4.Reflection of light

Focus Area

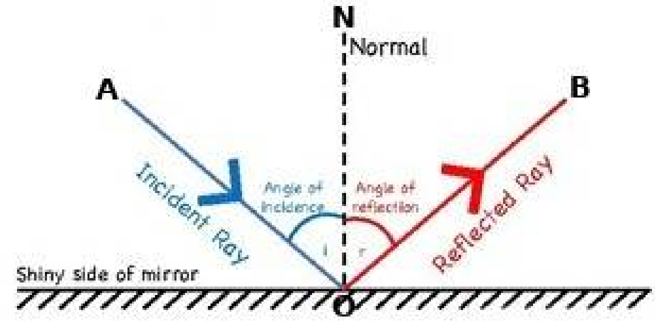
1. Reflection - laws of reflection.
2. Characteristics of image formed in concave mirror and convex mirror.
3. Mirror equation- related problems.
4. Magnification- related problems.
5. New cartesian sign convention.

1. Reflection - laws of reflection.

Reflection of light

* Light falling on the surface of an object comes back to the same medium. This is reflection of light.

Laws of reflection



• Which is the incident ray?
AO

• Which is the reflected ray?
OB

• Is there any relation between the angle of incidence and the angle of reflection?
angle of incidence is equal to the angle of reflection

• Are the incident ray, reflected ray and normal to the mirror at the point of incidence in the different planes?
In the same plane

Laws of reflection

When light is reflected from a smooth surface, the angle of incidence and angle of reflection are equal. The incident ray, reflected ray and normal to the surface are in the same plane.

2.Characteristics of image formed in concave mirror and convex mirror.

Plane mirror	Convex mirror	Concave mirror	
		Position of object	Position of image and features
Image is behind the mirror. Distance of object from the mirror and distance of the image from the mirror are equal. The image is virtual, erect and is of the same size as that of the object.	Image is formed In between the pole of the mirror and the principal focus. The image is diminished, virtual and erect.	At infinity	At focus, Small, real, inverted
		Beyond C	Between F and C, small, real, inverted
		At C	At C, Same size as object, real, inverted
		Between C and F	Beyond C, Big, real, inverted
		At F	At infinity
		Between F and P	At behind the mirror, Very large, virtual, Erect

Situations in daily life where we can make use of these mirrors

Mirror	Inferences (Position of image and features)	Situations making use of them
Plane mirror	The image is behind the mirror. Distance to object and distance to image from the mirror are the same. The image is virtual, erect and is of the same size as that of the object.	For observing the face.
Convex mirror	Image is always formed in between the pole of the mirror and the principal focus. The image is diminished, virtual and erect.	Used as rear view mirror
Concave mirror	Converges distant rays to the principal focus.	Used as solar concentrators
Concave mirror	Reflects the rays coming from principal focus as parallel rays.	Used as head light of car (As reflector)
Concave mirror	For the object placed between principal focus and pole, the images formed are enlarged and erect.	Used as shaving mirror. Dentist

3. Mirror equation- related problems.

Mirror Equation and Focal Length

The distance of the object from the mirror = u
The distance to the image from the mirror = v
The focal length of the mirror = f

$$\boxed{1/f = 1/u + 1/v}$$

This is known as mirror equation

$$1/f = 1/u + 1/v$$
$$= (u + v) / uv$$

$$f = uv/(u+v)$$

$$1/u = 1/f - 1/v$$
$$= (v - f)/vf$$

$$\boxed{u = vf/(v-f)}$$

$$1/v = 1/f - 1/u$$
$$= (u - f)/uf$$
$$\boxed{v = uf/(u-f)}$$

1. When an object is placed in front of a concave mirror at a distance 30 cm from an image is obtained on a screen at a distance of 20 cm from the mirror. Find the focal length of the mirror.

The distance of the object from the mirror u = - 30 cm
The distance to the image from the mirror v = - 20 cm
The focal length of the mirror f = ?

$$f = uv/(u+v)$$
$$= (-30 \text{ x } -20) / (-30 -20)$$
$$= (600) / (-50)$$
$$f = - 12 \text{ cm}$$

2. An object is placed in front of a concave mirror 20 cm away from it. If its focal length is 40 cm, locate the position of image and its nature

The distance of the object from the mirror u = - 20 cm

The distance to the image from the mirror $v = ?$
The focal length of the mirror $f = -40$ cm

$$v = uf/(u-f)$$
$$= (-20 \times -40) / (-20 + 40)$$
$$= (800) / (20)$$
$$v = 40 \text{ cm}$$

Nature of the image - erect and virtual

3. When an object is placed in front of a concave mirror at a distance 15 cm an image is formed on a screen 10 cm away from the mirror. If the object is placed 30 cm away what is the distance to the image?

