{ cm}$$
- $$v = ?$$
- $$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$
- $$\frac{1}{v} = \frac{-1}{12} + \frac{1}{6} = \frac{-1+2}{12} = \frac{1}{12}$$
- $$v = 12 \text{ cm}$$

70. (a) Define optical centre of a spherical lens.
- (b) You are given a convex lens of focal length 30 cm. Where would you place an object to get a real, inverted and highly enlarged image of the object? Draw a ray diagram showing the image formation.
- (c) A concave lens has a focal length of 20 cm. At what distance an object should be placed so that it forms an image at 15 cm away from the lens?

Ans : [All India 2011]

- a. Mid point of a lens through which a ray of light passes undeviated.
- b. At $f = +30 \text{ cm}$, because when object is kept at focus of a convex lens then its real, inverted and highly enlarged image is formed



- c.
- $$f = -20 \text{ cm}, v = -15 \text{ cm}, u = ?$$
- Lens formula

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

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

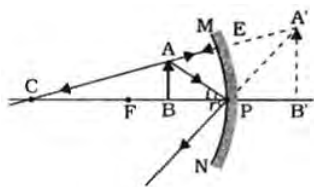
$$-\frac{1}{u} = \frac{-1}{20} + \frac{1}{15} = \frac{-3+4}{60} = \frac{1}{60}$$

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

71. (a) Under what condition, a concave mirror produces a virtual and magnified image? Draw a labelled ray diagram to show the formation of image in the above case. Also, state the position of object to produce magnified and real image.
- (b) A ray of light moving along principal axis is falling on a concave mirror. Draw the path of reflected ray. Also, state the values of angle of incidence and reflection in this case.

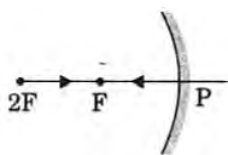
Ans : [All India 2011]

- a. A concave mirror will produce a virtual and magnified image of the object if placed in between F and pole of the mirror.



Real and magnified image will be formed if the object is placed in between $2F(C)$ and F in front of a concave mirror.

- b. Ray of light moving along the principal axis will retrace its path because incident angle $\angle i =$ reflected angle $\angle r = 0$.



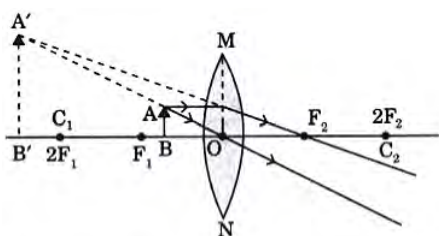
72. Which lens can be used as a magnifying glass? For which position of object does a convex lens form:

- a virtual and erect image?
- a real and inverted image of same size as that of object? Draw labelled ray diagrams to show the formation of the required image in each of the above two cases.

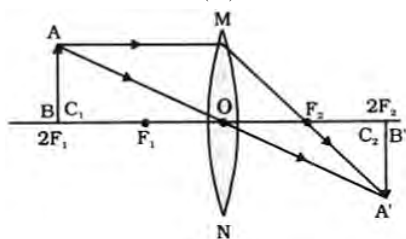
Ans : [All India 2011]

A convex lens of shorter focal length is used as a magnifying lens (glass).

- a. A virtual and erect image in a convex lens is formed when object is placed in between F and O .



- b. A real and inverted image of same size as that of an object is formed by a convex lens when the object is placed at $2F(C)$.

