2 Light, Shadows and Reflection

"You can see through the transparent glass in the window. You cannot see through the wall because it is opaque."

1. What makes things visible?

Look around your darkened room at night. You cannot see an object in the dark. This means that eyes alone cannot see any object. It is only when light from an object enters our eyes than only we can see the object. Thus, **light is a form of energy which excites our sense of sight**.

Sources of light

During the day, the primary source of light is the Sun and the secondary source is the brightness of the sky. Other common sources are flames, electric bulbs, tube lights (fluorescent tubes), compact fluorescent lamps (CFLs) and light emitting diodes (LEDs).

Luminous objects

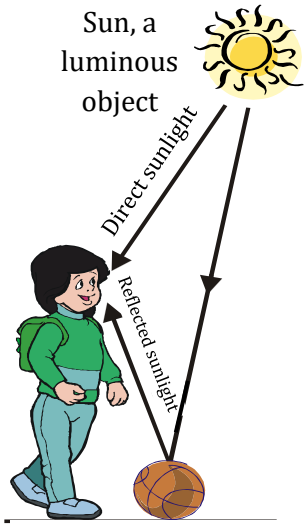
The objects which emit their own light are called **'luminous objects'**.

Examples : Sun and other stars, lamp (bulb), tube light, candle flame, etc.

Non-luminous objects

The objects which do not emit their own light but only reflect the light which falls on them are called **'non-luminous'** objects (or **illuminated objects**).

Examples : Table, chair, animals, plants, planets, satellites, moon, etc.



Seeing luminous and non-luminous objects

Building Concepts 1

How could we see non-luminous objects and luminous objects?

Explanation

When the light falls on a non-luminous object, it reflects a part of the light towards us. When this light reaches our eyes, we could see such an object. A luminous object emits its own light. When this light reaches our eyes, we could see luminous objects. Thus, for us to see an object, it must reflect or emit some light that reaches our eyes.

Building Concepts 2

Moon appears so bright. Is it a luminous object or a non-luminous object?

Explanation

Moonlight is the reflected sunlight i.e., Moon has no light of its own, it is a non-luminous object. Depending on the location of the Moon in its orbit around Earth, different parts of the Moon reflect sunlight onto the Earth. Since Earth and the Moon are so close together and since the Moon has such a shiny surface, large amount of sunlight come to the Earth after bouncing off the Moon. Thus, the Moon appears so bright.

2. Opaque, Translucent and Transparent objects

Opaque object

An **opaque** object or material only absorbs and reflects light, no light passes through it. If you tried to look through an opaque material, you would not be able to see an object on the other side i.e., you cannot see through opaque objects.

Translucent object

Object or material that allows small portion of light to pass through them are described as **translucent**. When light rays strike an object that is translucent, some light passes through, and some is either absorbed or reflected in different directions. Objects viewed through translucent materials do not look clear or crisp; they appear blurred i.e., you cannot see clearly through the translucent objects.

Transparent object

Transparent object or material transmits almost all the light striking them. Only a small amount of light is absorbed and reflected by transparent materials. Behind transparent objects, objects look clear and crisp, i.e., you can see objects clearly through them.

Active Physics 1

1. Take a steel tumbler, a glass tumbler and a milky or tinted glass tumbler. Take three wax candles of sizes smaller than the heights of the tumblers.
2. Place one candle each inside the above tumblers. Now, ignite all the three candles placed inside the tumblers. You will not see candle or its flame placed in the steel tumbler [see figure(a)]. You will see the candle and its flame clearly placed in the glass tumbler [see figure(b)]. The candle and its flame will appear to you blurred that was placed in the milky or tinted glass tumbler [see figure(c)].

   Thus, we can conclude that the steel tumbler is an opaque object, the glass tumbler is a transparent object and the milky or tinted glass tumbler is a translucent object.

(a)

A steel tumbler : we cannot see any object like an ignited candle placed inside it.

(b)

A plain glass tumbler : we can see clearly any object like an ignited candle placed inside it.

(c)

A tinted or milky glass tumbler : we cannot see clearly any object like an ignited candle placed inside it.

Active physics 1

Quick Tips

★ Human body (skin) is opaque in nature, in normal light but some parts of the body like palm acts as translucent when high intensity light of torch is touched near it, we can partially see inside it.

3. Properties of light

(1) Light is a form of energy that travels in the form of waves.

(2) Light waves spread out in all directions as they move away from a source.

