a. Explain the difference between a plane mirror, a concave mirror and a convex mirror with respect to the type and size of the images produced.

Type and size of the image :

(i) Plane mirror

Image virtual, upright (erect) and of the same size as that of the object.

(ii) Concave mirror

Depending on the distance between the object and the mirror, the image is real or virtual, inverted or erect, smaller than the object or larger than the object or of the same size as that of the object.

(iii) Convex mirror

Image virtual, erect and smaller than the object.

b. Describe the positions of the source of light with respect to a concave mirror in 1.Torch light 2. Projector lamp 3. Floodlight.

(a) In a torch light, the source of light is placed at the focus of the concave mirror to obtain a parallel beam of light.

(b) In a projector lamp, the source of light is placed at the centre of curvature of the concave mirror.

(c) In a floodlight, the source of light is placed just beyond the centre of curvature of the concave mirror.

c. Why are concave mirrors used in solar devices ?

(1) When rays of light coming from a distant object or source such as the sun and parallel to the principal axis are incident on a concave mirror, after reflection, they converge to a single point (focus). Thus, a concave mirror is a focusing mirror.

(2) This results in concentration of heat of the sunlight at the point. Hence, concave mirrors are used in solar devices.

d. Why are the mirrors fitted on the outside of cars convex ?

(1) When an object is kept in front of a convex mirror, we get an erect and diminished image of the object.

(2) Thus, the convex mirror fitted by the side of a car driver, enables him to get an erect, clear and complete view of the vehicles coming from behind. Hence, a convex mirror is used as a rear-view mirror in a car.

e. Why does obtaining the image of the sun on a paper with the help of a concave mirror burn the paper ?

(1) When rays of light coming from a distant of object or source such as the sun and parallel to the principal axis are incident on a concave mirror, after reflection, they converge to a single point (focus).

(2) This results in concentration of heat of the sunlight at that point.

(3) For the same reason, if the image of the sun is obtained on a paper, using a concave mirror, the paper burns.

f. If a spherical mirror breaks, what type of mirrors are the individual pieces ?

If a spherical mirror breaks, the individual pieces are of the same type as the original mirror (concave or convex) because there is no change in the nature of the reflecting surface and the radius of curvature.

2. What sign conventions are used for reflection from a spherical mirror ?

According to the Cartesian sign convention, the pole (P) of a spherical mirror is taken as the origin and principal axis is taken as the x-axis of the frame of reference.

(1) The object is always placed on the left of the mirror. All distances parallel to the principal axis are measured from the pole of the mirror.

(2) All distances measured to the right of the origin (pole) are taken as positive while distances measured to the left of the origin (pole) are taken as negative.

(3) Distances measured vertically upwards from the principal axis are taken as positive.

(4) Distances measured vertically downwards from the principal axis are taken as negative.

(5) The focal length of a convex mirror is positive while that of a concave mirror is negative.