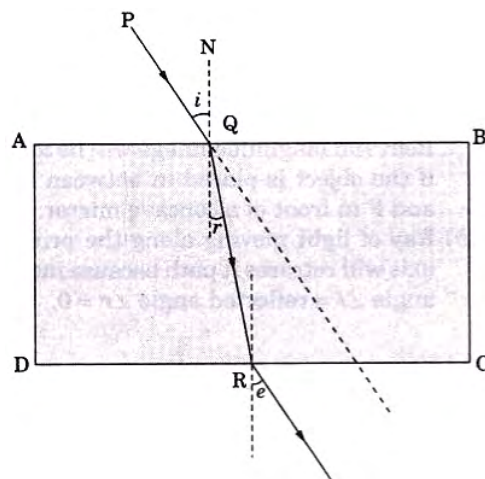


73. (a) Describe an activity to find the approximate value of focal length of a concave mirror.
 (b) What happens to the size of the image of an object when it is moved gradually away from a concave mirror?
 (c) In an experiment to study refraction through

a glass slab, it is observed that a ray of light undergoing refraction emerges parallel to the direction of incident ray. Why does it happen so? Explain with the help of a diagram.

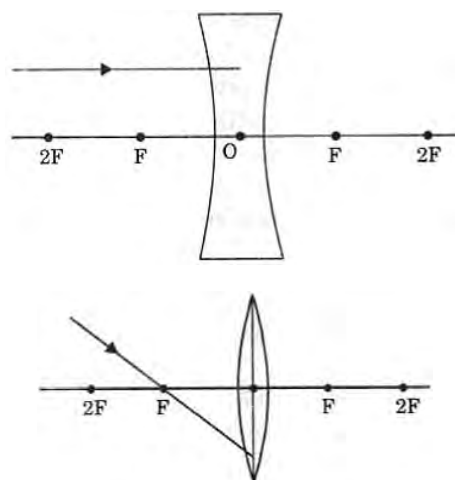
Ans : [All India 2011]

- By holding concave mirror, focus the reflected light incident on the mirror on a sheet of paper. The distance between paper sheet and mirror will give the approximate value of focal length of concave mirror.
- Size of image reduces



- c. The opposite faces of rectangular glass slab AB and DC are parallel and extent of bending on opposite faces is equal and opposite $\angle i = \angle e$. Hence incident ray is parallel to emergent ray.

74. (a) The refractive index of diamond is 2.42. What is the meaning of this statement?
 (b) Redraw the diagram given below in your answer book and complete the path of ray.

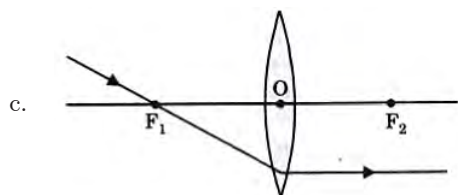
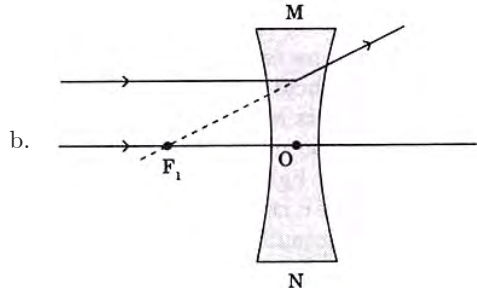


- What is the difference between virtual images produced by concave, plane and convex mirrors?
- What does the negative sign in the value of magnification produced by a mirror indicate about an image?

Ans : [All India 2012]

- a. The refractive index of diamond is 2.42 means that speed of light in diamond is $(1/2.42)$ times the speed of light in air.

$$\frac{c}{v} = 2.42 \text{ or } v = \frac{c}{2.42}$$



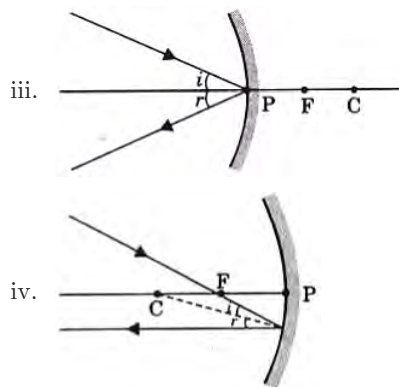
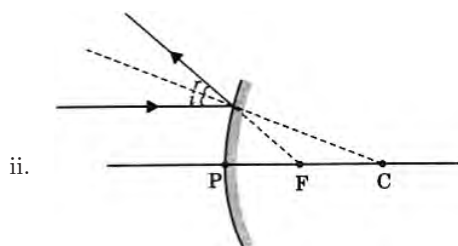
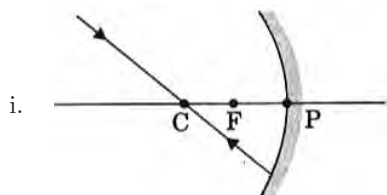
	Concave mirror	Convex mirror	Plane mirror
Virtual image	is magnified	smaller in size	same size as that of object