(3) Light can travel through empty space (vacuum), without needing a solid, liquid, or gas medium.

(4) Light rays from any source always travel in straight lines. This is called rectilinear propagation of light.

(5) Light travels through space at the fastest speed, about 300000 km/s or 3×10^8 m/s. The speed of light is represented in scientific formulas by the letter 'c'. In other transparent medium like water or glass, the speed of light is slightly less than the speed of light in space.

The light rays from the Sun travels in vacuum at a speed of 3×10^8 m/s and reach the Earth in 8 minutes 20 seconds.

SPOT LIGHT

Building Concepts 3

Look at the objects around you in your room. Are they visible to you because of their own light or some reflected light ?

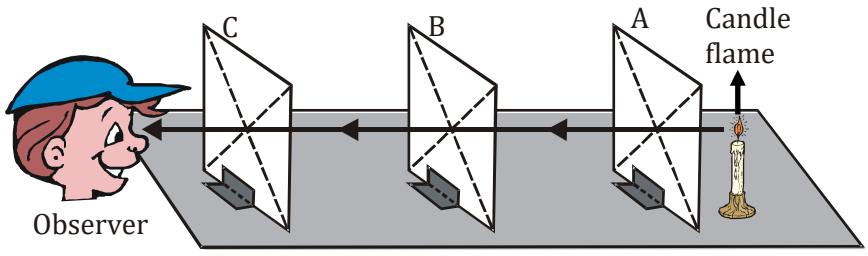
Explanation

When you see an object like a page of a book, light (may be sunlight or light of a bulb) available in the room reflects off the page and enters into your eyes. Thus, you see the page because light in the room reflects from it into your eyes. If you were sitting in a perfectly dark room with no light, you would not be able to see this page at all because the page does not give off its own light. We see most of the world by reflected light.

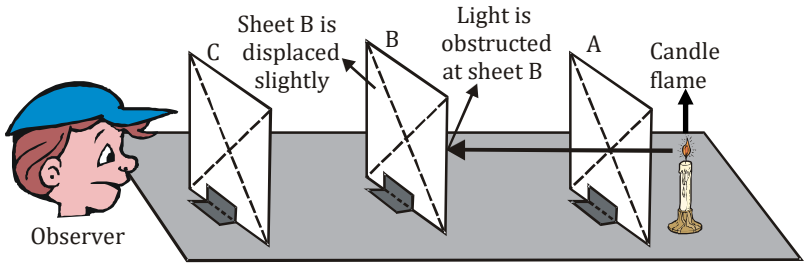
Active Physics 2

1. Take three rectangular cardboard sheets of equal size and make a tiny hole using a pin in the centre of each. The centre of the cardboard can be located by drawing the diagonals of the rectangular sheets. The point of intersection of the diagonals is the centre of the cardboard sheet.
2. Now, fix each cardboard sheet in vertical position by simply pasting them on a wooden or cardboard base using an adhesive (glue) so that their centres are in the same horizontal line [see figure(a)]. Let us mark these sheets as A, B and C.
3. Place a burning candle in front of the sheet A and look through the pin hole in sheet C. You will see the candle clearly.
4. Now remove the sheet B from its position and paste it again at small distance away from its original position [see figure(b)]. Again, look through pin hole C. This time you will not be able to see the candle.

From this activity we conclude that light travels in a straight line. When pin holes on the cardboard sheets are in straight line, the light passes through them. When pin holes on the cardboard sheet are not in straight line, light fails to pass through them.