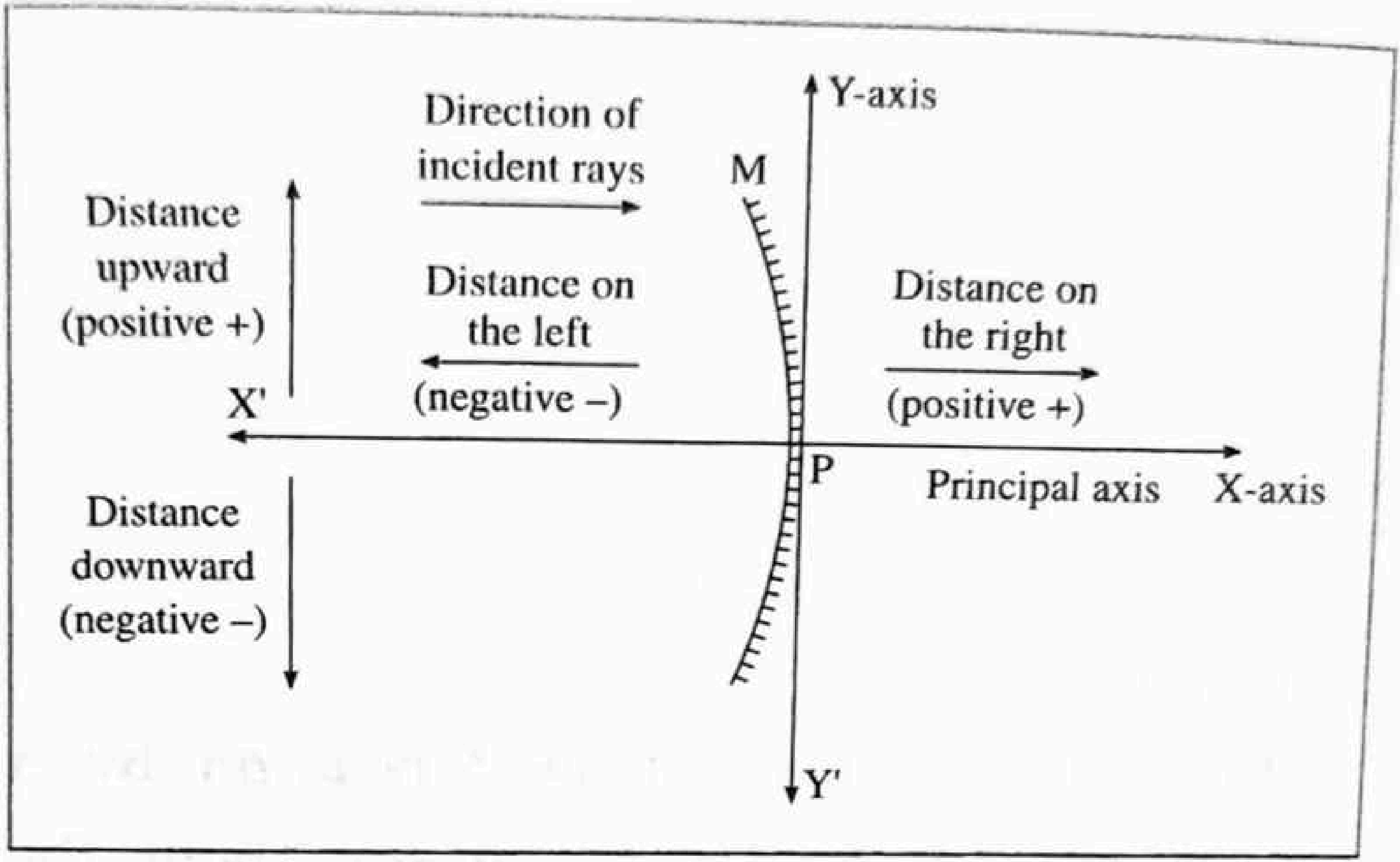


Fig. 11.23 : Cartesian sign conventions

[***Note*** : In Fig. 11.23 a concave mirror is shown. One may as well as show a convex mirror instead. The sign convention remains the same, whether the mirror is concave or convex.]

