semi-transparent paper at one side of the box which produces an inverted, diminished (smaller) image of the object.

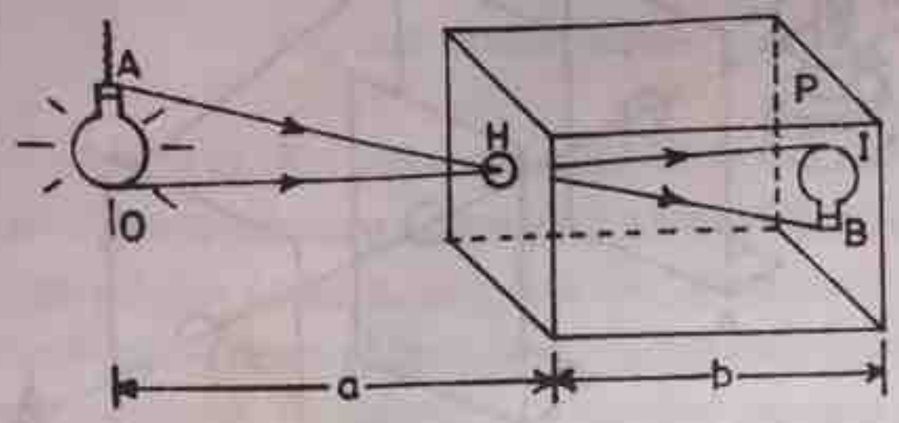


Fig. 28.11 .Pin-hole camera

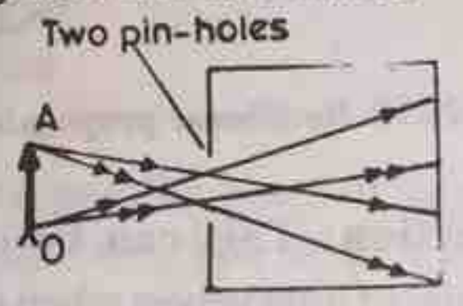


Fig. 28.12(a) Formation of image by pin-hole camera

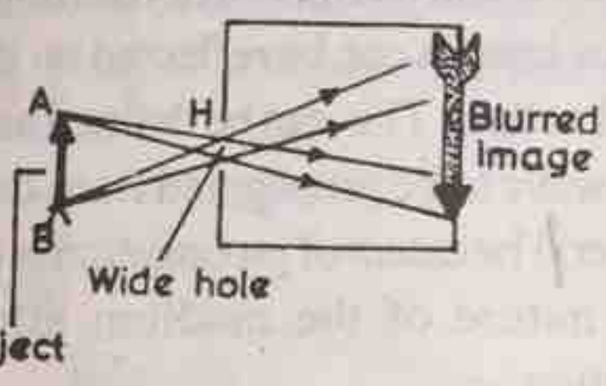


Fig. 28.12(b) Formation of image by pin-hole camera

28.7 Magnification

Magnification is defined as the ratio of the image distance to the object distance or the ratio of the image height to the object height.

$$\text{Magnification} = \frac{\text{image height}}{\text{object height}} = \frac{\text{image distance}}{\text{object distance}}$$

Thus, $M = \frac{D_i}{D_o} = \frac{H_i}{H_o}$

H_o = height of object,
H_i = height of image
D_i = distance of image from pin-hole
D_o = distance of object from pin-hole
M = linear magnification (it has no unit)

Worked example 28.1

The sun is just covered by a disc of 2cm diameter placed about 2m from the eye. If the length of the diameter of the sun's image formed by a pin-hole camera is 0.5cm, calculate the distance from the pin-hole to the screen.