(a) Candle flame can be seen as all three sheets are in a straight line

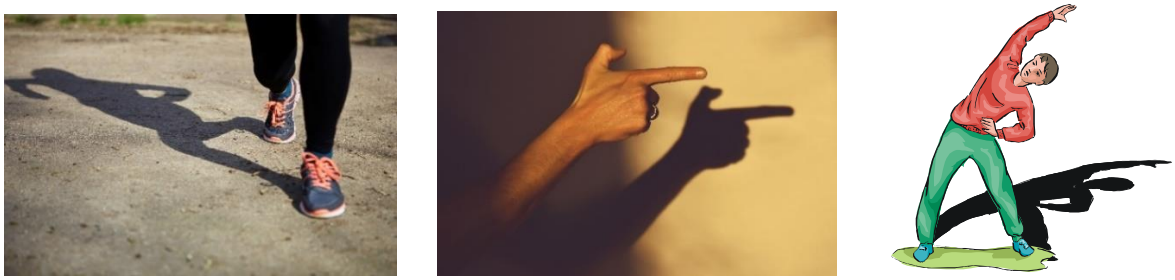


(b) Candle flame cannot be seen as all three sheets are not in a straight line

Active physics 2

4. What are shadows?

Whether light comes from the Sun, or from the lamp in your room, it travels in a straight line. If you turn on an electric torch and then place your hand in front of the light, a shadow of your hand will appear on the wall. The light travelling from the torch cannot travel through your hand. While light still appears on the wall, the area where your hand blocks the light has made a shadow. When you move your hand or fingers, the shadow moves to show where the light is being blocked. When you are walking on a sidewalk in the sunlight, you can see your shadow on the sidewalk. You are blocking the sunlight with your body. (see figure)



Formation of shadow

☞ **A shadow is a dark area produced by an opaque or a translucent object blocking the passage of light.**

Since light always moves in straight lines, when light is blocked by the surface of an opaque object, a shadow forms that is similar in shape to the object that produces it.

Characteristics of shadow

(1) Shadow formed is always dark and does not depend on the colour of the object and the colour of light.

(2) Shadow is always formed in the direction opposite to the light source.

(3) Shadow shows only outline of the object and does not give any detail about the object.

(4) The size of the shadow depends on the distance between the object and the screen.

Do You Remember ?

★ The shape, size and pattern of shadow formed depends upon three factors, (i) the size of light source, (ii) the size of the object, (iii) the distances between the light source, the object and the screen.

5. Formation of images

An image of an object is formed when light rays coming from the object meet or appear to meet at a point after reflection from a mirror or refraction from a lens.

Real image

A real image is one formed when the light rays actually meet at a point and which can be obtained on a screen.

Virtual image

A virtual image is one formed when the rays do not actually meet at a point but they appear to meet at a point. Such images cannot be obtained on the screen.

Pin hole camera

It is a device used to obtain image of an object on the screen. It is based on the principle of 'rectilinear propagation of light'. A pin hole camera consists of a rectangular box made of wood, cardboard or metal. Its one surface is replaced with a translucent material like ground glass (see figure). This surface serves as the screen on which the image is formed. A tiny (pin hole) hole is made on the side opposite to the ground glass. This allows light from the object to enter the box.

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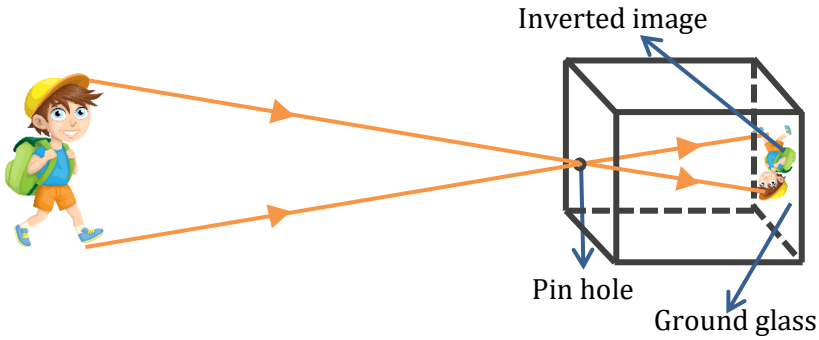


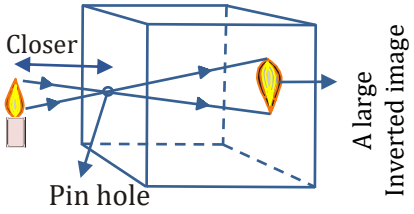
A pin hole camera

When an object like a boy is standing in front of the pin hole camera, the light rays from the boy reaches the screen of the camera through the pin hole. An image of the boy is seen on the screen. Since the image is formed on the screen, the image is real and it is inverted. The size of the image may be enlarged or diminished (see figure).