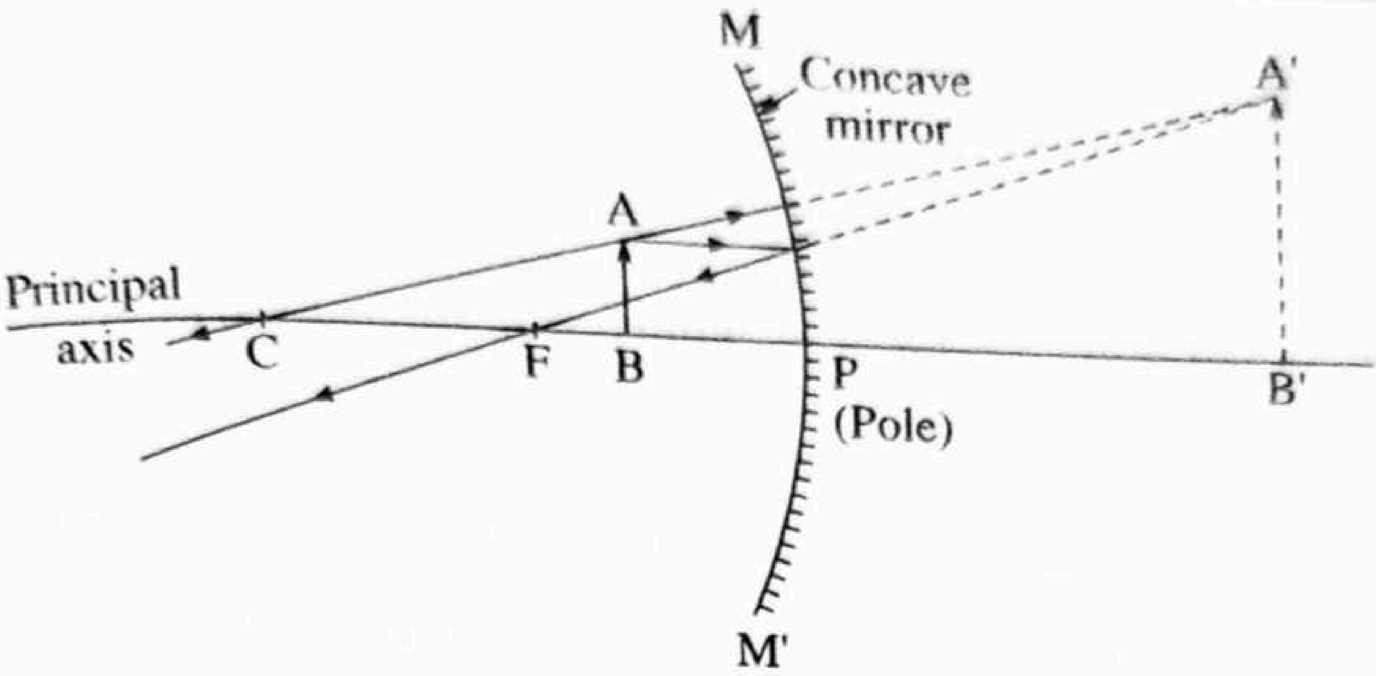
3. Draw ray diagrams for the cases of images obtained in concave mirrors as described in the table on page 122.

Images formed by concave mirrors

No.	Position of the object	Position of the image	Nature of image	Size of the image
1	Between pole and focus	Behind the mirror	Erect, virtual	Magnified
2	At the focus	At infinity	Inverted, real	Very large
3	Between focus and centre of curvature	Beyond the centre of curvature	Inverted, real	Magnified
4	At the centre of curvature	At the centre of curvature	Inverted, real	Same as the object
5	Beyond the centre of curvature	Between the centre of curvature and focus	Inverted, real	Diminished
6	At a very large (infinite) distance	At focus	Inverted, real	Point image

(1) Object between the pole and the focus of the mirror.

