16. Reflection of Light

We get different feelings through senses. The sense of vision is the most important among our five senses. Because of this we can see the hills, rivers, trees, people and objects around us. Only with this we can see the beautiful views of nature like clouds, rainbow, flying birds, Moon, stars etc.

Try this

Switch off the light in your room at night for some time and then turn it on again.

Could you see the objects in the room clearly when the light was switched off ? What did you feel when it was turned on again?

From the above activity you can notice that there is some connection between the sense of vision and light. When we switch off the light at night, the objects in the room cannot be seen and they can be seen as before when the light is switched on again. Thus, we can see objects when the light coming from these objects enters our eyes. The light entering our eyes may be emitted by the object or may be reflected by that object. What is meant by light reflected by an object? To understand this, let us learn about the reflection of light.

Reflection of light : When light rays fall on an object their direction changes and they turn back. This is called the reflection of light.

Try this

Material : Torch light, mirror, a stand for hanging the mirror, black paper, comb, white paper, drawing board.

Activity

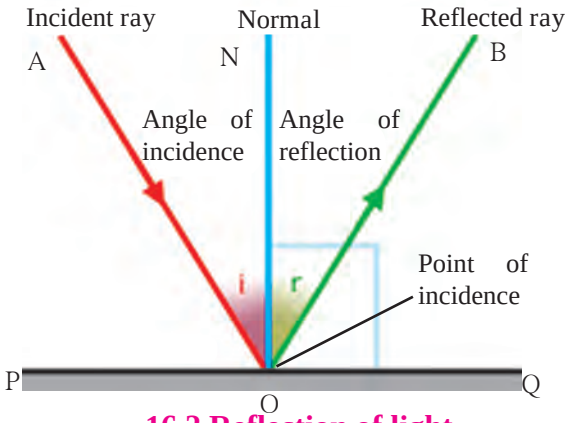
1. Fit a white paper tightly over a table or drawing board.
2. Leaving out some portion in the middle of the comb, cover the rest with black paper so that light can only pass through the open central portaion. (figure 16.1)
3. Hold the comb perpendicular to the white paper and throw torch light on its central portion.
4. Adjust comb and torch so as to get light rays on the white paper. Now keep a mirror in the path of this ray of light as shown in the figure.
5. What do you observe ?

16.1 Reflection of light

In this activity, light rays which fall on the mirror, get reflected and travel in a different direction. The rays falling on any surface are called incident rays. The point at which an incident ray falls is called the point of incidence. the rays going away from the surface after reflection are called reflected rays. The direction of the reflected rays is decided by some rules which are called laws of reflection. Let us learn some definitions before learning about these laws.

(As shown in figure 16.2)

1. Draw a line PQ, showing the position of the mirror.
2. Draw the incident ray AO and the reflected ray OB.
3. Draw a perpendicular to the line showing the position of the mirror i.e. PQ at O. This line, ON, is called normal to the mirror. As ON is perpendicular to PQ
   $\angle PON = \angle QON = 90^0$



16.2 Reflection of light

Laws of reflection

There are three laws of reflection. These are as given below.

1. The angle of reflection is equal to the angle of incidence.
2. The incident ray, the reflected ray and the normal lie in the same plane.
3. The incident ray and the reflected ray are on the opposite sides of the normal.

Some terms related to reflection are as follows.

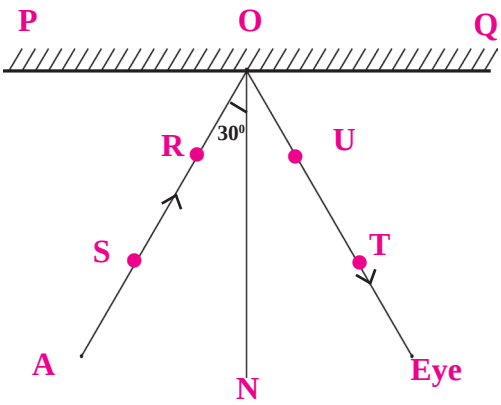
i. Ray AO is the incident ray ii. Point O is the point of incidence
iii. Ray OB is the reflected ray iv. Line ON is the normal
v. The angle $\angle AON$, between incident ray and the normal is the angle of incidence (i)
vi. The angle $\angle BON$ between the reflected ray and the normal is the angle of reflection (r)

