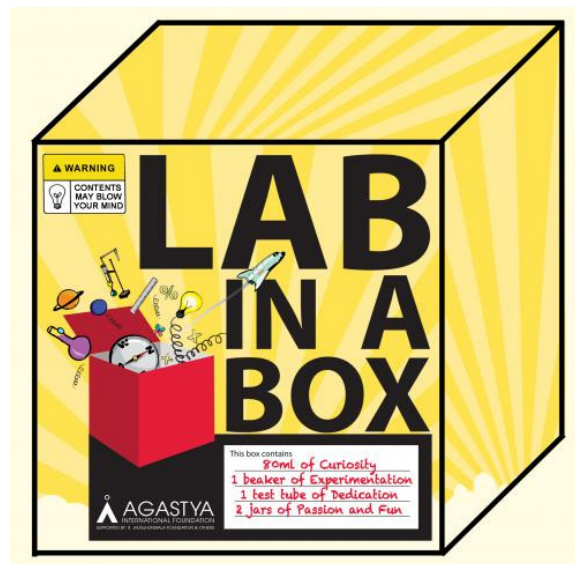


OPTICS



Inventory

Sl. No.	Description	Quantity
1	A4 sheets bundle	1
2	Aluminium foil	1
3	Aluminium foil fixed on wooden plank	1
4	Candle packet	1
5	Concave mirrors	5
5	Convex Lens	5
6	Frosted glass	1
7	Glass beaker	1
8	Acrylic slabs	5
9	Laser pointer	4
10	Laser light green	1
10	LED torch with cells	1
11	Optical fibers strip	1
12	Pencils	12
13	Pins	1 box
14	Plane mirrors	5
16	Screens	5
17	Shadow kit	1
18	Spoon	1
19	Torch stand	1
20	Optic kit	1

	Optic kit	
20.1	Concave mirror (half portion)	1
20.2	Convex mirror (Half portion)	1
20.3	Plane mirror strips	2
20.4	Unit to demonstrate principle of periscope	1
20.5	Assembly of concave lens	1
20.6	Assembly of convex lens	1
20.7	Double concave lens $f = 50$ cm	1
20.8	Double concave lens $f = 15$ cm	1
20.9	Double convex lens $f = 10$ cm	1
20.10	Double convex lens $f = 100$ cm	1
20.11	Prism	1
20.12	Prism right angled	1
20.13	Protractor fixed with plane mirror	1
20.14	Rectangular slab acrylic	1
20.15	Semi circular slab acrylic	1
20.16	Single slit	1
20.17	Triple slit	1

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1 Properties of light

1.1 Introduction

Light plays an important role in our daily life. Like air and water, light is a prerequisite for life on earth. Air and water occupy space and have mass. So, both are classified as matter. Light neither occupies space nor has mass. Thus, it cannot be called matter. Then what is light?

Can you see anything when there is no light? No.

Objects are visible only in the presence of light. Light by itself is invisible, but it makes objects visible.

Light is a form of energy which enables us to see objects. It is treated as a particle and as a wave.

1.2 Preparatory

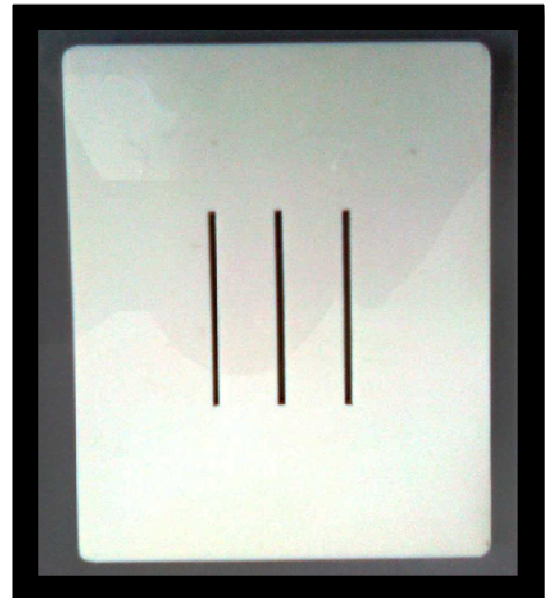
The ray box is to be kept ready for carrying out the experiments. This is done as follows:

Step 1: Take a ray box and accessories. Fix the platform to the ray box as shown in the figure below.

Plano convex lens



Triple Slit



Step 2

Insert the triple slit and switch on the bulb. Adjust the platform such that three rays appear on it.



Step 3

Place the plano-convex lens between the bulb and slit and adjust its position such that a parallel beam of light appears on the platform.



Use this ray box for all the experiments.

1.3 Light travels in straight line

Aim

To show that light travels in a straight line

Procedure

Step 1

Insert a single slit in the ray box.

Step 2

Switch on the bulb.

Step 3

Move the platform to and fro slowly.

What do you observe?

Observation

You observe that light ray moves in a straight line.

Inference

Light travels in a straight line.

1.4 Types of light beams

Aim

To show different types of light beams

Procedure

Case 1:

Step 1

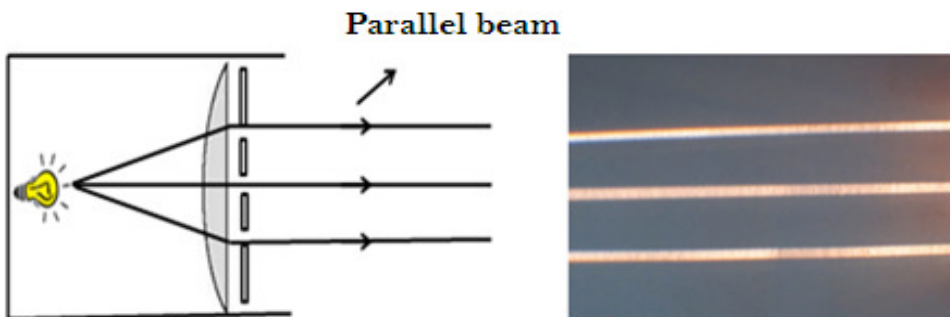
Insert the triple slit and the plano-convex lens in the box.

Step 2

Adjust the platform such that the light beam of three rays appears on the platform.

Observation

All the three light rays are parallel to each other.



Inference

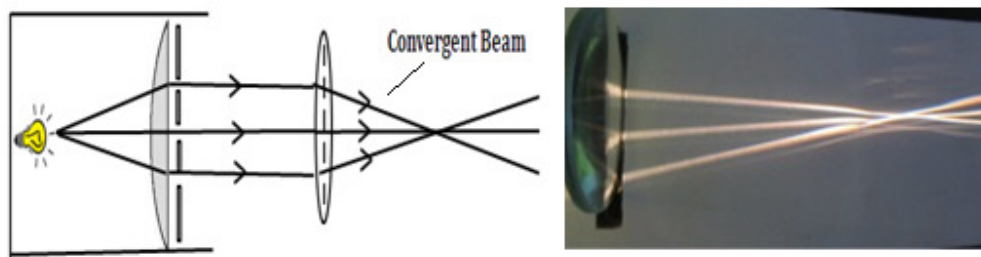
This type of beam is called a parallel beam of light.