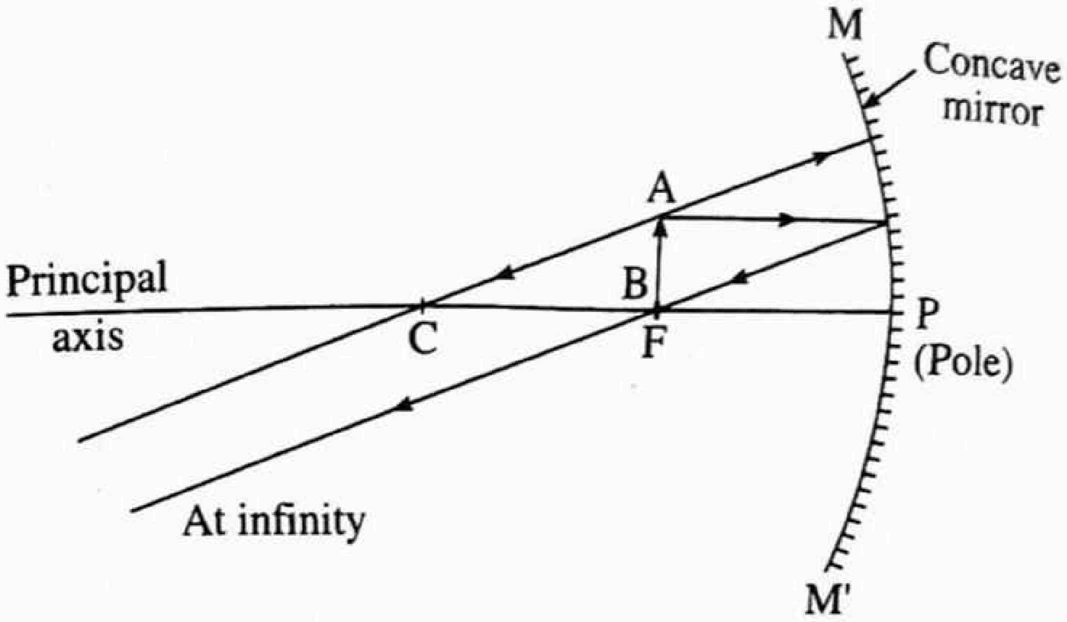
Object between P and F



P : Pole, C : Centre of curvature, F : Focus,
PF : Focal length (f), PC : Radius of curvature (R),
AB : Object, A′B′ : Image, PB : Object distance (u),
PB′ : Image distance (v)

(2) Object at the focus of the mirror.

Object at F



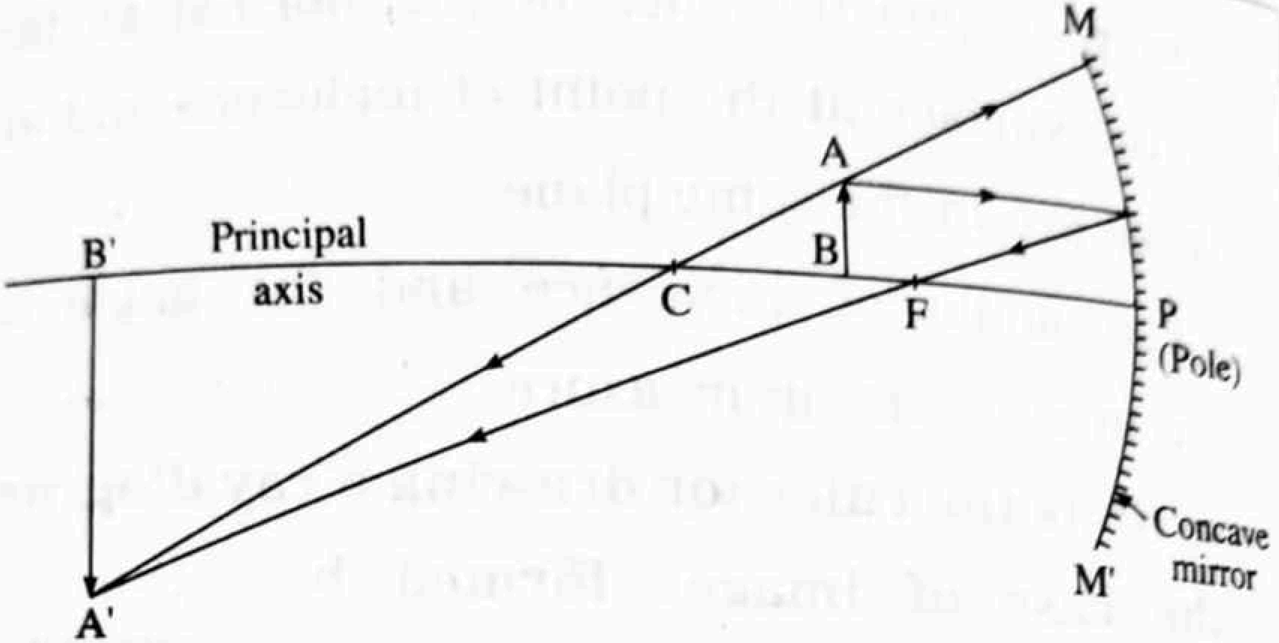
C : Centre of curvature, F : Focus,

PF : Focal length (f), PC : Radius of curvature (R),

AB : Object, PB : Object distance (u)

(3) Object between the centre of curvature and the focus of the mirror.