Try this

Equipment : Mirror, drawing board, pins, white paper, protractor, scale, pencil

Activity :

1. Fit a white paper on the drawing board tightly as possible.
2. On the paper draw a line PQ indicating the position of the mirror. (figure 16.3)
3. Draw a perpendicular ON to PQ at point O.
4. Draw a ray AO making an angle of 30^0 with ON
5. Fix two pins S and R along AO.
6. Fix the mirror to a stand and place it along PQ perpendicular to the drawing board.
7. Fix pins at T and U along the line joining the bottom of the reflected images of the pins at S and R.
8. Remove the mirror and join the points T and U and extend it up to O.
9. Measure $\angle TON$.
10. Repeat steps 4 to 9 for angle of incidence equal to 45^0 and 60^0 and write down the angles in the following table.



16.3 Verification of the laws of reflection

S.No.	Angle of incidence ($\angle i$)	Angle of reflection ($\angle r$)
1.	30^0	
2.	45^0	
3.	60^0	

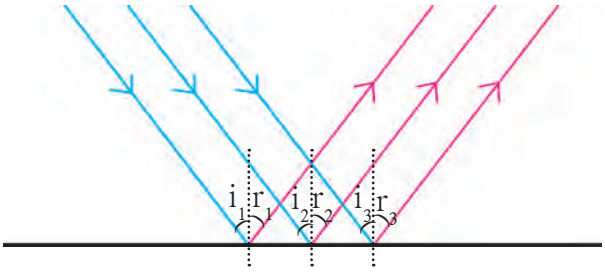
What relation do you find between the angle of incidence and the angle of reflection? If you have done the experiment carefully, you will find that the angle of incidence is equal to the angle of reflection in all three cases. This verifies the laws of reflection.

Try this

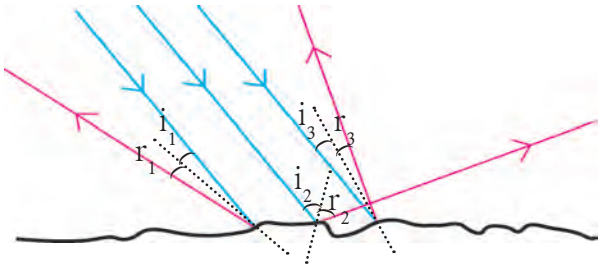
What will happen when a light ray is incident perpendicular to the mirror ?

Figure 16.4 (a) and (b) show three parallel rays, shown in blue, incident on smooth and rough surfaces. The reflected rays drawn using laws of reflection shown in red.

1. Rays reflected from which surface are parallel to one another ?
2. What conclusion can you draw from the figure ?



(a) Smooth surface



(b) Rough surface

16.4 Reflection of light from a smooth and a rough surface

1. Regular reflection of light : The reflection of light from a plane and smooth surface is called regular reflection of light. For regular reflection, the angles of incidence as well as of reflection are the same for all parallel rays falling on the surface. Thus, the reflected rays are also parallel to one another. If the angles of incidence for incident rays are i_1, i_2, i_3,.... and their angles of reflection are r_1, r_2, r_3 respectively then, $i_1 = i_2 = i_3 .... = r_1 = r_2 = r_3$ ..... (fig. 16.4 a).

2. Irregular reflection of light : Reflection of light from a rough surface is called irregular reflection of light. In irregular reflection, the angles of incidence for parallel rays of incidence are not equal and therefore their angles of reflection are also not equal $i_1 \neq i_2 \neq i_3$..... and $i_1 = r_1 \neq r_2 \neq r_3$.....

Thus, the reflected rays are not parallel to one another and spread over a large surface. This is clear from figure 16.4 (b).

Always remember

1. Laws of reflection are followed in both regular and irregular reflection.
2. The reflection of light in irregular reflection has not been obtained because the laws of reflection are not followed but they are obtained because the surface is rough. (irregular).
3. In irregular reflection the angles of incidence at different points are different. But at any one point, the angles of incidence and reflection are equal, i.e $i_1 = r_1$, $i_2 = r_2$,…

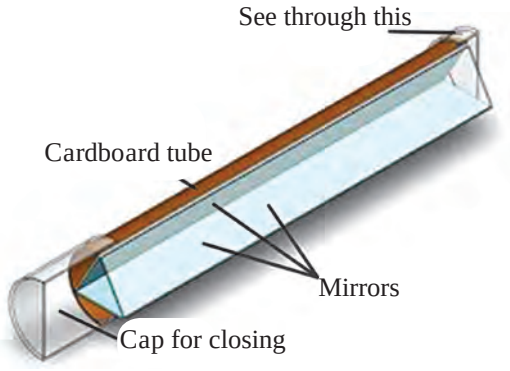
Reflection of reflected light

Can you tell?