Case 2

Step 1

Take a convex lens and insert it in the slit as shown in the figure.

What do you observe?



Observation

The three rays meet at a point; they converge at a point.

Inference

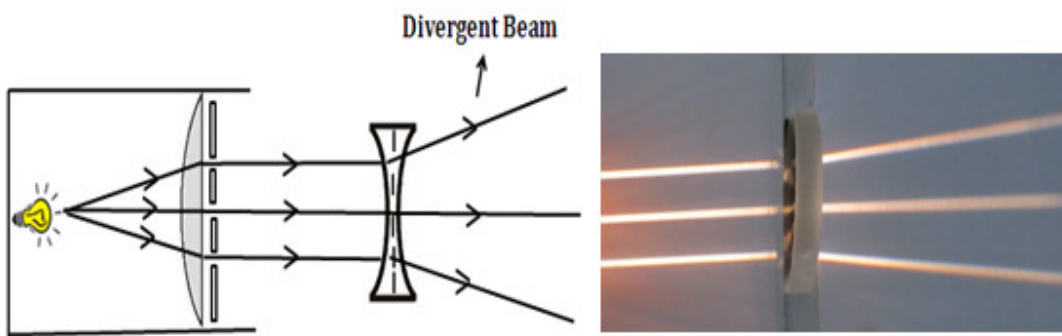
This type of beam is called a convergent beam.

Case 3

Step 1

Replace the convex lens in the slit by a concave lens.

What do you observe?



Observation

Rays on the platform moves away from each other or diverges.

Inference

This type of beam is called a divergent beam.

Real life observations

You have learnt about three types of beams i.e., parallel, convergent and divergent. Below are real applications of the same.

1. A parallel beam of light is used in search light.



2. The parallel rays of light from far away source converge at the back of eye on the retina.

3. A lamp sends a divergent beam of light.



1.5 Interaction of light with matter

Aim

To study how light interacts with matter

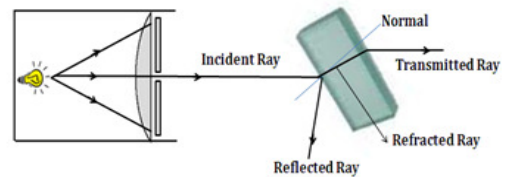
Procedure

Step 1

Take a ray box and place a single slit in the box. Switch on the bulb.

Step 2

Adjust the platform such that a ray of light appears on it.



Step 3

Place an acrylic slab obliquely in the path of the ray.



Step 4

Observe the intensity of incidence ray, reflected ray and refracted ray through the slab.

What do you observe?

Observation

→ Part of the ray is reflected.

→ Part of it is transmitted.

→ Part of it is absorbed. (Intensity of the ray inside the slab is less when compared to intensity of incident ray)

Inference

If an object reflects most of the light, it appears white. If it absorbs most of the light, it appears black. If it reflects only red light it appears red. Rose appears red because it reflects red light, while other colors are absorbed.

1.6 Transparent, translucent and opaque objects

Aim

To show opaque, transparent and translucent objects .

Procedure

Step 1

Place a torch on the stand and a screen at some distance from the torch.

Step 2

Take a spoon and hold it in between the torch and the screen.

Step 3

Replace the spoon with a clean glass plate and hold it in between the torch and screen.

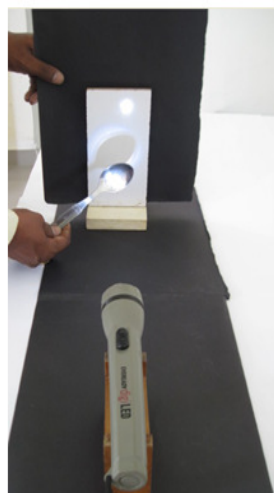
Step 4

Hold a frosted glass in between the torch and screen.

What do you observe in each case?



Set-up



Spoon



Transparent glass



Frosted glass

Observation

- In the case of spoon, a dark shadow is formed on the screen. It means that the spoon blocks most of the light.
- In case of glass plate, most of the light passes through it and no shadow is formed.
- In case of frosted glass, we see a faint shadow on the screen indicating that light is partially transmitted through the frosted glass.

Inference

- If a material does not allow any light to pass through it, it is opaque.
- A material which allows most of the light to pass through it is called transparent.
- If a material allows only a part of light to pass through it, then it is translucent.

The above can be expressed in another way. If an object produces a dark shadow, it is opaque. If it produces a faint shadow, the object is translucent. A transparent object does not produce any shadow.

2 Light and shadows

2.1 Shadow formation

Aim

To show formation of shadow

Procedure

Let us consider three cases.

- (i) Point source of light
- (ii) Extended source of light but smaller than the object
- (iii) Extended source of light bigger than the object.

Case 1

Shadow due to point source of light

Step 1

Take a torch light and keep it on the stand.

Step 2

Place the screen about one meter away from the torch.

Step 3

Place an iron stand with a hole at the center just in front of torch light, so that the light source behaves like a point source.

Step 4

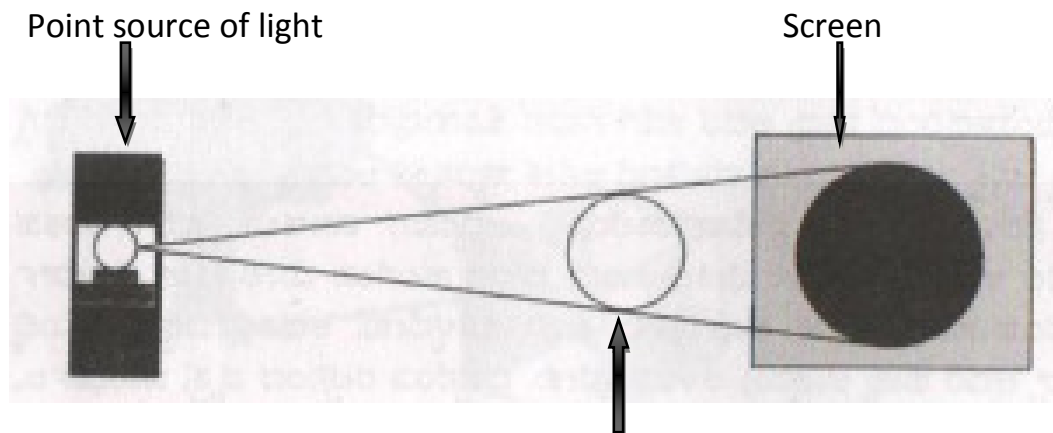
Place an opaque object between the torch and the screen.

What do you observe?

Step 5

Move the opaque object to and fro from the screen.

Observe the nature of the shadow.