Solution

$H_o = 2\text{cm}, \quad D_o = 2\text{m} = 200\text{cm}$

$H_i = 0.5\text{cm}, \quad D_i = ?$

$$M = \frac{H_i}{H_o} = \frac{D_i}{D_o}$$

$$\therefore \quad \frac{0.5}{2} = \frac{D_i}{200}$$

$$D_i = \frac{0.5 \times 200}{2} = 50\text{cm}\ (0.5\text{m})$$

Worked example 28.2

The distance between the pin-hole camera and the screen of a pin-hole camera is 12.5cm and the plate is 20cm long. At what minimum distance from the pin-hole must a 1.8m tall man stand if a full length photo is required.

Solution

Given that

Image distance = $V = 12.5\text{cm}$

Object height = $H_o = 1.8\text{m} = 1.8 \times 100 = 180\text{cm}$

Object distance = $U = ?$

Image height = $H_i = 20\text{cm}$

Using $M = \frac{V_H}{U_H} = \frac{V_d}{U_d}$

$$= \frac{20}{180} = \frac{12.5}{U_d}$$

$$U_d \times 20 = 180 \times 12.5$$

$$U_d = \frac{180 \times 12.5}{20}$$

$$U_d = 112.5\text{cm}$$

Worked example 28.3

A small hole is made up of a window shutter of a room, 10.5m wide and image of a tree outside the

room cast on the opposite. If the image is 4.5m high and the tree is 30.5cm from the window, what is the height of the tree?

Solution

Image height = $H_i = 4.5m$

Object height = $H_o = ?$

Image distance = $V = 10.5m$

Object distance = $U = 30.5cm$

$$m = \frac{H_i}{H_o} = \frac{V}{U}$$

$$\frac{4.5}{H_o} = \frac{10.5}{30.5}$$

$$H_o = \frac{4.5 \times 30.5}{10.5}$$

$$= 13.07m$$

Revision exercise

1. Explain how a light wave can be propagated in accordance with the principle of reversibility.
2. Name five properties of light waves and explain how they can be produced using a torch light as the source of rays.
3. Define the following terms: (i) *ray* (ii) *beam*. Mention three types of beams and explain with diagram/s.
4. Explain the term *rectilinear propagation of light*. With the help of a diagram, explain how shadows of objects are formed on a screen.
5. Using the sun as a source of light focused on the earth and moon, explain: (i) how eclipse of the moon and sun are formed (ii) annular eclipse.
6. Using a large source of rays, explain: (i) how the umbra and prenumbra are formed.
7. Describe how an image is formed in a pin-hole camera. State the characteristics of the images formed.
8. List three differences between a luminous and non-luminous objects and explain the following: (i) transparent body (ii) translucent body (iii) opaque body (object) in accordance with the transmission of light.
9. If the distance of an object from a pin-hole camera is 10cm and the height of the object is 5m, find the height of the image formed if the image is at a distance of 2m from the camera. Find the magnification also.
10. The distance between the pin-hole and screen of a pin-hole camera is 12.67cm and the plane is 16cm long. At what minimum distance from the pin-hole must a 1.86m tall man stand if a full photo is required. Leave your answer in meters.
11. What is *magnification*?
12(a) State the properties of light. (b) Light travels in a straight line. Argue for or against, supporting your answer with proof or experiment.
13(a) What is meant by *a beam of polarised light?*
(b) With the aid of a well labelled diagram, illustrate the action of a polaroid spectacle on a beam of sunlight (WASSCE, June 2001)
14. An object, 3.0m high is placed at a distance of 7.50m from a pin-hole camera. If the image height is 6.00cm, what is the distance of the film from the pin-hole? [NECO, 2001]
15. What is the effect of increasing the size of the hole of a pin-hole camera on:
    (a) the size of the image?
    (b) the brightness of the image?
    (c) the sharpness of the image?
16. The screen of a pin-hole camera is a square of side 160mm and it is 150mm behind the pin-hole. The camera is placed 11m from a flag staff and positioned so that the image of the flag staff is formed centrally on the screen. The image occupies three quarters of the height of screen. What is the height of the flag staff?
Ans = 8.8m.
17. Explain with a diagram the conditions necessary for a partial eclipse of the moon to occur. Why does eclipse not occur every lunar month?
18. The length of a pin-hole camera is 0.1m. What will be the height of an image when an object 1m high is placed 2m from the pin-hole?