1. How do you see if the barber in a saloon has cut the hair on your neck properly or not?
2. What type of image do we see in a mirror? What happens to the left and right sides?
3. How do we see the image of the Moon in water?

In saloon, there are mirrors in your front and at back. The image of the back of your head is formed in the mirror at the back. The image of this image is formed in the mirror in front of you. Thus you can see how the hair at the back side of your head is cut.

How do we see the image of the Moon in water? As moon is not self luminous, the Sun light falling on the surface of the Moon is reflected. This reflected light is again reflected by water to give us the image of the Moon. In this way light can be refleted serveral times.



16.5 Kaleidoscope

Try this

Kaleidoscope

Activity :

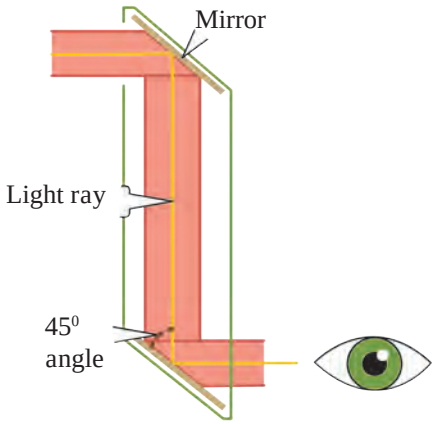
1. Take three rectangular mirrors of the same size.
2. Using sticking tape, stick the mirrors together making a triangle with the reflecting surface facing inwards (see figure16.5)
3. Take a white paper of triangular shape and fix it with tape at one end of the mirrors closing that end.
4. Insert 4-5 coloured glass pieces in the hollow of the mirrors.
5. Close the other end also with a paper and make a hole in it.
6. Look through the hole towards light. You will see innumerable images of the glass pieces. These are formed due to reflections by the three mirrors.

You can see diferent designs in the Kaleidoscope. The speciality of a Kaleidoscope is that the designs do not easily repeat themselves. Every time the design is different. People making wall papers which are used to decorate walls and cloth designers use Kaleidoscope for making new designs.

Periscope :

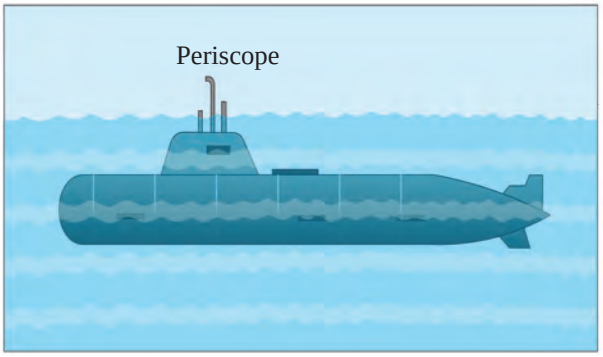
Activity :

1. Take a cardboard box. Make slits in the top and bottom sides of the box and place the two mirrors so that they make an angle of 45^0 with the sides of the box and are parallel to each other. Fix them with sticking tape (see figure 16.6).
2. Make two windows of 1 inch each near the two mirrors. Now see through the bottom window.
3. Make note of what you see.



16.6 Periscope

From the bottom window, one can see what is in front of the top window. This device is called a periscope. This is used in submarianes to see objects above the surface of water. It is also used to observe and keep a watch on the objects or persons on the ground from an underground bunker. Kaleidoscope and Periscope both use the properties of reflection of light.



16.7 Periscope on a Submarine

Solved Example

1. If the reflected ray makes an angle of 60^0 with the nomal, what angle must the incident ray make with the normal?

Given :

Angle of reflection = $\angle r = 60^0$.

Angle of incidence = $\angle i$ = ?

According to the law of reflection,

$\angle i = \angle r$ But $r = 60^0$

$\therefore \angle i = 60^0$

The incident ray will make an angle of 60^0 with the normal.