Observation

- When an opaque object is placed between a point source of light and a screen, a shadow is formed. This shadow is uniformly dark, sharp at the edges and is of the same shape as the object.
- If the object is moved towards the source of light, the size of shadow increases.
- If the object is moved towards the screen, the size of shadow decreases.

Case 2

Shadow due to extended source of light but smaller than the object

Step 1

Remove the iron stand having a hole.

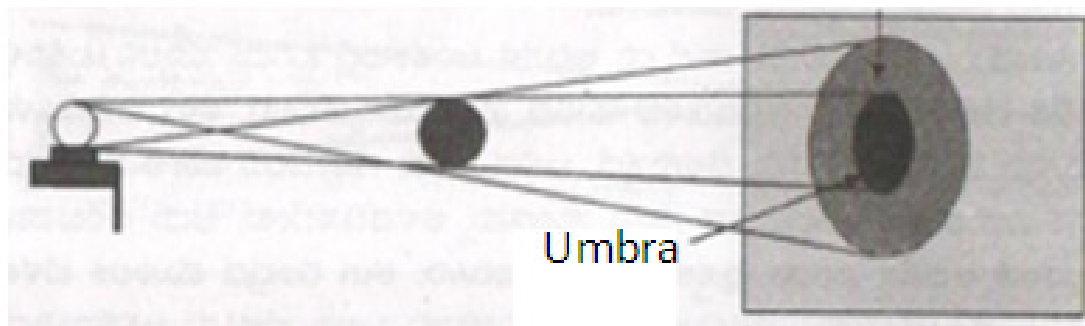
Step 2

Take an object whose diameter is more than the diameter of the torch.

Step 3

Place the opaque object at different positions between the light source and screen.

Observe the shadow.



Obse

rvation:

In this case, the shadow has two parts, the umbra and the penumbra.

Inference

The umbra is the darkest inner part of the shadow, where no light falls. The penumbra is the part which surrounds the umbra. Some rays of light fall in this region. Therefore, this portion of the shadow is faint. The penumbra is a region of partial darkness.

Case 3

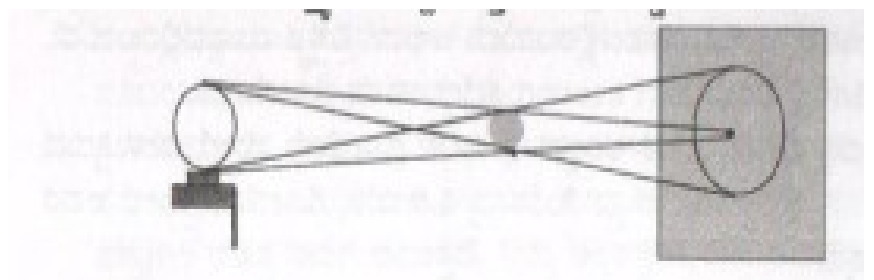
Shadow due to extended source of light but bigger than the object

Step 1

Take an object which is smaller than the source.

Step 2

Place it between light source and the screen at different positions.



Observe the nature of shadow.

Observation:

Here again, the umbra and penumbra regions are seen on the screen.
But, the size of the umbra decreases if the object is moved away from the screen.

Inference:

If the object is moved sufficiently away from the screen there will be no umbra.
The result is a larger and fainter penumbra that is hardly visible.

Daily life examples

The sun is very large compared to objects on earth. Thus, when a bird flies very close to the ground, we see its shadow. If it flies at a great height, no shadow is found on the ground.



An aircraft flying at a great height will not cast a shadow. Why? In both the cases, there is no umbra and the penumbra is so weak that it is practically non-existent.

2.2 Solar and lunar eclipse

Lunar and solar eclipse

Procedure

Step 1

Place the torch light on the stand and the screen about a meter away from the torch. Here, torch is treated as the sun.

Step 2

Take two metallic stands from shadow kit.

These metallic stands have circular screens at the top; one disk is bigger than the other. Big disk is treated as earth while the small disk is taken for the moon.

Step 3

Place a stand with a bigger disk (earth) between torch light (sun) and screen.

Step 4

Switch on the torch. Hold the stand with the smaller disc (moon) in your hand and rotate it around the bigger disk (earth). When moon comes in this shadow cast by the big screen, it is not visible to people on earth. This is lunar eclipse.



Step 5

When moon comes between sun and the earth, we can see the shadow of the moon on earth. For the people who are in this shadow region, sun is not visible. This is solar eclipse.



3 Reflection of light

3.1 Introduction

You might have seen reflections of buildings and birds in still water.



When you look into the mirror, what do you see? You see your reflection.

What is Reflection?

Ancient people thought that our eyes emit light. This light falls on the objects and then come back to our eyes. This makes objects visible to us. Ibnal- Haitham who lived in 10th century explained that we can see an object only when light from a source falls on that object and gets reflected on to our eyes. Haitham was a philosopher, physicist and mathematician.



When light falls on an object, some of it is absorbed and some bounces back; i.e. it is coming back in the same medium. This bouncing back of light rays from an object is called reflection.

Mirrors reflect most of the light falling on them.

3.2 Reflection of light From plane mirror

Aim

To study reflection of light from a plane mirror

Procedure

Step 1

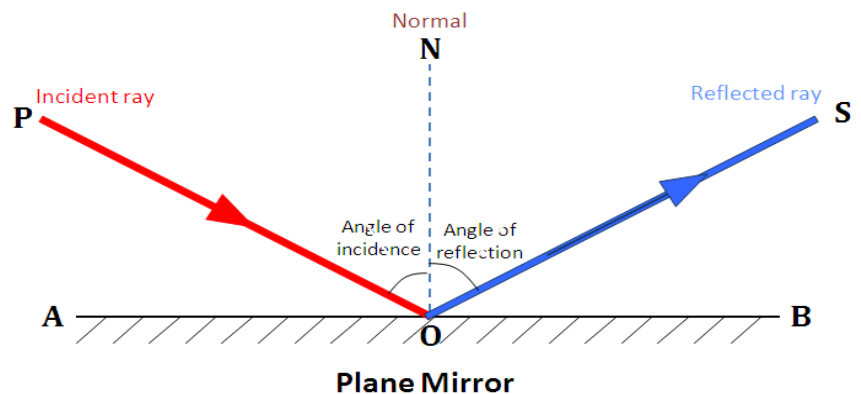
Keep a white sheet of paper on the table and draw a straight line AB. Draw a perpendicular ON from O with the help of protractor.

Step 2

Keep a plane mirror which is fixed on a wooden plank, in a vertical position on the line AB.

Step 3

Take a laser torch and send a beam towards the mirror along the surface of the white paper. Let it strike the mirror at O. This is the incident ray. At the same time you can observe the reflected ray also.



Step 4

Make pencil marks on incident ray and reflected ray and join them with O. Now PO and OS are incident and reflected rays respectively.

$$\text{Angle of incidence} = \angle PON$$

$$\text{Angle of reflection} = \angle SON$$

Measure the angles.

Observation

You find that both the angles are equal.