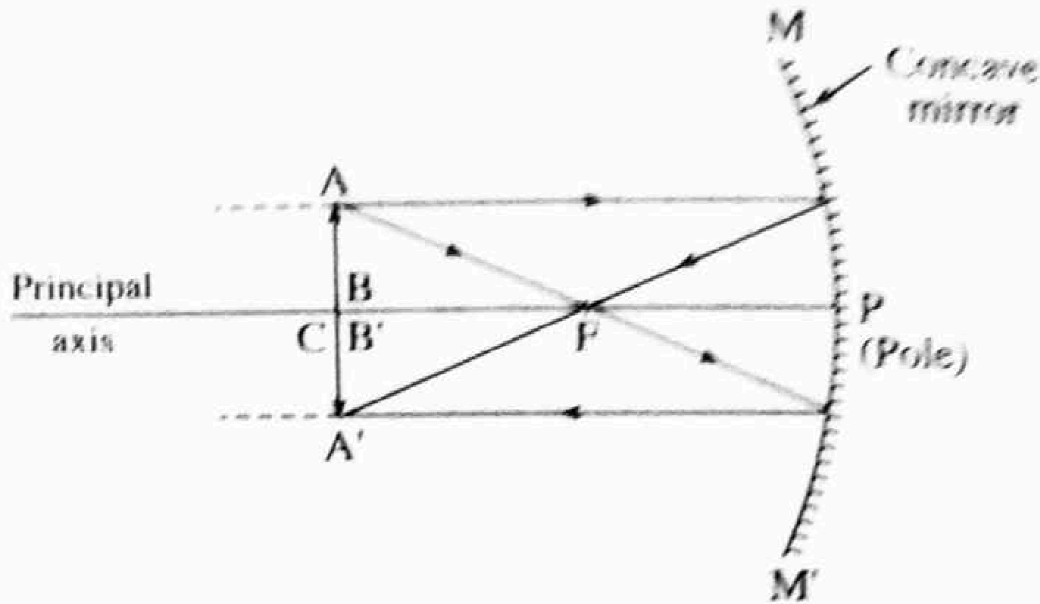
Object between C and F



C : Centre of curvature, F : Focus, PF : Focal length (f),
PC : Radius of curvature (R), AB : Object, A′B′ : Image,
PB : Object distance (u), PB′ : Image distance (v)