d. negative magnification produced by a mirror mean image is real.

75. (a) Write one use of concave mirror as well as convex mirror.
 (b) Draw ray diagrams for the following cases when a ray of light:
 (i) passing through centre of curvature of a concave mirror is incident on it.
 (ii) parallel to principal axis is incident on convex mirror.
 (iii) is incident at the pole of a convex mirror.
 (iv) passing through focus of a concave mirror incident on it.

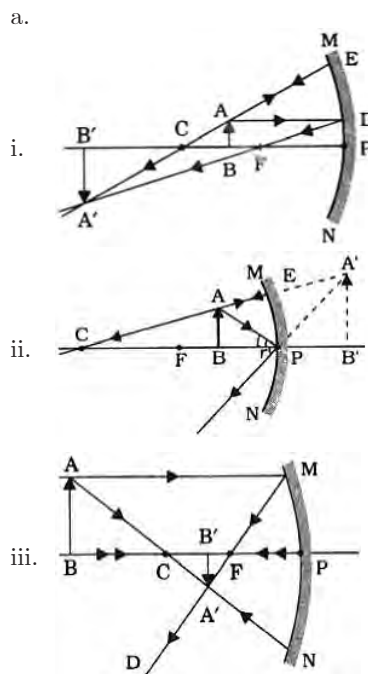
Ans : [All India 2012]

- a. Use of concave mirrors
 (i) Head light of vehicles
 (ii) Used by ENT doctors to focus the light
Use of convex mirror: Used as rear view mirrors in vehicles.



76. (a) Draw a ray diagram in each of the following cases to show the position and nature of the image formed when object is placed:
 (i) between focus and centre of curvature of a concave mirror.
 (ii) between focus and pole of a concave mirror.
 (iii) between centre of curvature and infinity for a concave mirror.
 (b) (i) Give mathematical formulae for determining magnification produced by a spherical mirror.
 (ii) What does $m = -1$ signify? Identify the mirror that can produce it.

Ans : [All India 2012]



- b.
- $$m = -1$$
- $$m = \frac{v}{u} = -1$$
- $$v = -u$$
- (i) Size of image = Size of object
 (ii) Minus sign mean that the image is real and inverted. A concave mirror can produce it when object is kept at $2F(C)$.

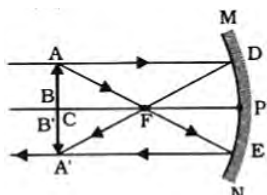
77. Draw the ray diagram in each case to show the position, nature of image formed when the object is placed:
 a. at the centre of curvature of a concave mirror
 b. within focal length of a convex lens

- c. between pole and focus of concave mirror
- d. in front of concave lens
- e. in front of convex mirror

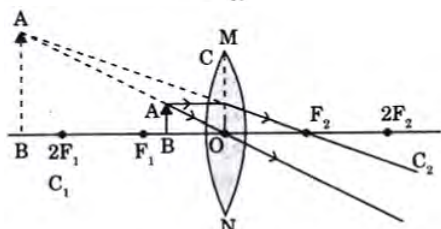
Ans :

[All India 2013]

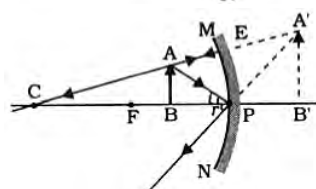
a.