The incident ray PO, the normal ON, and reflected ray OS are in the same plane, which is the plane of the white paper

Inference

Laws of reflection

1st law: Incident ray, reflected ray and normal drawn from the point of incidence all lie in the same plane.

2nd law: Angle of incidence is equal to the angle of reflection.

3.3 Types of reflection

Aim

To demonstrate regular and irregular reflection

Procedure

Step 1

Place the plane mirror attached to wooden plank on a white paper.

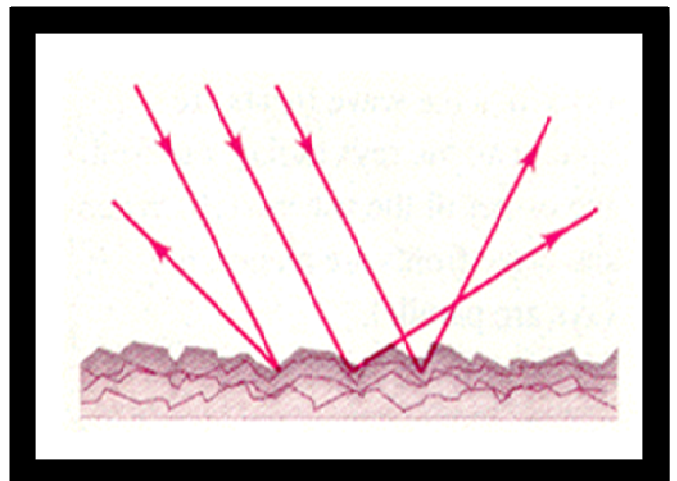
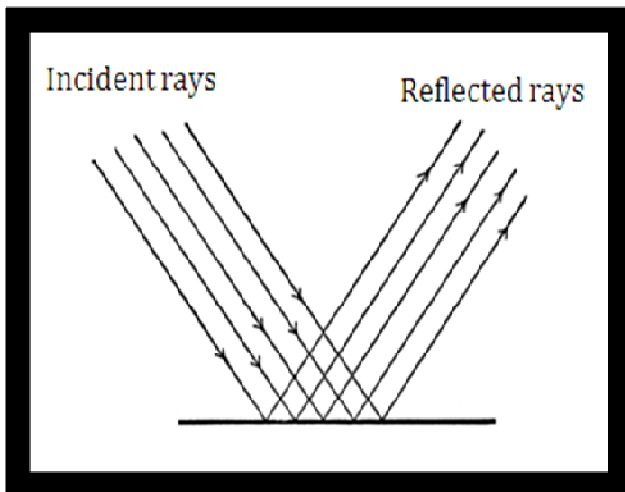
Step 2

Take two or three laser torches, send a parallel beam towards the mirror along the surface of the paper.

Observe reflected beam.

Step 3

Replace the plane mirror by an aluminium foil fixed on a wooden plank. Repeat the experiment.



Observe the reflected beam.

Observation

When a parallel beam of light is incident on the plane mirror, reflected beam is also parallel.

In the case of aluminium foil, the reflected beam is not parallel.

Inference

Regular and Irregular Reflection

If a parallel beam of light is incident on a smooth surface like plane mirror, it is reflected as parallel beam. This kind of reflection is called 'regular reflection'.

A diffused reflection appears dull and not shiny. It cuts glare, spreads the light over a large area and helps in general illumination.

Real life observations

Most of the objects around us reflect light irregularly. The light sent to our eyes by most of the objects we see is due to irregular reflection from their surface.



3.4 Image formation in plane mirror

Aim

To prove that the object distance is equal to the image distance.

Procedure

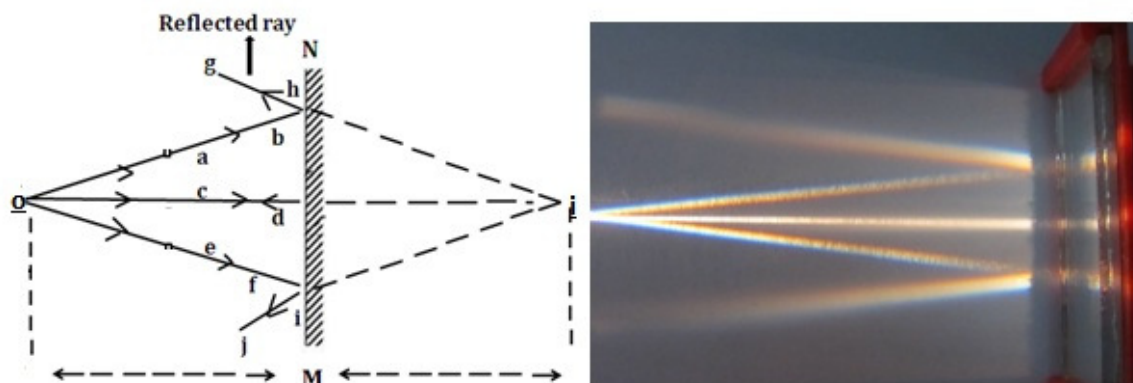
Step 1: Set the ray box and adjust the platform such that a parallel beam of light appears on it.

Step 2: Insert a convex lens in the slit.

Observation: The convex lens converges rays to a point and then diverges. This point of convergence is taken as the object.

Step 3: Stick a white card board on the platform with cello tape.

Step 4: Place a plane mirror perpendicular to the path of divergent beam. You get reflected rays which are divergent as shown in the figure. Mark it as MN.



Step 5

Mark two points on each incident ray as a & b, c & d, and e & f.

Step 6

Mark again two points on each reflected ray such as h & g and i & j.

Step 7

Remove the mirror and take out the paper. Join the points M and N which represent the position of mirror.

Step 8

Draw the ray diagram for incident rays by joining the points a&b, c&d, e&f. Let them meet at O. O represents the position of object.

Similarly, draw the ray diagram for reflected rays, joining the points g&h, i&j. These lines are divergent. They never meet in front of the mirror. Therefore, extend them backwards to meet at I which represents the position of the image.

Step 9

Measure the distances of the object and the image from the mirror.

Observation

We find both distances are equal.

Inference

Object distance = image distance.

3.5 Lateral inversion

Aim

To explain lateral inversion on reflection

Procedure

Step 1

Place the plane mirror on the card board sheet in a vertical position.

Step 2

Write a letter W in front of the mirror. Observe its image in the mirror.

Step 3

Draw a line AB on the paper to indicate the position of the mirror. Write a letter W at some distance from this line (mirror).

Step 4

Mark points 1, 2, 3,4, and 5 on the letter W as shown in the figure. Measure the distance of these points from the mirror.