The distance of the object from the mirror $u = -15$ cm
The distance to the image from the mirror $v = -10$ cm
The focal length of the mirror $f = ?$

$$f = uv/(u+v)$$
$$= (-15 \times -10) / (-15 - 10)$$
$$= (150) / (-25)$$
$$f = -6 \text{ cm}$$

The distance of the object from the mirror $u = -30$ cm
The distance to the image from the mirror $v = ?$
The focal length of the mirror $f = -6$ cm

$$v = uf/(u-f)$$
$$= (-30 \times -6) / (-30 + 6)$$
$$= (180) / (-24)$$
$$v = -7.5 \text{ cm}$$

Nature of the image - real and inverted

4. New Cartesian Sign Convention

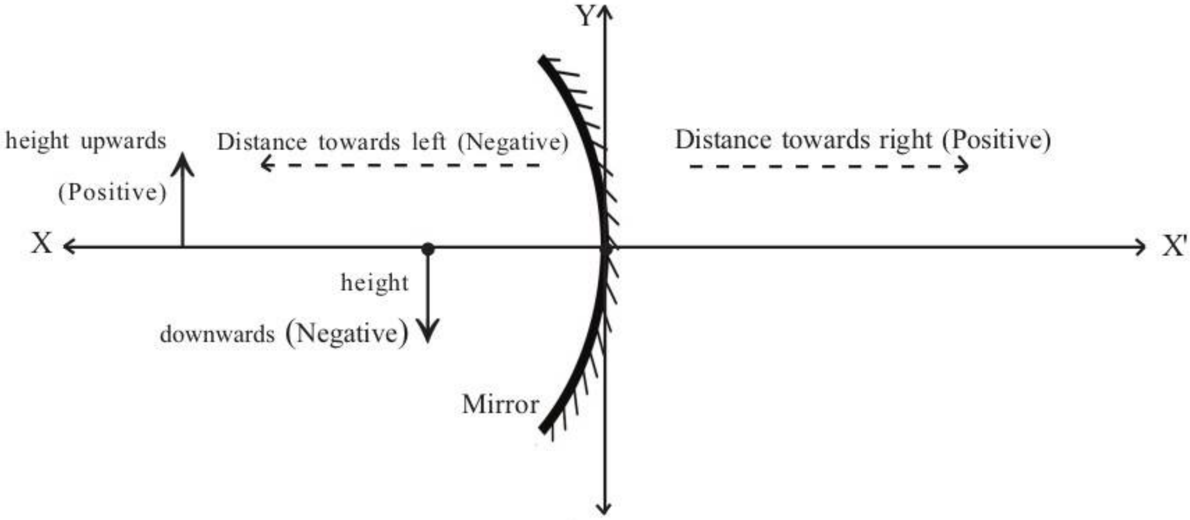
In all experiments related to lenses and mirrors the distances are measured in the same way as in graphs.

- Distances are measured considering the Pole of the mirror as the origin (O).

- Those measured to the right from O are positive and those in the opposite direction are negative.

• Distances measured upwards from X axis are positive and those downwards are negative. The incident ray is to be considered as travelling from left to right.

Record the measurements shown in the figure using the New Cartesian Sign Convention.



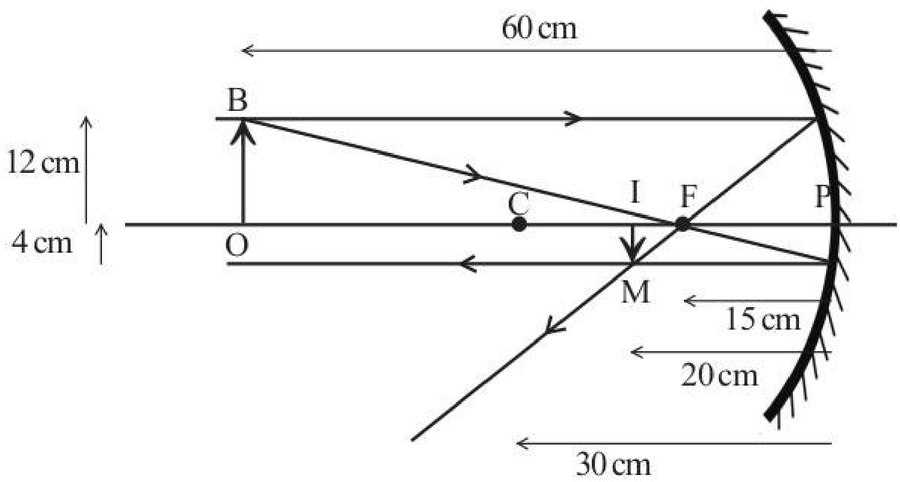
Distance to the object from the mirror (u) = Negative

Distance to the image from the mirror (v) = Negative

Height of object (OB) = Positive

Height of image (IM) = Negative

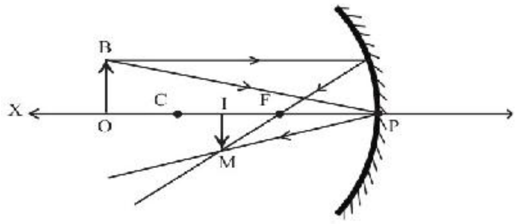
The given figure shows the image formation by a concave mirror. Analyse the figure and write down different measures using New Cartesian Sign Convention.