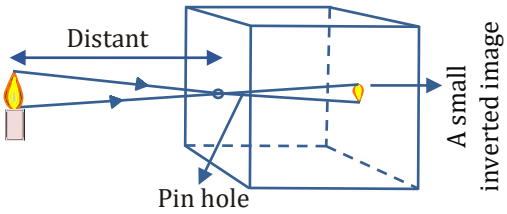
Size of image formed by pin hole camera depend on the following factors

(1) distance of the object from the pin hole camera

(2) length of the pin hole camera

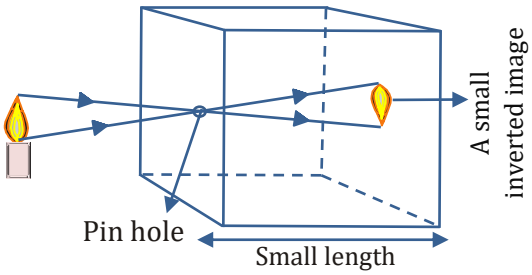


(a) Image of a closer object is large



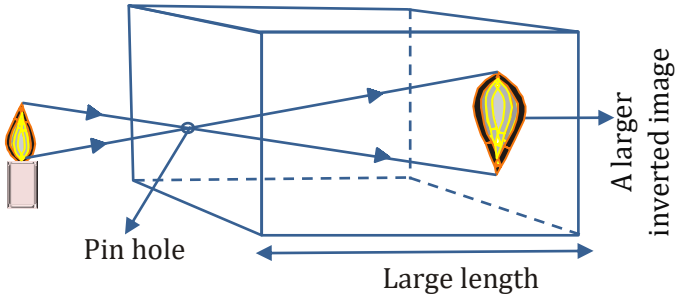
(b) Image of a distant object is small

Changing the distance between the pinhole camera and the object changes the size of the image formed on the screen.



(a)

Smaller the length of pin hole camera, smaller will be the image formed.



(b)

Larger the length of pin hole camera, larger will be the image formed.

Changing the length of the pin hole camera changes the size of the image formed.

Quick Tips

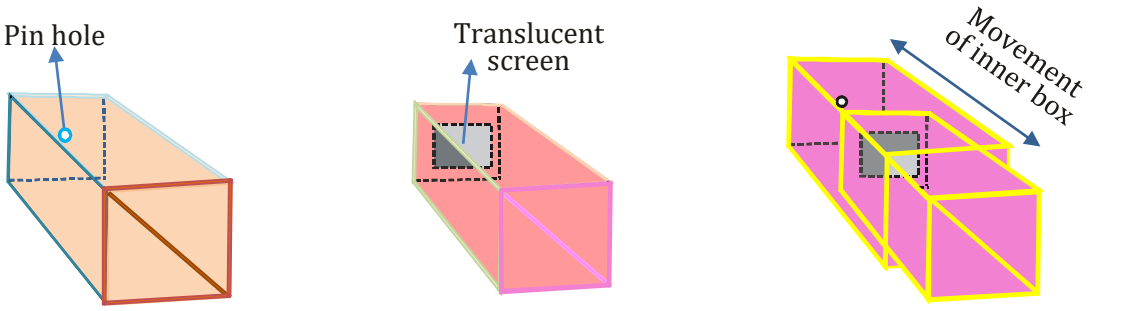
★ You can check for natural pin hole camera also like one present in Virupaksha temple, Hampi, Karnataka.

Check your Concepts 1

1. An object is placed behind a plate looks blurred. Which type of material, the plate is being made of ? Why does the object appear blurred?
2. Why image formed by the pin hole camera inverted?

Active Physics 3

1. Take two boxes so that one can slide into another with no gap in between them. Cut and open one side of each box. On the opposite face of the larger box, make a small hole in the middle [see figure(a)]. In the smaller box, cut out from the middle a square with a side of about 5 to 6 cm. Cover this open square in the box with a tracing paper i.e., a translucent screen [see figure(b)].
2. Slide the smaller box inside the larger one with the hole, in such a way that the side with the tracing paper is inside [see figure(c)]. Your pin hole camera is ready for use.



(a) Bigger outer box with a pin hole

(b) Smaller inner box with a translucent screen

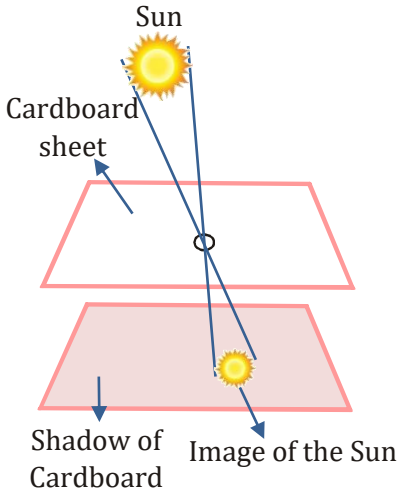
(c) Smaller inner box is moved inside the bigger outer box.