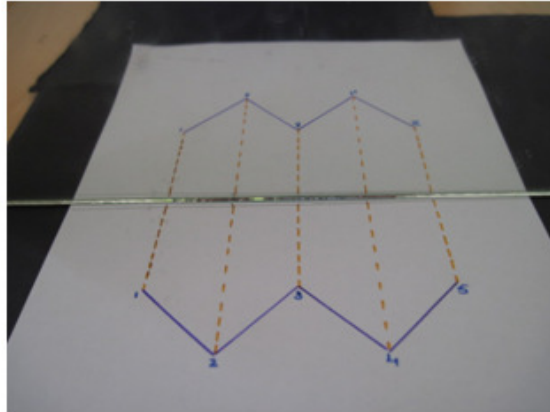
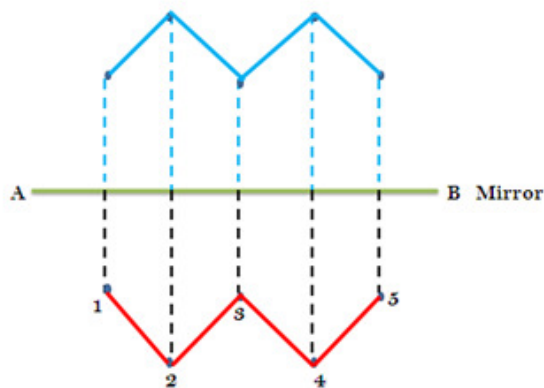
Step 5

We know that

Distance of object in front of mirror = Distance of image inside the mirror. So the image of 1 is formed 5cm away, image of 2 is formed 10cm away, image of 3 is formed 7cm away, image of 4 is again 10cm away and image of 5 is 5cm away. Then, join the points to get the image of W.

Observation:

We see that the image is laterally inverted. Letter 'W' is seen as 'M'.



Observation

We find that the image of W is laterally inverted and appears as M.

Inference

Images are laterally inverted.

Additional activity:

Procedure

Step 1

Fix the plane mirror vertically on white paper.

Step 2

Write "bob KICKED pop" on the white paper

Observe the image in the mirror.

What does it read?

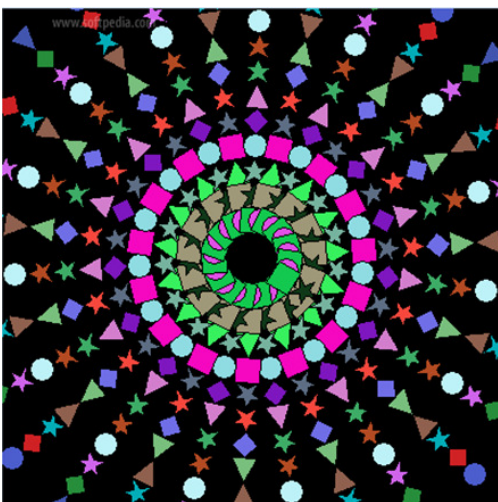
3.6 Kaleidoscope

Aim

Image in the Kaleidoscope

Activity

Kaleidoscope consists of three plane mirrors in which colored bangle pieces are kept. When you see through the Kaleidoscope you see the multiple reflections, which make very beautiful patterns. Some patterns are given below.



3.7 Periscope

Aim

Understanding the principle of periscope

Procedure

Step 1

Take the assembly of two parallel plane mirrors kept at an angle 45 degrees from the ray box.

Step 2

Use laser light and send a beam towards the upper mirror. What do you observe?



Observation

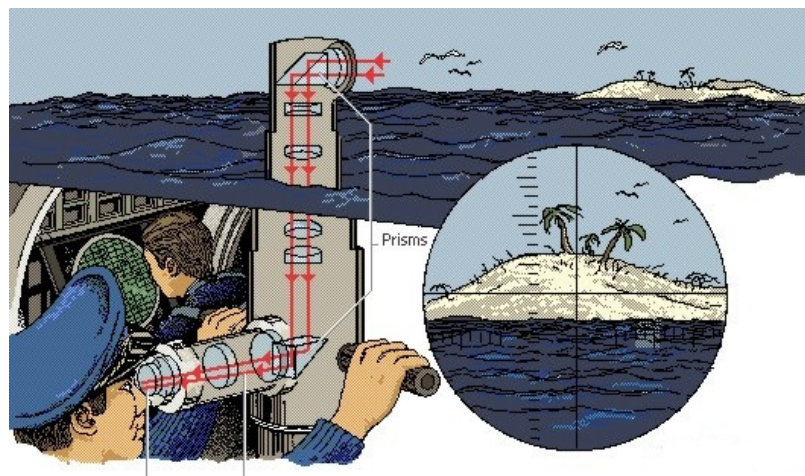
Ray incident on the first mirror gets reflected towards the second mirror. After reflection from the second mirror, it travels parallel to the incident ray.

Inference

Periscope works on this principle.

Daily life applications

From a submerged submarine, one can see events on the surface using the periscope.



4 Spherical Mirrors

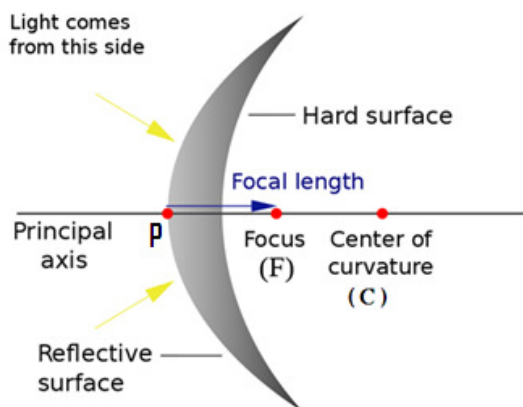
4.1 Introduction

When you hear the word mirror, immediately a plane mirror comes to your mind, since we are acquainted with it. Not all mirrors are plane mirrors. There are spherical mirrors, cylindrical mirrors, parabolic mirrors etc.

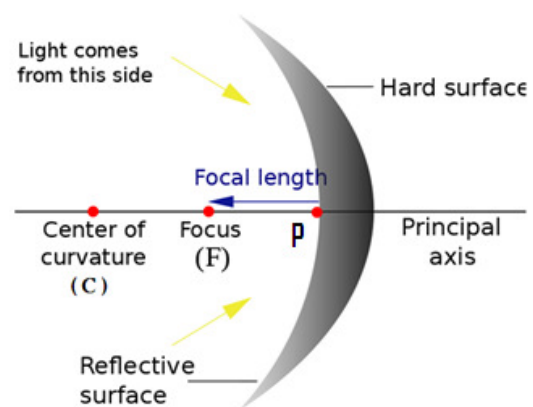
4.2 Types of spherical mirrors

Let us discuss spherical mirrors. There are two types of spherical mirrors: concave and convex mirrors. With simple geometrical description, we identify the various parameters of these mirror.

Draw a straight line on a white sheet of paper. Mark a length of 20cm. With a compass draw an arc of 20 cm to cut this line on the left side. Similarly draw another arc of same radius on the right side.



Convex Mirror



Concave Mirror

The point where the arc touches the straight line is the pole P of the mirror. The point where the tip of the compass makes a mark on the straight line is centre of curvature C. Produce PC as the principal axis. Mark the midpoint between P and C. It is focal point F.