Distance of object from the mirror, (u)	-60 cm
Distance of image from the mirror, (v)	-20 cm
Focal length (f)	-15 cm
Radius of curvature (r)	-30 cm
Height of object (OB)	+12 cm
Height of image (IM)	-4 cm

5. Magnification- related problems.

Magnification is the ratio of height of the image to the height of the object. It is the number that indicates how many times the size of the object is the size of the image.



The figure shows the image formation when an object is placed beyond the centre of curvature C. The ray parallel and close to the principal axis has been considered. In the figure OBP and IMP are similar triangles according to the concept of similarity. Let s write down the ratio of corresponding sides of similar triangles.

$$IM/IP = OB/OP$$

In the figure, IM = h_i , OB = h_o , IP = v, OP = u. On substituting in the above equation we get $h_i / h_o = v/u$. On writing this equation in accordance with the New Cartesian Sign Convention we get

h_o = positive , h_i = negative, u = negative, v = negative.

that is $-h_i / h_o = -v/-u$

$-h_i / h_o = v/u$

But $m = h_i / h_o$

Hence $m = h_i / h_o = -v/u$

Magnification is $m = h_i / h_o = -v/u$

Height of the object	= h_o
Height of the image	= h_i
Position of the object	= u
Position of the image	= v
Magnification is	$m = h_i / h_o = -v/u$

1. When an object of height 6 cm is placed in front of a concave mirror at a distance 10 cm away from it , an image is obtained 16 cm away, on the same side. Find out the height of image and magnification.

Distance to object $u = -10$ cm
Distance to image $v = -16$ cm
Height of object $h_o = +6$ cm
Height of image $h_i = ?$
Magnification is $m = -v/u$

$$m = -(-16/-10)$$
$$= -1.6$$

Magnification is $m = h_i / h_o$

$$h_i = m \times h_o$$

Height of image $h_i = -1.6 \times 6 = -9.6$ cm

Nature of the image - Real and inverted

<u>Features of an image that is obtained from magnification</u>

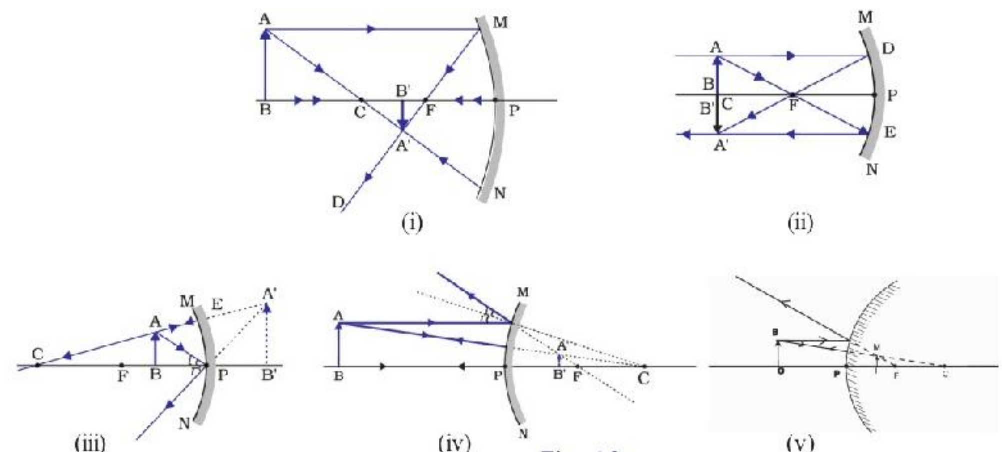


Fig. 4.9

Fig	h_i	h_o	Magnification $m = \frac{h_i}{h_o}$	Erect, virtual/ inverted, real	Size is same as that of the object/ magnified / diminished
Fig 1	Negative	Positive	Negative	inverted, real	diminished
Fig 2	Negative	Positive	Negative	Inverted,real	Same as that of object
Fig 3	Positive	Positive	Positive	Erect,Virtual	Magnified (bigger than object)
Fig 4	Positive	Positive	Positive	Erect,Virtual	Diminished (smaller than object)
Fig 5	Positive	Positive	Positive	Erect,Virtual	Diminished (smaller than object)

1. What are the features of an image that is obtained from magnification?

- When magnification is 1, the size of the image and the size of the object are equal.
- When magnification is more than 1, the size of the image is greater than the size of the object.
- When magnification is less than 1, the size of the image is smaller than the size of the object.
- When the magnification is positive, image is virtual and erect.
- When the magnification is negative, image is real and inverted.

2. From the above table, find out which mirror always gives an erect and diminished image and write it down.

- The image formed by a convex mirror is always erect and diminished.

3. Why it is written on rear view mirrors that “Objects in the mirror are closer than they appear”

- The image formed by a convex mirror is always erect and diminished. Hence the driver who sees the image of vehicles on the mirror develops a feeling that the vehicles coming from behind are at a greater distance. This may turn out to be dangerous.