Active physics 3 : Your own pin hole camera

3. Holding the pin hole camera look through the open face of the smaller box. You should use a piece of black cloth to cover your head and the pinhole camera. Now, try to look at some distant objects like a tree or a building through the pinhole camera. Make sure that the objects you wish to look at through your pinhole camera are in bright sun shine. Move the smaller box forward or backward till you get a picture on the tracing paper pasted at the other end.

Active Physics 4

1. Take a large cardboard sheet and make a small pin hole in the middle using a pin/needle. Hold the sheet up in the Sun and let its shadow fall on a clear area or floor.
2. You will see a small circular image of the Sun in the middle of the shadow of the cardboard sheet (see figure).



Active physics 4

6. Reflection of light

As the light hits an object, some of the light is reflected or bounced off the object. The light travels back to your eye and lets you to see the object.

☞ Reflection is the bouncing of light rays off a surface. In other words 'reflection is the sending back of all or a part of a beam of light as it strikes a surface'.

Building Concepts 4

Why do you see your image in water when you stand on the edge of a lake and look in the water? Is it always possible to see a clear image in water?

Explanation

You see your image in water due to reflection of light from the surface of water. When light bounces off a smooth surface of lake, the reflection is clear. You can see exactly what is reflected. But if a strong wind blew across the smooth lake, it would be hard to see your reflection clearly in the wavy water. The light would be bouncing off in all directions, and your reflection would be blurry (unclear).

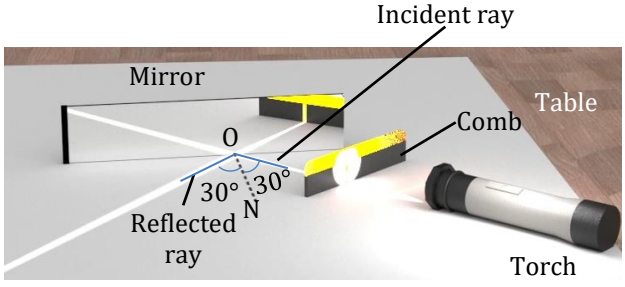
Active Physics 5

1. Fix a white sheet of paper on a drawing board or a table. Take a comb and close all its openings using a black paper sheet except one in the middle. Hold the comb perpendicular to the sheet of paper.

2. Mark a point O at the middle of the bottom edge of the mirror (see figure). Then use the protractor and the ruler to draw a line on the paper perpendicular to the mirror from the mark. Label this line N. This line is called **'normal'**. Draw a line on the paper from O at a particular angle say 30° to line N.

3. Turn on the flashlight (torch) and place it so the beam is along the 30° line. This is the angle of incidence. Measure and record the angle that the reflected beam makes with line N. This is the angle of reflection.

4. Now, measure the angle of reflection (r). You will find that the angle of reflection is 30°. Repeat this activity, by making other angles such as 45°, 60° with the line N. In each case you will say that the, **'angle of incidence is equal to the angle of reflection'**.(see figure)

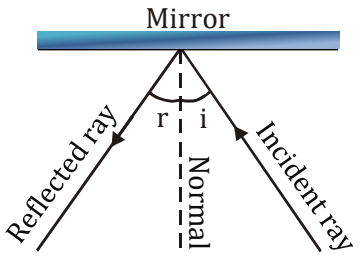


Active physics 5

Laws of reflection

The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

The angle between an incoming light ray and a surface is equal to the angle between the reflected light ray and the same surface (see figure). This relationship is called the **law of reflection**.



Angle of incidence is always equal to the angle of reflection.

$\angle i = \angle r$

$\angle i$ = angle of incidence

$\angle r$ = angle of reflection

Mirrors

You can see yourself in a mirror because light bouncing off the mirror is reflected back into your eyes.

Do You Remember ?

★ A **mirror** is an object with a polished surface that forms reflected images. Light rays that bounce off a mirror can form an image of an object.

A **plane mirror** has a flat surface. Plane-mirror images appear as exact copies. Most everyday mirrors are plane mirrors.

Some basic terms related to reflection of light

Incident ray : The ray of light which falls on the mirror surface is called **incident ray**.

Reflected ray : The ray of light which is sent back by the mirror is called 'reflected ray'.

Point of incidence : The point at which the incident ray falls on the mirror is called 'point of incidence'.

Normal : A line perpendicular to the surface of a mirror passing through the point of incidence is called 'normal'.

Angle of incidence : The angle made by incident ray with the normal at the point of incidence is called 'angle of incidence'.