4.3 Focal Point of concave mirror

Aim

To determine the focal length of concave mirror.

Procedure

Step 1

Set the ray box for parallel beam of light.

Step 2

Place the concave mirror perpendicular to the path of parallel rays.

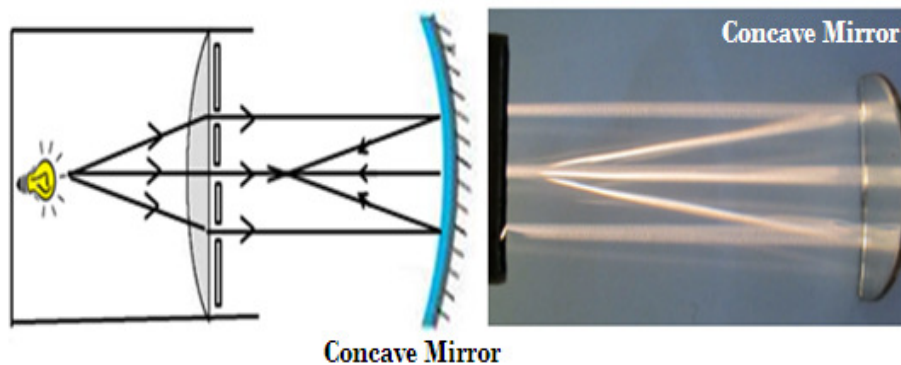
Step 3

Move the platform in the front and back direction.

What do you observe?

Observation

Reflected rays from the concave mirror converge at a point.



Inference

Measure the distance between the focus and the mirror which gives you the focal length of the concave mirror.

4.4 Image formation in concave mirror

Aim

To show image formation in a concave mirror

Procedure

Step 1

Place a drawing sheet on the table and place a mirror stand, candle and screen on the drawing sheet.

Step 2

Insert a concave mirror in the mirror stand and keep it in front of a lighted candle.

Step 3

Keep the screen and candle side by side and move both of them together till a distinct image of the candle is formed on the screen.

Mark the position of the candle as **C** , and position of mirror as **P**.

Step 4

Join P and C and extend the line which represents the principle axis of concave mirror. Make a midpoint between P and C, which is F.

Step 5

Keep the object (candle) at different positions from the mirror on the principal axis and find the position of the image.

Step 6

Taking any case of real image, measure object distance and image distance.

Using the following formula you can calculate the focal length of concave mirror:

$$1/f = 1/u + 1/v$$

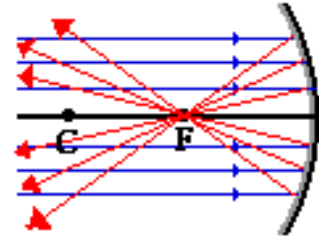
Focal length f = product of image distance and object distance / (Sum of image distance and object distance)



Observation

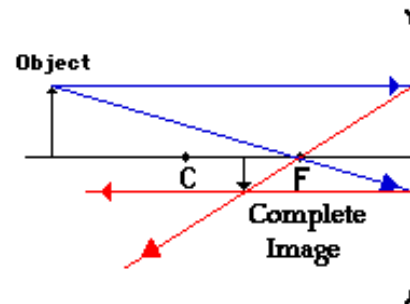
1. Object at Infinity

Image is formed at F It is real, inverted and diminished.



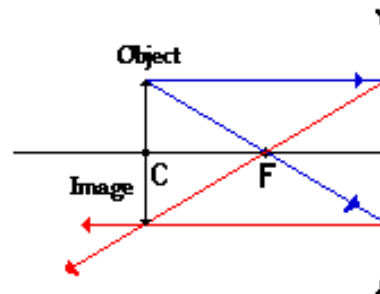
2. Object beyond C

Image is formed between F and C. It is real, inverted and diminished



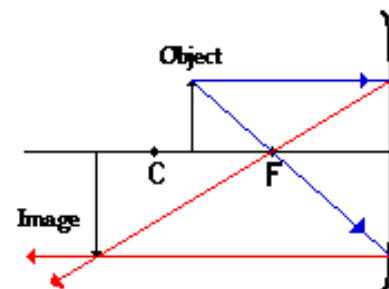
3. Object at C

Image will be formed at C itself. It will be real, inverted and of the same size as the object



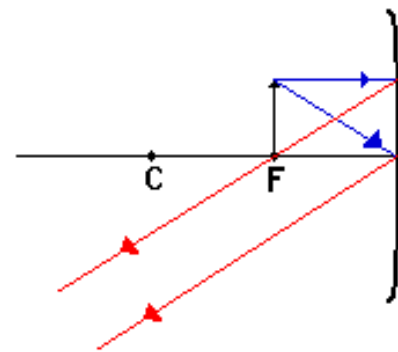
4. Object between F and C

Image will be formed beyond C. It is real, inverted and magnified.



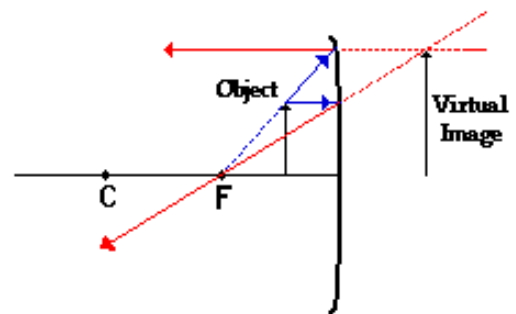
5. Object at F

The rays will emerge parallel after reflection. Since parallel rays are assumed to meet at infinity- the image will be formed at infinity.



6. Object between F and P

The image is behind the mirror. It is virtual, erect and magnified.



Inference:

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

4.5 Application of concave mirror



5 Refraction of light

5.1 Refraction of light – pencil method

Aim

To understand the phenomenon of refraction of light

Procedure

Step 1

Fill $3/4^{\text{th}}$ of the beaker with water.

Step 2

Place a pencil in it.

Step 3

Observe the pencil kept inside the water.



Observation:

A portion of the pencil inside the water appears slanted and bulged.

5.2 Refraction of light – Coin method

Aim

To understand the phenomenon of refraction of light

Procedure

Step 1

Place a glass trough on the table.

Step 2

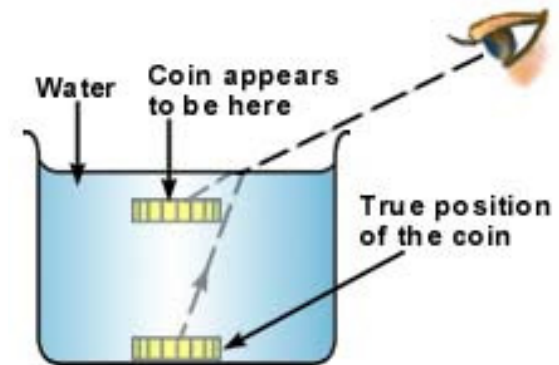
Keep a coin at the center of the trough.

Step 3

Move back until the coin is no longer visible to you.