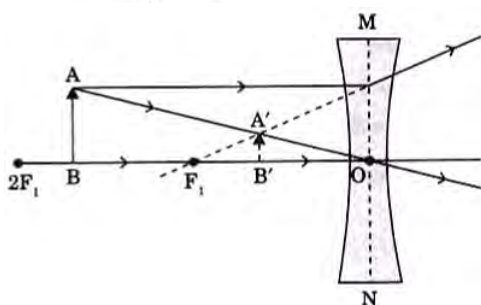
i.



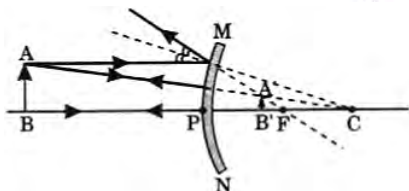
ii.



iii.



iv.



v.

78. (a) A converging lens forms a real and inverted image of an object at a distance of 100 cm from it. Where should an object be placed in front of the lens, so that the size of the image is twice the size of the object? Also, calculate the power of a lens.
- (b) State laws of refraction.

Ans :

[All India 2014]

(a)

$$v = +100 \text{ cm}$$

$$m = +2$$

$$m = \frac{v}{u} = \frac{100}{u} = 2 \Rightarrow u = 50 \text{ cm}$$

Lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{100} - \frac{1}{(-50)} = \frac{3}{100}$

$$f = \frac{100}{3} \text{ cm} = \frac{1}{3} \text{ m}$$

$$P = \frac{1}{f} = +3 \text{ D}$$

(b) (i) Snell's law

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

- (ii) Incident ray, normal to the point of incidence and refracted ray lie in the same plane.

79. (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.

Ans :

[All India 2014]

- a. See the key points in the beginning of this chapter.

- b. $f = +12 \text{ cm}$,
 $v = +48 \text{ cm}$
 $u = ?$

Lens formula

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

$$\frac{1}{48} - \frac{1}{u} = \frac{1}{12} \text{ or } \frac{1}{u} = \frac{1}{48} - \frac{1}{12}$$

or

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

80. Draw a labelled ray diagram to locate the image of an object formed by a convex lens of focal length 20 cm when the object is placed 30 cm away from the lens.

Ans :

[All India 2015]

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

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

$$v = ?$$

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

$$\frac{1}{v} - \frac{1}{(-30)} = \frac{1}{20}$$

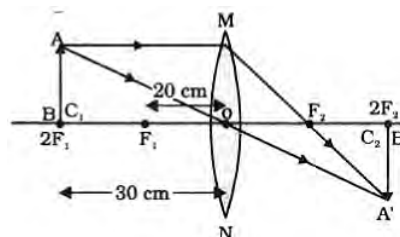
$$\frac{1}{v} = \frac{1}{20} - \frac{1}{30} \Rightarrow v = 60 \text{ cm}$$

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

$$R = 40 \text{ cm},$$

$$u = 30 \text{ cm}$$

Object is placed in between F and $C(2F)$ image is formed beyond $2F(C)$ enlarged image.



81. An object is situated at 8 cm from a convex lens of focal length 10 cm. Find the position and nature of image. Draw ray diagram to illustrate the formation

of image (not to scale).

Ans :

[All India 2015]

$$u = -8 \text{ cm}$$

$$f = +10 \text{ cm}$$

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

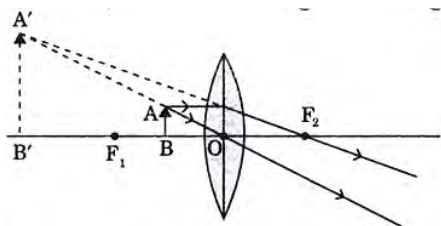
$$\frac{1}{v} - \frac{1}{-8} = \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{8}$$