Angle of reflection : The angle made by reflected ray with the normal at the point of incidence is called 'angle of reflection'.

Check your Answers 1

1. The plate is made of a material that is 'translucent' in nature. Objects viewed through translucent materials do not look clear or crisp, they appear blurred because only a small part of light of the object passes through the translucent materials and reaches our eye.

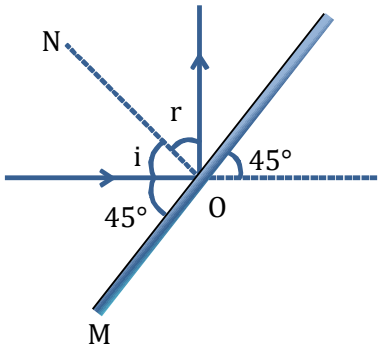
2. If you look at figure (pin hole camera), you will find that rays of light coming from the top and bottom of an object cross the hole and continue to move in straight lines. Thus, rays from the top of the object fall at the bottom of the screen and those from the bottom of the object fall at the top of the screen. That is why, the image formed is inverted.

SPOT LIGHT

Mirrors can also be made with curved surfaces. If they are 'curved in', they are concave. If they are 'curved out', they are convex.

Numerical Ability 1

1. Find the angle of reflection (r) in the figure.



Numerical Ability 1 (1)

Solution

As shown in the figure, the angle between the surface of the mirror and the incident ray is 45°.

$\angle i + 45° = 90°$ (angle between the mirror surface and the normal is 90°)

$\angle i = 90° - 45°$; $\angle i = 45°$

$\angle i = \angle r$

$\angle r = 45°$

Decode the problem

Here we have to use law of reflection where $\angle i = \angle r$.

Quick Tips

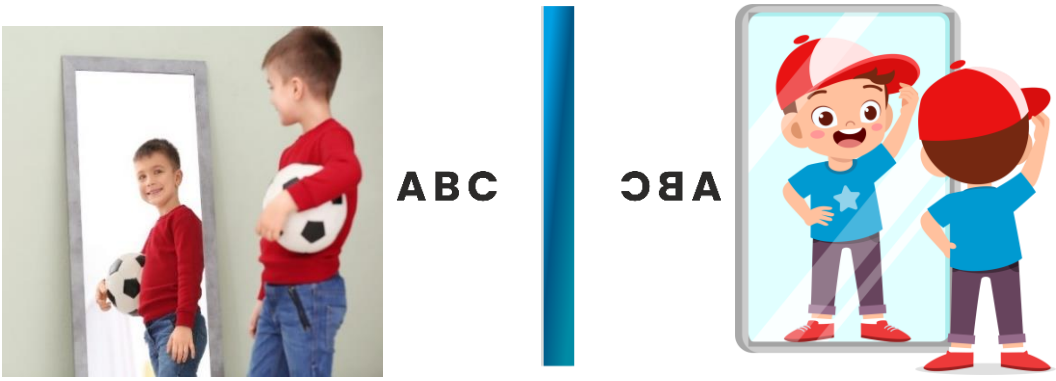
★ If any of the angle in the given diagram is 45°, all the other angles are found to be 45° only.

Building Concepts 5

Images formed by a plane mirror appear as exact copies. Are they truely the exact copies of the object placed in front of the plane mirror?

Explanation

The images you see in a plane mirror look almost as if they exist on the other side of a window, with one important exception. The image that appears in the mirror is 'reversed'. For example, if you raise your left hand in front of a mirror, in your reflection it appears that your right hand is raised. When an object is placed in front of a plane mirror, the right side of the object appears to be the left side of image and the left side of the object appears to be the right side of its image. This change of sides of an object seen in the image is called 'left-right inversion' or 'lateral inversion' (see figure). Thus, though the plane-mirror images appear as exact copies, but they are laterally inverted.



Lateral inversion of image in a plane mirror

Image formed by a plane mirror

The properties of image formed by a plane mirrors are,

(1) The image is virtual and erect.

(2) The distance of image from mirror is equal to distance of object from mirror.

(3) The size of image is exactly equal to the size of object.

(4) The image is laterally inverted.

Be Alert !

★ Lateral inversion is always horizontal not vertical.