29. REFLECTION ON PLANE MIRROR

29.1 Reflection

Reflection can simply be defined as the re-propagation of light waves when incidented at a particular angle on a plane surface.
There are two types of reflections: (i) smooth/ regular reflection (ii) diffuse/irregular reflection.
(i) Smooth/regular reflection: This is produced only on smooth surfaces. The rays are reflected and the moment they strike smooth surfaces, rays are produced. Rays formed after reflection are called *reflected rays*.

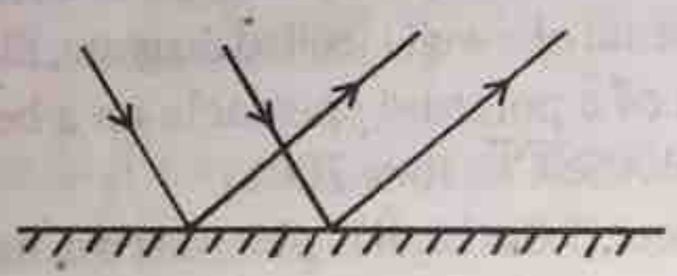


Fig. 29.1 Smooth/regular reflection

(ii) Diffused/Irregular reflection: Diffused or irregular reflection is produced from rough surfaces. Rays striking the rough surfaces are scattered or diffusely reflected in different angles. This is because of the lack of arrangement or smoothness on the surface.

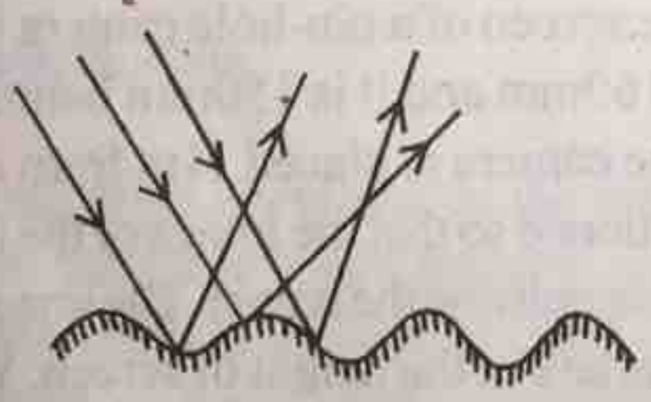


Fig. 29.2 Diffused/Irregular reflection

29.2 Laws of Reflection

There are two laws associated with reflection. The first law of reflection states that the incident ray, the reflected ray and the normal ray all lie on the same plane.

The second law of reflection states that, the angle of incidence is equal to the angle of reflection.

According to the law, incident angle i, is equal to the angle of reflection. i.e $i = r$.