$$\frac{1}{v} = \frac{4-5}{40} = \frac{-1}{40}$$

$$v = -40 \text{ cm}$$

Virtual, erected and magnified image



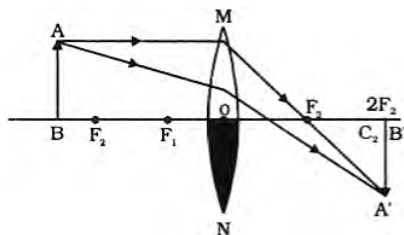
82. One half of a convex lens of focal length 10 cm is covered with a black paper. Can such a lens produce an image of a complete object placed at a distance of 30 cm from the lens? Draw a ray diagram to justify your answer.

A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image.

Ans :

[All India 2015]

Yes, the lens will produce a complete image but brightness of image will be reduced



$$h = 4 \text{ cm}$$

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

$$v = ?$$

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

$$h' = ?$$

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

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

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{15} = \frac{3-4}{60} = \frac{-1}{60}$$

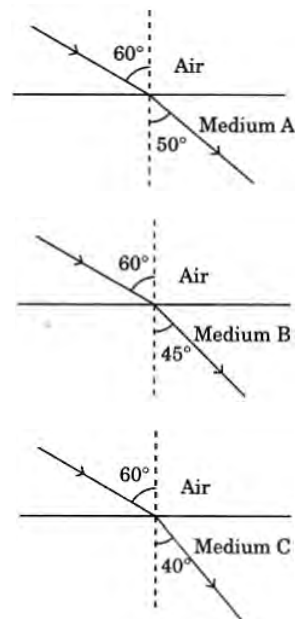
$$v = -60 \text{ cm}$$

Virtual, erect, $\frac{h'}{h} = \frac{v}{u} \Rightarrow \frac{h'}{4} = \frac{(-60)}{(-15)}$

$$h' = \frac{60}{15} \times 4$$

$$h' = 16 \text{ cm}$$

83. (a) Define absolute refractive index.
(b) The path of a light ray from three different media A, B and C for a given angle of incidence is shown below. Study the diagrams and answer the following questions:



- Which of the three media A, B or C has maximum optical density?
- Through which of the three media, will the speed of light be maximum?
- Will the light travelling from A to B bend towards or away from the normal?
- Will the refractive index of B relative to C be more than unity or less than unity?

Ans :

[All India 2015]

- Absolute refractive index of a medium is the ratio of speed of light in air/vacuum to the speed of light in medium.
- Angle of refraction in medium C is minimum. Hence medium C is maximum optical denser.
 - In least denser medium i.e. A the speed of light will be maximum.
 - Towards normal
 - Less than 1

84. State the relation between object distance, image distance and focal length of a concave or convex mirror. A concave mirror produces two times magnified real image of an object at 10 cm from it. Find the position of the image.

Ans :

[CBSE 2016]

For concave or convex mirrors the relation between u, v and f is given by

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

$$m = -2$$

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

$$m = -\frac{v}{u} = -2 \text{ or } v = 2u = -20 \text{ cm}$$

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

85. (a) Write relation between u, v, f for lenses and for mirrors, where u, v, f are object distance, image distance and focal length respectively.
- (b) The magnification produced by a concave mirror is $m = +4$. Write the information about the image given by this statement.
- (c) Draw a ray diagram for the following and show the formation of the images in case of concave mirror when the object is placed:
- between the pole and focus point.
 - at the centre of curvature.

Ans : [All India 2016]

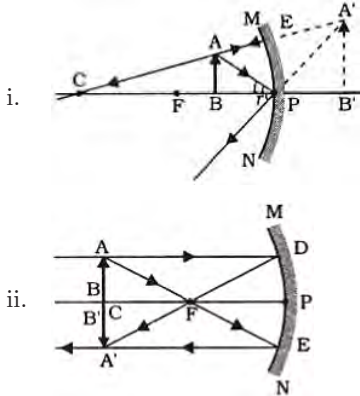
- a. u, v and f relation is given by lens formula

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

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

- b. $m = +4$ of a concave mirror means virtual, enlarged image is formed behind the mirror.

c.