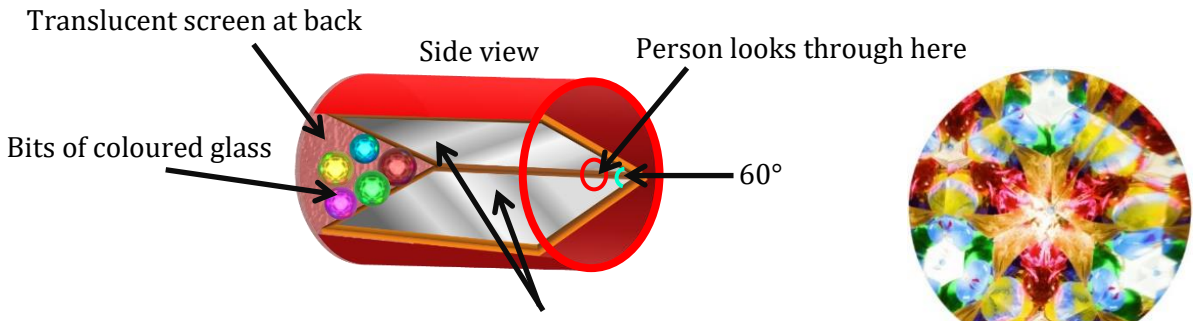
7. Reflected light can be reflected again

When you visited a hair dresser, he makes you sit in front of a mirror. After your hair cut is complete, he places a mirror at your back to show you how the hair has been cut. You could see the hair at the back of your head because the light reflected by the smaller mirror placed at your back is again reflected by the bigger front mirror and finally the light reaches your eyes. This is called multiple reflection of light.

Some devices based on multiple reflection of light are given below.

Kaleidoscope

This child's toy is a visual delight of changing colours as the toy is rotated. The effects are produced by multi-coloured glass pieces that tumble around when the toy is turned (see figure). Here, two (or three) mirrors are positioned 60° to each other and five images of the object are produced for this orientation.



A kaleidoscope

Periscope

The periscope makes use of multiple reflection of light. A periscope is an instrument for observation from a hidden position. In its simplest form, it consists of a tube with mirrors at each end set parallel to each other at a 45° angle (see figure). This form of periscope, with the addition of two simple lenses, served for observation purposes in the trenches or bunkers during World War I. Military personnel also use periscopes in some gun turrets and in armored vehicles like tanks. Periscopes allow a submarine, when submerged at a shallow depth, to search visually for nearby targets and threats on the surface of the water and in the air.

Quick Tips

★ Two mirrors are used in periscope so there are to lateral inversion of the image, so we see image exactly as an object.

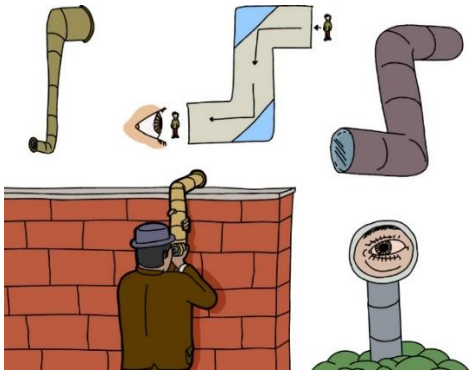
Uses of mirror

(1) As a dressing mirror.

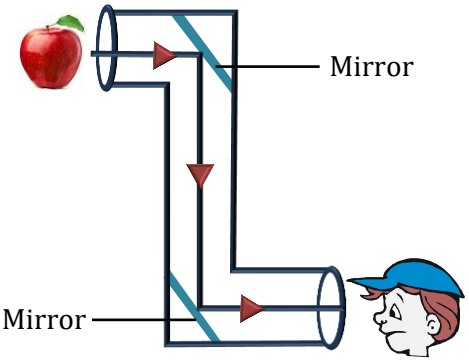
(2) In the optician's room to double the effective length of the room by keeping the mirror in opposite wall of room.

(3) In barber's shop for seeing the rear view at the back, two mirrors are fixed on the opposite wall facing each other.