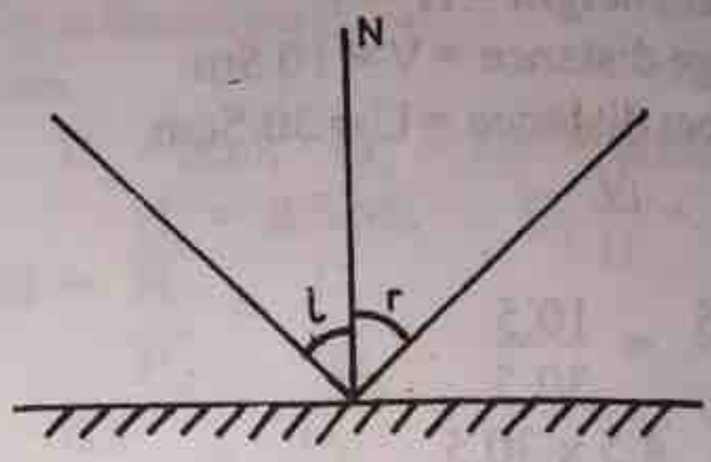


Fig. 29.3 Laws of reflection

29.3 Terms Associated with Reflection

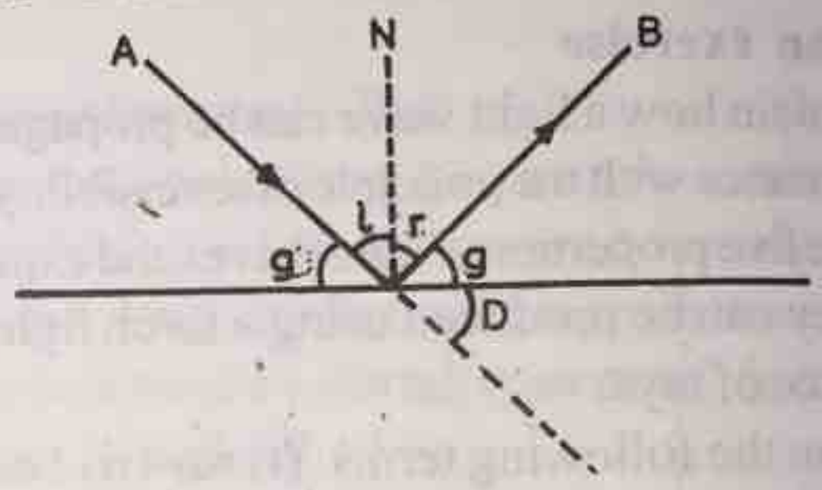


Fig. 29.4 Terms associated with reflection

Incident ray = AO
Reflected ray = OB
Normal = ON
Angle of incidence = i
Angle of reflection = r
Angle of glance = g
Angle of deviation = D
from mathematical expression, the angle of deviation (d) is equal to 2 x angle of a glance.

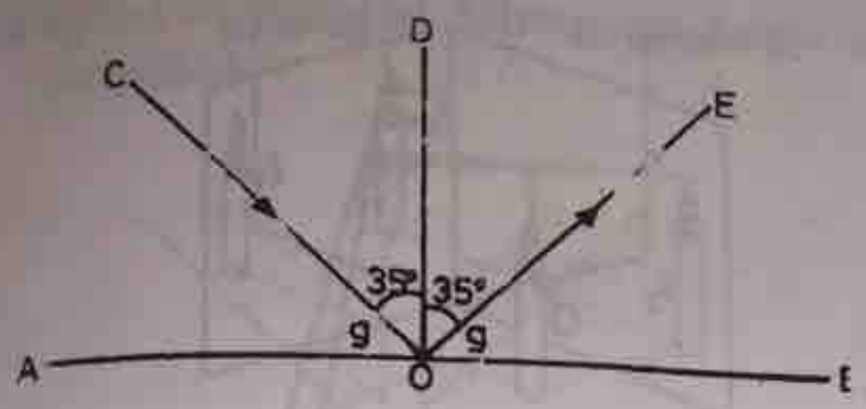
$$2 \times g = D$$
$$D = 2g$$

Worked example 29.1

If a ray incidented on a plane mirror, the incident angle is 35° to the normal, the reflected angle is also 35 to the normal. Find the angle of glance.

Solution

Since incidented and reflected angles are equal, let incident angle be x
Reflected angle = y



taking the sum of angles on a straight line that is, g

$+35° + 35° + g = 180°$

$2g + 70° = 180°$

$2g = 180° - 70°$

$180 - 70° = 2g$

$110 = 2g$

$g = \frac{110°}{2}$

$g = 55°$

Angle of glance = 55

29.4 Locating Images

If a plane mirror is placed on a wooden table, so that pins placed in front of the mirror will be able to hold their stand. The pins are placed some distance away from the mirror. If one looks through the mirror to the object pin, an image is seen.

In order to locate the position of the image, an image pin is placed on the spot where the image is formed behind the mirror.