86. The focal length of a concave mirror is 30 cm. Find the position of the object in front of the mirror so that the image is three times the size of the object.

Ans : [All India 2016]

$$f = -30 \text{ cm}, m = -3$$

$$u = ?$$

- a. For real image

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

$$v = 3u$$

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

$$\frac{1}{(-30)} = \frac{1}{3u} + \frac{1}{u}$$

$$-\frac{1}{30} = \frac{4}{3u} \text{ or } u = -40 \text{ cm}$$

object must be 40 cm in front of mirror to get a real inverted image by the concave mirror.

- b. For virtual image

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

$$v = -3u$$

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

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

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

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

i.e. if the object is placed at a distance of 20 cm in front of mirror then virtual, an erect image is produced by the concave mirror.

87. A 5 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30 cm. Find the

- position
- nature
- size of the image formed.

Ans : [All India 2014]

Given, $h = 5 \text{ cm}$

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

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

$$v = ?$$

- a. Lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{(-30)} = \frac{1}{20}$$

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

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

- b. Nature of the image is real, inverted and magnified.

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

$$\frac{h_2}{5} = \frac{60}{-30}$$

$$h_2 = -10 \text{ cm}$$

88. An object 4 cm high is placed at a distance of 27 cm in front of a convex lens of focal length 18 cm. Find the position, nature and size of the image formed.

Ans : [All India 2013]

We have $h_1 = 4 \text{ cm}$

$$u = -27 \text{ cm}$$

$$f = +18 \text{ cm}$$

$$v = ?$$

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

$$\frac{1}{18} = \frac{1}{v} + \frac{1}{27}$$

$$\frac{1}{v} = \frac{1}{18} - \frac{1}{27}$$

$$v = +54 \text{ cm}$$

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

$$\frac{h_2}{4} = \frac{54}{-27}$$

$$h_2 = -8$$

Size of image is 8 cm, -ve sign means image is real,

inverted and 2 times magnified.

- 89.** An object 5 cm high is kept 25 cm away from a converging lens (convex lens) of focal length 10 cm. What is nature, position and the size of the image?

Ans : [All India 2016]

Given: $h_1 = 5$ cm (height of object)

$$u = -25 \text{ cm}$$

$$f = +10 \text{ cm}$$

$$v = ?$$

Lens formula

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

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

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$$

$$v = \frac{50}{3} \text{ cm} = 16.7 \text{ cm}$$

Size of image,

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

$$\frac{h_2}{5} = \frac{16.7}{-25}$$

$$h_2 = -\frac{16.7}{5} = -3.3 \text{ cm}$$

Image is real, smaller in size, inverted at a distance of 16.7 cm from the lens.

- 90.** An object is placed 15 cm from a convex mirror of radius of curvature 60 cm. Find the position of image and its magnification.

Ans : [All India 2016]

Here, $u = -15$ cm

$$R = +60 \text{ cm}$$

$$f = \frac{R}{2} = +30 \text{ cm}$$

$$v = ?$$

$$m = ?$$

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

$$\frac{1}{30} = \frac{1}{v} - \frac{1}{15}$$

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

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

$$m = -\frac{v}{u} = -\frac{10}{-15} = \frac{2}{3}$$

- 91.** A point object is placed at a distance of 12 cm from a convex lens on its principal axis. Its image is formed on the other side of the lens at a distance of 18 cm from the lens. Find the focal length of the lens. Is the image magnified? Justify your answer.

Ans : [All India 2011]

Here, $u = -12$ cm

$$v = 18 \text{ cm}$$

$$f = ?$$

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

$$= \frac{2+3}{36} = \frac{5}{36}$$

$$f = \frac{36}{5} \text{ cm} = 7.2 \text{ cm}$$

$$m = \frac{v}{u} = \frac{18}{-12} = -1.5$$

$m = -1.5$ means the image is magnified

- 92.** (a) Two lenses have power of (i) $+2D$ (ii) $-4D$. What is the nature and focal length of each lens?
(b) An object is kept at a distance of 100 cm from a lens of power $-4D$. Calculate image distance.