2. If the angle between the incident ray and the reflected ray is 90^0, what are the values of the angle of incidence and angle of reflection?

Given : Angle between the incident ray and the reflected ray is 90^0.

i.e. $\angle i + \angle r = 90^0$ .....(1)

According to the law of reflection,

$\angle i = \angle r$ .....(2)

$\angle i + \angle i = 90^0$

$2 \angle i = 90^0$

$\therefore \angle i = 45^0$

Angle of incidence and reflection are 45^0.

3. The angle between the plane mirror and incident ray is 35^0, what is the angle of incidence and angle of reflection?

Given : In figure 16.2, line PQ = mirror ray AO = incident ray, line ON = normal ray OB = reflected ray.

From the figure $\angle POA = 35^0$

$\angle PON = 90$ (normal)

$\angle POA + \angle AON = \angle PON$

$35^0 + \angle AON = 90^0$

$\angle AON = 90\text{-}35 = 55^0$

Thus, the angle of incidence $\angle AON = \angle i = 55^0$.

As, according to the law of reflection, $\angle i = \angle r$

$\angle r = 55^0$. angle of incidence and angle of reflection are 55^0

4. What angle will the reflected ray make with the mirror if the angle of incidence is 40^0 ?

Given : From figure 16.2.

$\angle QON = 90^0$ ..... (normal)

Angle of incidence = $\angle i = 40^0$.

$\angle NOB = \angle r = 40^0$ - (according to the law of reflection)

$\angle NOB + \angle QOB = \angle QON$

$40^0 + \angle QOB = 90^0$

$\angle QOB = 90^0 - 40^0 = 50^0$

The reflected ray will make an angle of 50^0 with the mirror.

Exercises

1. Fill in the blanks

i. The perpendicular to the mirror at the point of incidence is called.....

ii. The reflection of light from a wooden surface is..... reflection.

iii. The working of Kaleidoscope is based on the properties of .....

2. Draw a figure describing the following.

The reflecting surfaces of two mirrors make an angle of 90^0 with each other. If a ray incident of one mirror has an angle of incidence of 30^0, draw the ray reflected from the second mirror. What will be its angle of reflection?

3. How will you explain the statement 'we cannot see the objects in a dark room'?

4. Explain the difference between regular and irregular reflection of light.

5. Draw a figure showing the following.

a. Incident Ray
b. Normal
c. Angle of incidence
d. Angle of reflection
e. Point of incidence
f. Reflected ray

6. Study the following incident.

Swara and Yash were looking in a water filled vessel. They could see their images clearly in the still water. At that instant, Yash threw a stone in the water. Now their images were blurred. Swara could not understand the reason for the blurring of the images.

Explain the reason for blurring of the images to Swara by answering the following question.

i. Is there a relation between the reflection of light and the blurring of the images?

ii. Which types of reflection of light can you notice from this?

iii. Are laws of reflection followed in these types of reflection?

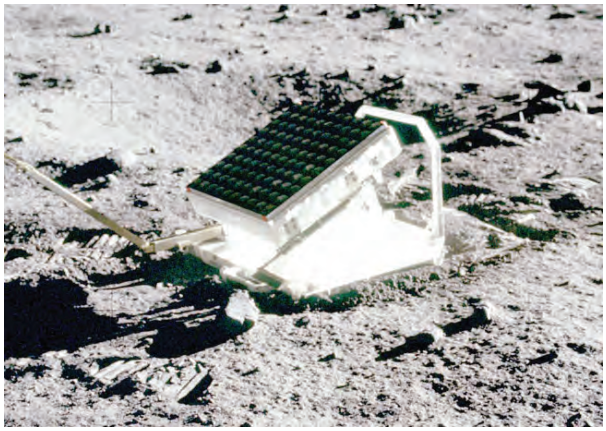
7. Solve the following examples.

a. If the angle between the plane mirror and the incident ray is 40^0, what are the angles of incidence and reflection?
(Ans. 50^0)

b. If the angle between the mirror and reflected ray is 23^0, what is the angle of incidence of the incident ray?
(Ans. 67^0)

Project :

Apollo astronauts who stepped on the moon have kept some large mirrors there. Collect information about how the distance to the moon is measured using these.



JXESFS