Step 4

Ask your friend to pour water in to the trough until the coin is well under water. What happens?



Observation

Coin which was invisible earlier becomes visible.

Inference

Light rays from the coin first travel through water. When they reach the surface they travel through air. This causes the light rays to bend when they travel from one medium to another i.e. from water to air. The same thing holds true for the pencil.

5.3 Refraction of light in Acrylic slab

Aim

To understand the phenomenon the refraction of light

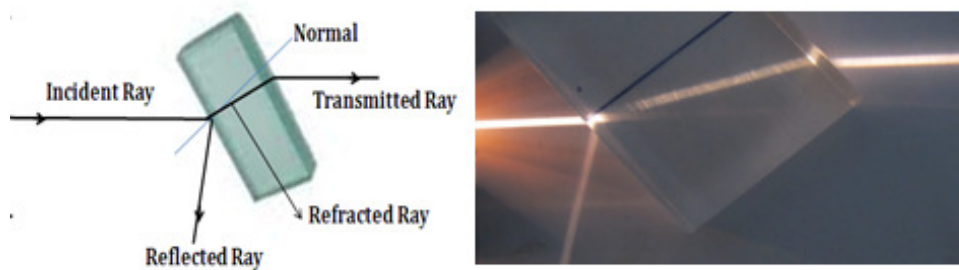
Procedure

Step 1

Take an Acrylic slab and place on the white sheet.

Step 2

Direct a beam of laser light obliquely on the surface of the glass slab. What do you observe?



Observation

The ray of light bends when it travels through the slab

Inference

When light travels from one medium to another medium, it changes its direction. This phenomenon is called refraction of light.

5.4 Total internal reflection

Aim

To understand the phenomenon of total internal reflection

Procedure

Step 1

Place the semi-circular slab on a sheet of paper.
Draw a normal to the flat surface at its centre.

Step 2

Direct a beam of laser light such that it is incident along the normal.

You see that it is not deviated.



Step 3

Direct the light on the curved surface making some angle to the normal.

In this case, the ray travels from denser to rarer medium. The emergent ray bends away from the normal.



Step 4

Increase the angle of incidence by shifting the laser pointer till emergent ray grazes the flat surface of semi circular slab. This angle of incidence is called the CRITICAL ANGLE.



Step 5

Gradually increase the angle of incidence such that it becomes greater than the critical angle. You see the ray is not refracted but is reflected inside the same medium. This phenomenon is called 'Total Internal Reflection'.

Total internal reflection occurs in materials in which the speed of light is less than the speed of light outside.



Observation

When the angle of incidence is greater than the critical angle, the ray is not refracted but is reflected.

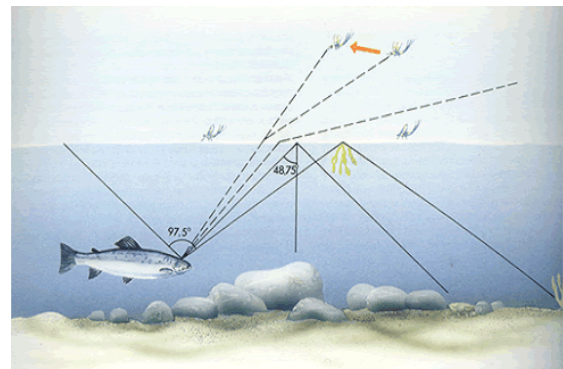
Inference

Total internal reflection occurs when light travels from denser medium to rarer medium, and when the incident angle is greater than the critical angle.

Applications of Total Internal Reflection

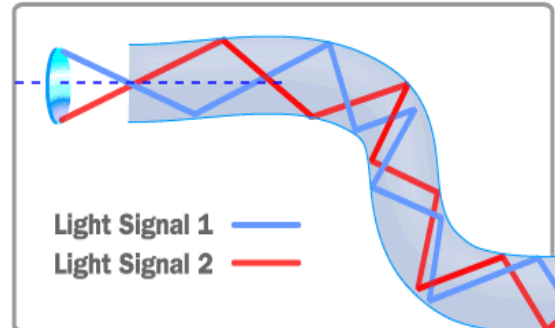
The speed of light in water is less than that in air, so all the light rays in water that reach the surface at more than 48° (critical angle for water is 48°) are reflected back into the water.

Because the critical angle for water is 48° , the gold fish looks up to see a reflected view of the sides and bottom of the aquarium.



5.5 Optical fibers

Optical fibers operate on the principle of total internal reflection. An optical fiber sends light from one place to another by a series of total internal reflections. Light ray bounces along the inner walls, following the twists and turns of the fiber.



They are used to see what is going on in inaccessible places, such as the interior of motor or inner parts of a patient. They can be made small enough to snake through blood vessels.



Optical fibers are used in decorative lamps.



Optical fibers in decorative lamps

5.6 Dispersion of light

Aim

To understand the phenomenon of dispersion of light

Procedure

Step 1

Set the ray box and insert single slit.

Step 2

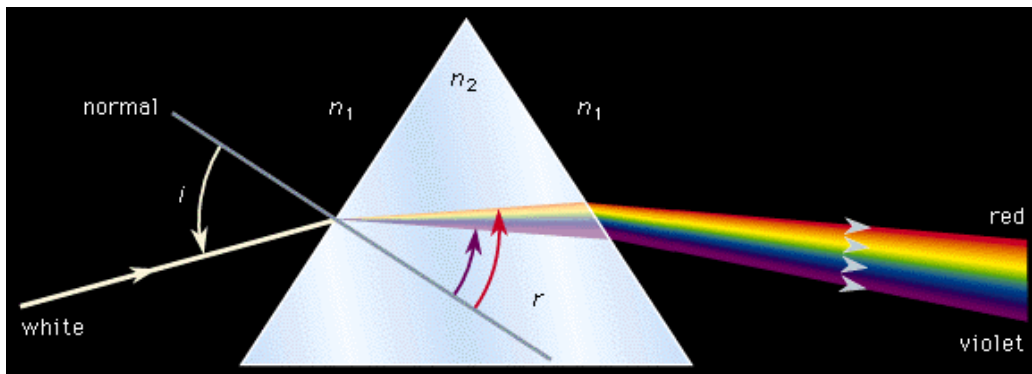
Adjust the platform such that single beam of light appears on it.

Step 3

Place the prism in the path of white light beam and rotate the prism slowly and observe on either side. What do you see?

Observation

You see a spectrum of colors.



Inference

When white light passes through a prism, it splits into seven different colours. This phenomenon is called dispersion of light.

Daily life example

Rainbow formed in the rainy season is a result of dispersion.

6 Low cost Models

6.1 Periscope

Materials

2 plane mirror strips, protractor, scale, glue, scissors and card-board sheet.

Procedure

Step 1

Fold the card sheet as shown in the figure 1.

Step 2

Glue it and make a rectangular tube.