Ans : [All India 2012]

(a) (i) $P_1 = +2D$

$$f_1 = \frac{1}{P_1} = \frac{1}{2} \text{ m}$$

$$f_1 = 50 \text{ cm}$$

Lens is convex lens.

(ii) $P_2 = -4D$

$$f_2 = \frac{1}{P_2} = \frac{1}{-4} \text{ m}$$

$$f_2 = -25 \text{ cm}$$

Lens is concave lens.

b. For the lens of power $P = -4D$, we have

$$f = -25 \text{ cm}, u = -100 \text{ cm}$$

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

$$\frac{1}{v} - \frac{1}{(-100)} = \frac{1}{-25}$$

$$\frac{1}{v} = -\frac{1}{25} - \frac{1}{100} = \frac{-5}{100}$$

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

- 93.** A 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 its magnification.

Ans : [All India 2016]

$$h_1 = 4.5 \text{ cm}, u = -12 \text{ cm}$$

$$f = +15 \text{ cm}, v = ?$$

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

$$\begin{aligned}\frac{1}{v} + \frac{1}{-12} &= \frac{1}{15} \\ \frac{1}{v} &= \frac{9}{60} \\ v &= \frac{60}{9} = 6.7 \text{ cm} \\ m &= \frac{h_2}{h_1} = -\frac{v}{u} \\ \frac{h_2}{4.5} &= \frac{-6.7}{(-12)} \\ h_2 &= +\frac{6.7}{12} \times 4.5 \\ &= +2.5 \text{ cm}\end{aligned}$$

Size of image is +2.5, virtual, erect and smaller behind the mirror.

94. A convex mirror used on an automobile has 3 m radius of curvature. If a bus is located at 5 m from this mirror, find the position, nature and size of the image.

Ans : [All India 2016]

We have $R = +3 \text{ m}$

$$f = \frac{R}{2} = 1.5 \text{ m}$$

$$u = -5 \text{ m}$$

Mirror formula,

$$\begin{aligned}\frac{1}{v} + \frac{1}{u} &= \frac{1}{f} \\ \frac{1}{v} + \frac{1}{(-5)} &= \frac{1}{1.5} \\ \frac{1}{v} &= \frac{1}{1.5} + \frac{1}{5} = \frac{1 + .3}{1.5} = \frac{1.3}{1.5} \\ v &= \frac{15}{13} = 1.15 \text{ m} \\ m &= \frac{h_2}{h_1} = -\frac{v}{u} = -\frac{1.15}{(-5)} = 0.23\end{aligned}$$

i.e. image is virtual, erected and smaller in size behind the mirror.

95. An object, 4.0 cm in size, is placed 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of the image.

Ans : [All India 2016]

We have $h_1 = 4.0 \text{ cm}$

$$u = -25 \text{ cm}$$

$$f = -15.0 \text{ cm}$$

$$v = ?$$

$$h_2 = ?$$

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

$$\begin{aligned}\frac{1}{v} + \frac{1}{(-25)} &= \frac{1}{-15} \\ \frac{1}{v} &= -\frac{1}{15} + \frac{1}{25} = \frac{-5 + 3}{75} = \frac{-2}{75} \\ v &= -\frac{75}{2} = -37.5 \text{ cm}\end{aligned}$$

The position of screen must be 37.5 cm from the mirror.

$$\begin{aligned}m &= \frac{h_2}{h_1} = -\frac{v}{u} \\ \frac{h_2}{4.0} &= \frac{(-37.5)}{(-25)} \\ h_2 &= -\frac{37.5 \times 4}{25} = -6 \text{ cm}\end{aligned}$$

Image is enlarged, inverted, real and same side of object.