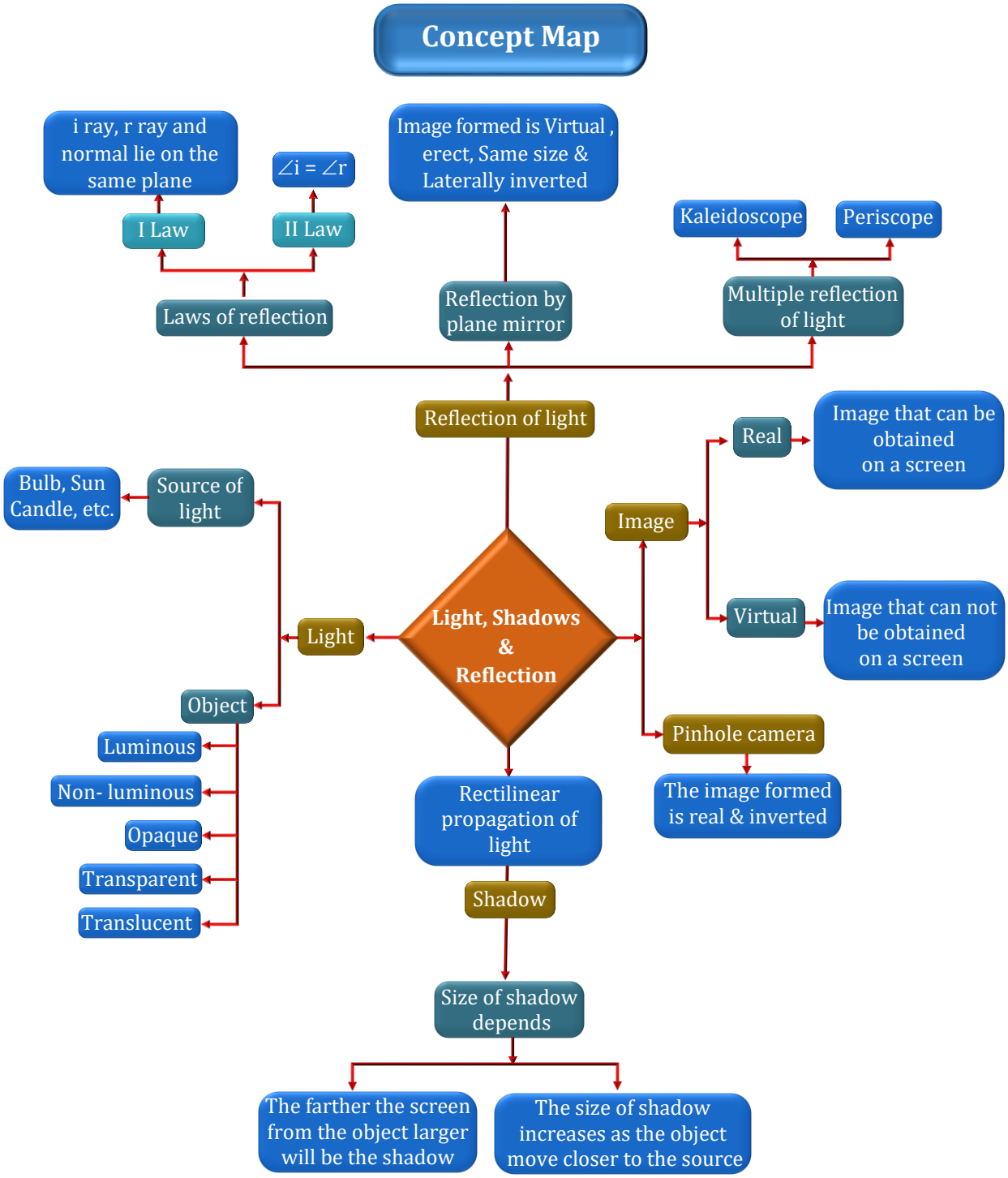
(4) In periscope, kaleidoscope, used as reflector, etc.



A periscope



Concept Map



Some Basic Terms

1. **Excites** – To make somebody/something react in a particular way.
2. **Illuminated** – To shine light on something.
3. **Reflect** – To send back light from a surface in same medium.
4. **Crisp** – Firm and fresh or new.
5. **Efficient** – Able to work well without wasting time and energy.
6. **Diminished** – To become or to make something smaller.
7. **Bouncing** – To move away quickly after it had hit a hard surface.
8. **Lateral inversion** – A phenomenon in which left appears to be right and vice-versa (Daayan-Baayan).
9. **Delight** – Great pleasure, joy
10. **Tumble** – To fall down suddenly.
11. **Trenches** – A long deep hole dug in the ground for soldier to hide in during enemy attacks.
12. **Turrets** – A small tower on the top of the large building.
13. **Armour** – Clothing, often made of metal, that soldiers wore in earlier times to protect themselves.
14. **Inverted** – To put something in the opposite order or position to the way it usually is
15. **Enlarged** – To make something bigger.
16. **Partially** – Not completely, part of something.
17. **Erect** – Standing straight up.
18. **Propagation** – Spreading of something into new regions.