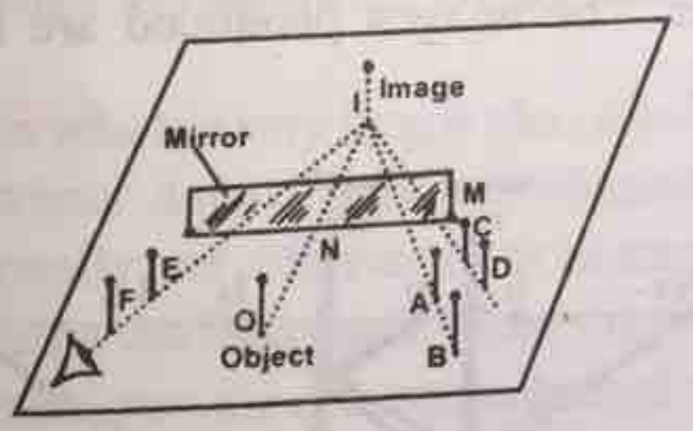


Fig. 29.5 Locating images on plane mirrors

Parallax: This refers to the deviation of the image formed as a result of improper placement of the search pins. It occurs when they are not at the same distance or linear arrangement. A slight change will balance it.

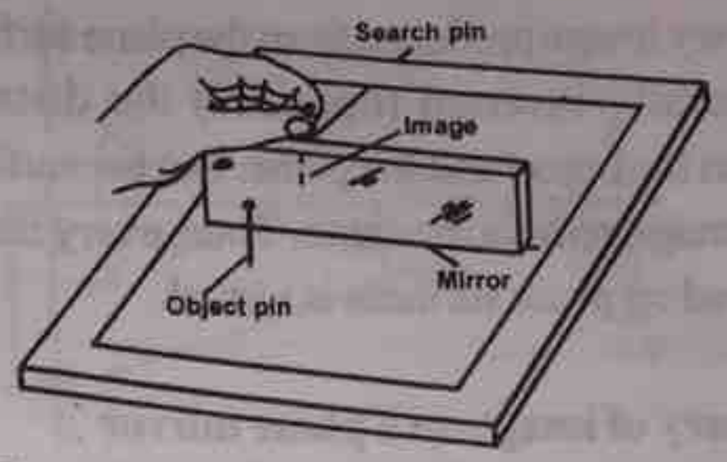


Fig. 29.6 Finding image position by no-parallax

Lateral inversion: This is the property of a plane glass which helps to differentiate plane glass from mirrors.