96. The power of a lens is 2.5 dioptre. What is the focal length and the type of lens?

Ans : [Delhi 2015]

$$\begin{aligned}P &= +2.5 \text{ D} \\ f &= \frac{1}{P} = \frac{100}{2.5} \text{ cm} \\ f &= 40 \text{ cm}\end{aligned}$$

Focal length is positive hence it is a convex lens.

97. A 10 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 30 cm. The distance of the object from the lens is 20 cm. Find the (i) position, (ii) nature and (iii) size of the image formed.

Ans : [All India 2014]

We have $h_1 = 10 \text{ cm}$

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

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

$$v = ?$$

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

$$\begin{aligned}\frac{1}{v} - \frac{1}{-20} &= \frac{1}{30} \\ \frac{1}{v} &= \frac{1}{30} - \frac{1}{20} = \frac{2 - 3}{60} = \frac{-1}{60}\end{aligned}$$

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

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

$$\frac{h_2}{10} = \frac{-60}{-20} = 3$$

$$h_2 = +30 \text{ cm}$$

Virtual, erect, enlarged image.

98. Find the position, nature and size of the image of an object 3 cm high placed at a distance of 9 cm from a concave mirror of focal length 18 cm.

Ans : [All India 2004]

$$\begin{aligned}h_1 &= 3 \text{ cm} \\ u &= -9 \text{ cm} \\ f &= -18 \text{ cm} \\ v &= ?\end{aligned}$$

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

$$\frac{1}{v} + \frac{1}{-9} = \frac{1}{-18}$$

$$\frac{1}{v} = \frac{1}{18} + \frac{1}{9} = \frac{1}{18}$$

$$v = 18 \text{ cm}$$

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

$$\frac{h_2}{3} = -\frac{18}{(-9)}$$

$$h_2 = 6 \text{ cm}$$

Image is formed at a distance of 18 cm behind the mirror which is erected, virtual and magnified image.

99. (a) 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.
(b) 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.

Ans : [All India 2012]

- (a) $u = -10 \text{ cm}$

Let a real image is formed in concave mirror i.e.,

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

$$v = 3u$$

$$v = 3 \times 10 \text{ cm} = 30 \text{ cm}$$

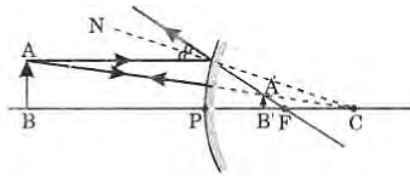
Mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

$$\frac{1}{f} = -\frac{1}{30} - \frac{1}{10} = -\frac{4}{30}$$

$$f = -\frac{30}{4} = -7.5 \text{ cm}$$

- (b) When $u = -6 \text{ cm}$ from pole of a convex mirror.
For convex mirror, the image will be virtual, erected and smaller.



100. An object 1 cm tall is placed at a distance of 15 cm from a concave mirror of focal length 10 cm. Find the position, size and nature of the image formed.

Ans : [All India 2013]

In concave mirror

$$h_1 = 1 \text{ cm}$$

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

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

$$v = ?$$

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

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

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

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

$$m = \frac{h_2}{h_1} = -\frac{v}{u} \Rightarrow \frac{h_2}{1} = -\frac{(-30)}{(-15)}$$

$$h_2 = -2 \text{ cm}$$

Image is real, inverted and 2 times larger.

101. A 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of 1 focal length 10 cm. The distance of the object from the lens is 15 cm. Find the position, nature and size of the image forms.

Ans : [All India 2013]

In convex lens, $h_1 = 2.0 \text{ cm}$

$$f = 10 \text{ cm}$$

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

$$v = ?$$

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

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

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$$

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

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

$$\frac{h_2}{2.0} = \frac{30}{-15}$$

$$h_2 = -4 \text{ cm}$$

Image is real, inverted and four times enlarged.