(4) Object at the centre of curvature of the mirror

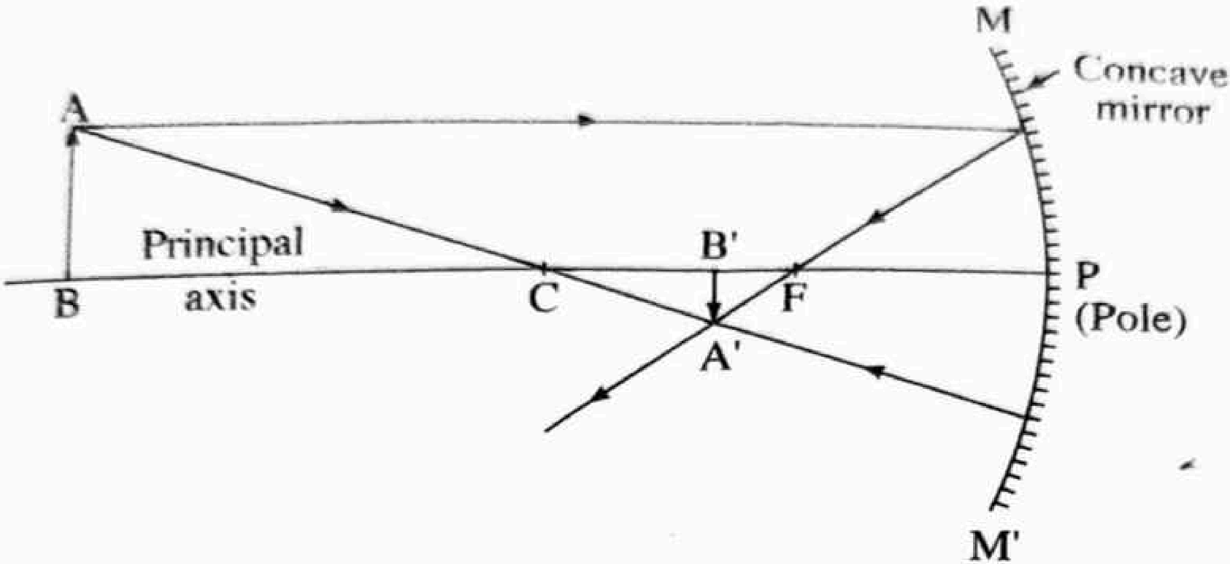
Object at C



C : Centre of curvature, F : Focus, PF : Focal length (f),
PC : Radius of curvature (R), AB : Object, A′B′ : Image,
PB : Object distance (u), PB′ : Image distance (v)

Fig. 11.17 : Object at C

(5) Object beyond the cenre of curvature of the mirror.

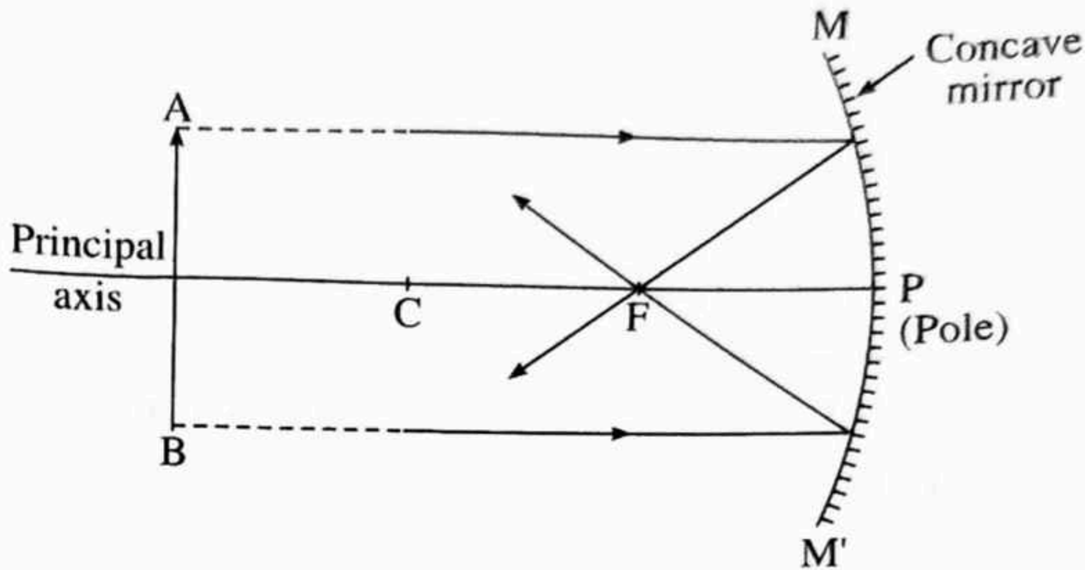


C : Centre of curvature, F : Focus, AB : Object, A′B′ : Image,

PF : Focal length (f), PC : Radius of curvature (R),

PB : Object distance (u), PB' : Image distance (v)

(6) Object at infinity



C : Centre of curvature, F : Focus, AB : Object at infinity

PF : Focal length (f), PC : Radius of curvature (R)

4. Which type of mirrors are used in the following ?

Periscope, floodlights, shaving mirror, kaleidoscope, street lights, head lamps of a car

Periscope - plane mirror,
floodlights - concave mirror,
shaving mirror - concave mirror,
kaleidoscope - plane mirror,
street lights - convex mirror,
head lamps of a car - concave mirror.

5. Solve the following examples

a. An object of height 7 cm is kept at a distance of 25 cm in front of a concave mirror. The focal length of the mirror is 15 cm. At what distance from the mirror should a screen be kept so as to get a clear image? What will be the size and nature of the image?