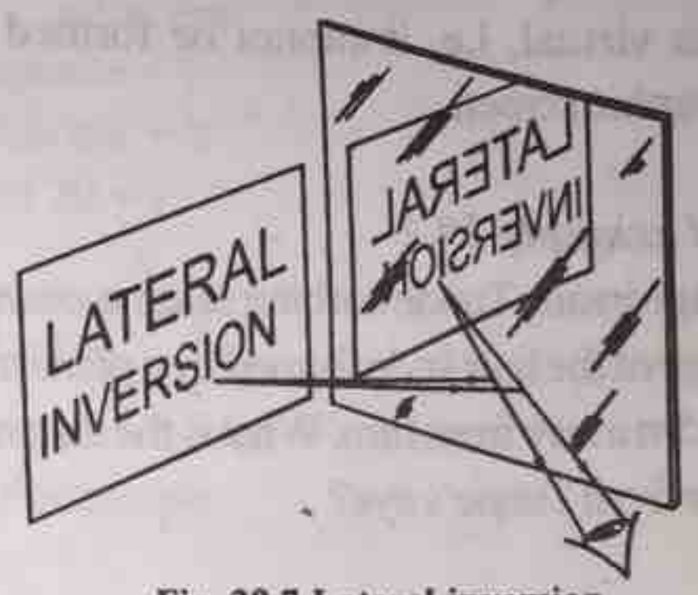


Fig. 29.7 Lateral inversion

29.5 Images Produced on Plane Surfaces

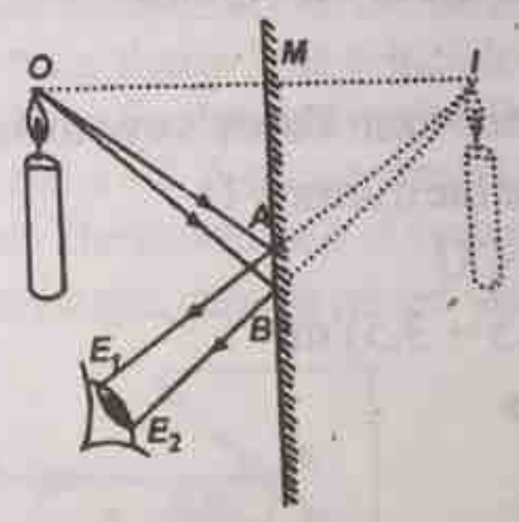


Fig. 29.8 Viewing image in a plane mirror

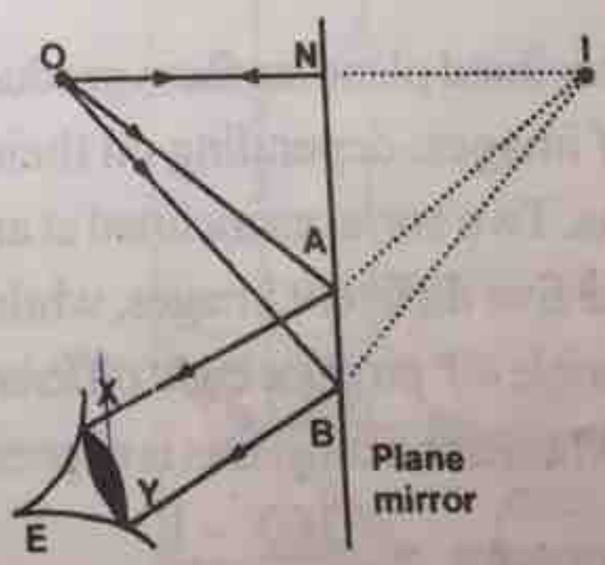


Fig. 29.9 Virtual image in a plane mirror

Every image produced from the plane surfaces are laterally inverted (opposite) the distance between the object and the plane. But the surfaces to the image remain the same. Thus, every image produced on plane surfaces is virtual.

Summary of image on a plane mirror

(i) The image is the same size as the object.
(ii) It maintains the same distance behind the mirror as the object in front.
(iii) It is laterally inverted.
(iv) It is virtual, i.e, it cannot be formed on a photographic screen.

Worked example 29.2

An image inside Tunde barbing salon is observed. The image of the hair style formed by a plane mirror is kept 3.5m away from him. What is the distance of the mirror from Tunde's eye?

Solution

Image distance = V = 3.5m
Object distance = U = 3.5m

The distance from Tunde's eye to the image formed behind the mirror = D

$D = V + U$
$= (3.5 + 3.5)\ m$
$= 7m$

29.6 Image Produced on an Inclined Plane

Most inclined plane surfaces produce limited number of images, depending on their angle of inclinations. Two surfaces inclined at an angle of 90° produce five different images, while surfaces inclined at angle 40° produce eight different number of images. Mathematically, this is expressed as:

$$\text{number of images} = \frac{360}{\theta} - 1$$

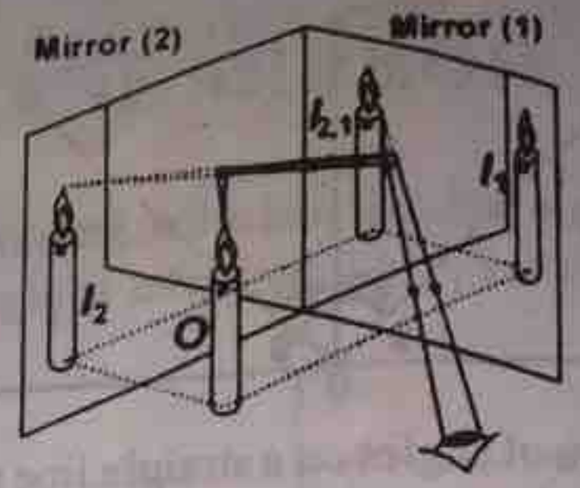


Fig. 29.10 Images formed by two mirrors at 90°

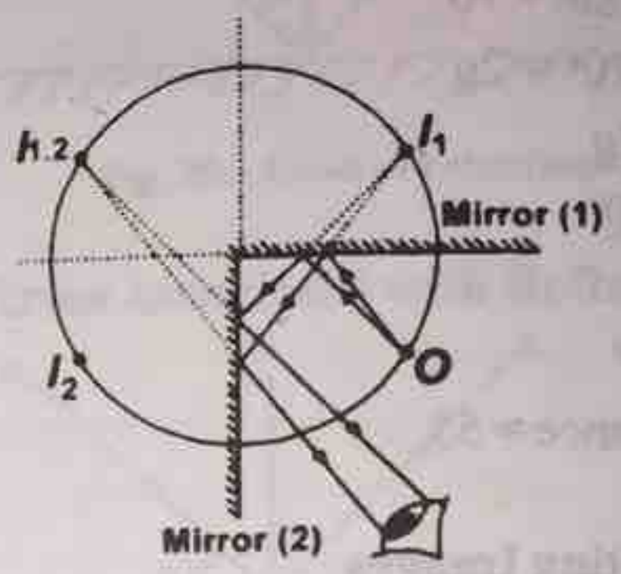


Fig. 29.11 Reflection from two mirrors at 90°

29.7 Images Produced from Parallel Plane Surfaces

The number of images produced on parallel surfaces is unlimited but sometimes it could be obstructed, depending on the position of the observer. The images produced are laterally inverted.

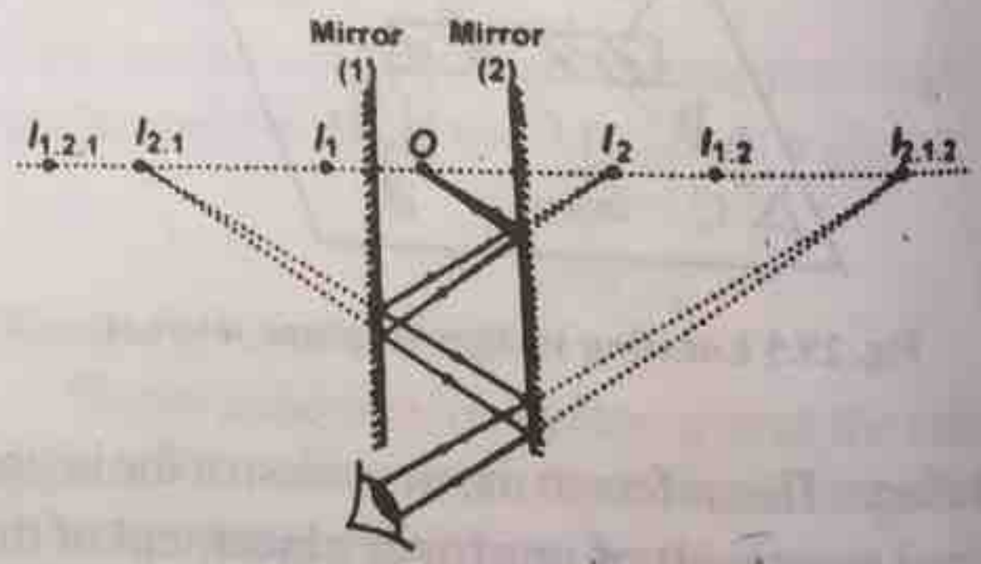


Fig. 29.12 Images formed by two parallel mirrors