Solution:

Given: Object size (h_1) = 7 cm

Object distance (u) = -25 cm

Focal length (f) = -15cm

To find: Image distance (u) = ?

Image size (h_2) = ?

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

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

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

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

$$\therefore \quad \frac{1}{v}=\frac{1}{-15}-\frac{1}{-25}$$

$$\therefore \quad \frac{1}{v}=\frac{-1}{15}+\frac{1}{25}$$

$$\therefore \quad \frac{1}{v}=\frac{-5+3}{75}$$

$$\therefore \quad \frac{1}{v}=\frac{-2}{75}$$

$$\therefore \quad v=\frac{-75}{2}$$

$$\therefore \quad v=-37.5 \text{ cm}$$

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

$$\therefore \quad h_2 = \frac{-vh_1}{u}$$

$$\therefore \quad h_2 = -\left(\frac{-75}{2} \times \frac{7}{-25}\right)$$

$$\therefore \quad h_2 = \frac{-21}{2}$$

$$\therefore \quad h_2 = -10.5 \text{ cm}$$

The height of the image is 10.5 cm, it is an inverted and enlarged image.

b. A convex mirror has a focal length of 18 cm. The image of an object kept in front of the mirror is half the height of the object. What is the distance of the object from the mirror?

Solution:

Given: Image size (h_2) = $^1/_2\, h_1$

Focal length (f) = 18 cm

To find: Object distance (u) ?

Formula:

(i) $M = \frac{h_2}{h_1} = -\frac{v}{u}$ (ii) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Solution: $M = \frac{h_2}{h_1}$

$\therefore \quad M = \frac{1}{2} \times \frac{\cancel{h_1}}{\cancel{h_1}}$

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

Now $M = -\frac{v}{u}$

$\therefore \quad -\frac{v}{u} = \frac{1}{2}$

$\therefore \quad v = -\frac{1}{2}u = -\frac{u}{2}$

$\therefore \quad \frac{1}{v} = \frac{-2}{u}$

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

$\frac{-2}{u} + \frac{1}{u} = \frac{1}{f}$

$\frac{(-2+1)}{u} = \frac{1}{18}$

$\frac{-1}{u} = \frac{1}{18}$

$\therefore \quad u = -18 \text{ cm}$

The object is placed in front of the convex mirror at a distance of 18 cm.

c. A 10 cm long stick is kept in front of a concave mirror having focal length of 10 cm in such a way that the end of the stick closest to the pole is at a distance of 20 cm. What will be the length of the image?

Solution:

Given: Object size (h_1) = 10 cm

Object distance (u) = -20 cm

Focal length (f) = -10 cm

To find : Image size (h_2) = ?

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

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

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

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

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

$\therefore \quad \frac{1}{v}=\frac{(-2+1)}{20}$

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

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

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

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

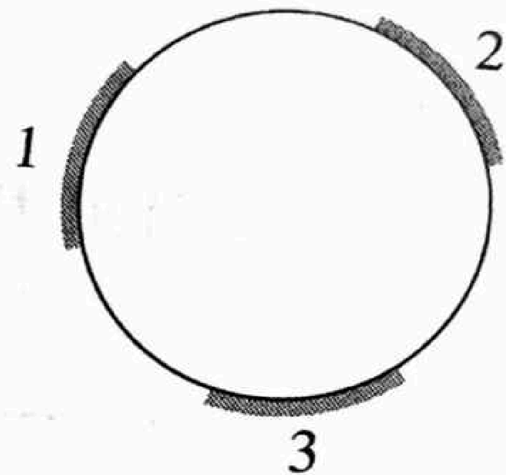
$\therefore \quad h_2=\frac{-(v \times h_1)}{u}$

$\therefore \quad h_2=\frac{-(-20 \times 10)}{-20}$

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

The height of the image is 10 cm and it is a real and inverted image.

6. Three mirrors are created from a single sphere. Which of the following - pole, centre of curvature, radius of curvature, principal axis - will be common to them and which will not be common ?



The centre of curvature, and the radius of curvature will be common to the three mirrors, while the pole and principal axis will not be common.