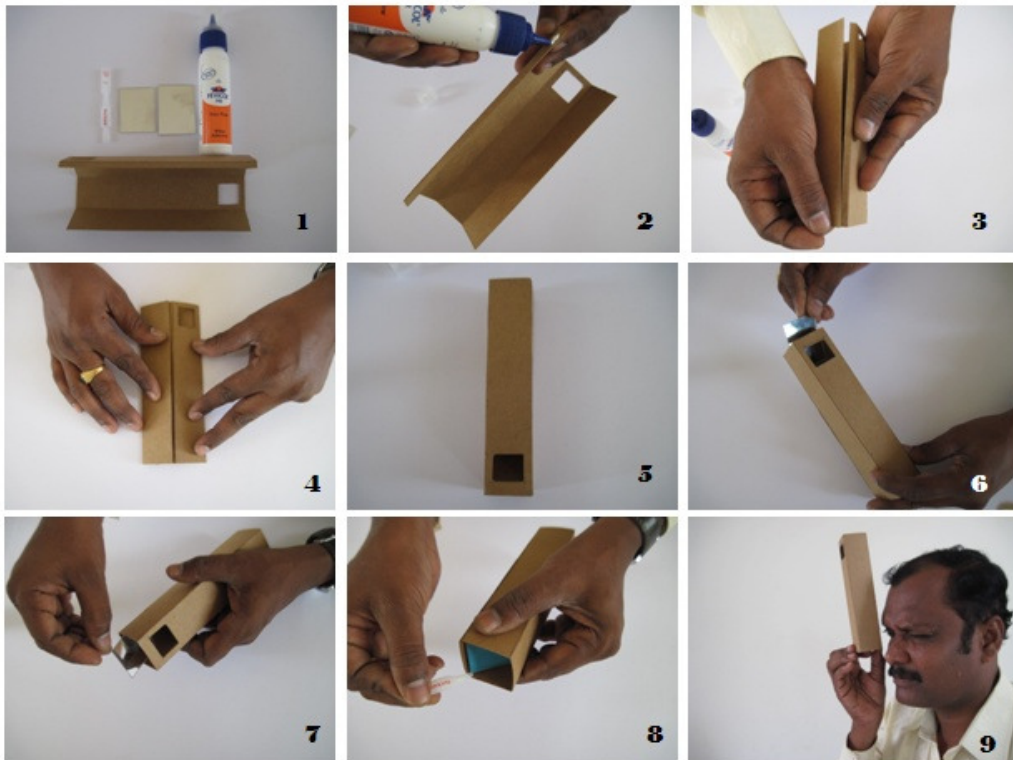
Step 3

Make two rectangular holes at the end of the tube in the opposite sides as shown in the figure 6 and 7.

Step 4

Insert two mirror pieces on both the ends so that they are parallel and their reflected surface face each other.

Now periscope is ready



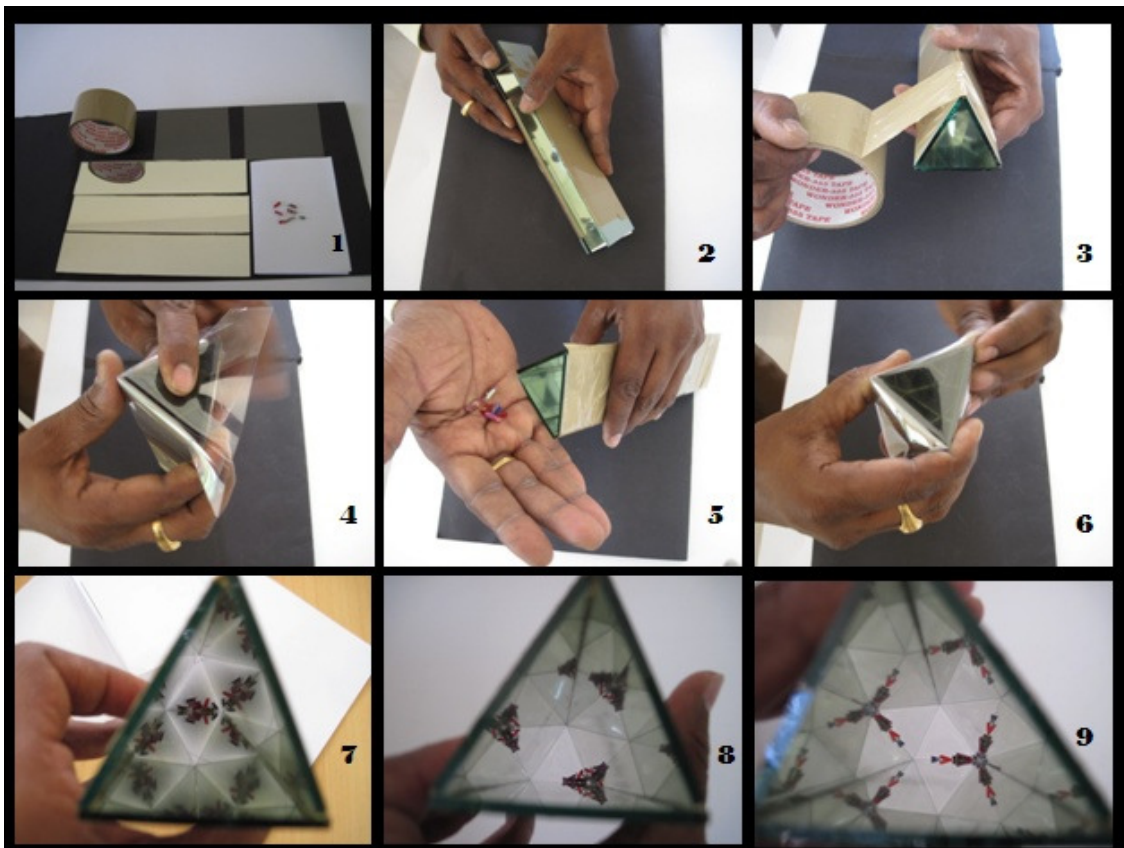
6.2 Kaleidoscope

Materials

Three plane mirror strips of same size (3 cm x 10 cm), cello tape, card-board sheet, butter paper, broken pieces of bangles, rubber bands.

Procedure

- Tape the three mirror strips together to form a long triangular prism.
- Roll a piece of card board around the prism and fix it tightly with rubber bands.
- Stick butter paper over both the ends. And make a peephole at one end.
- Put some pieces of bangles through peep hole.
- Look through the peephole while rotating the tube.
- You see beautiful patterns formed by multiple reflections of glass pieces.



6.3 Pin hole camera

Materials:

- A cylindrical can with a metal bottom. This works best, but you can also use a cardboard tube.
- Aluminium foil
- Tracing paper
- Black construction paper
- Tape (electrical insulation)
- Pin
- Ruler
- Marker
- Box cutter

Procedure:

1. Use a ruler to measure two inches from the bottom of the can and mark the spot. Do this several more times around the can and then connect the marks so that you have a circle all the way around. Cut the can in two pieces along this line.

2. Make a hole in the centre of the metal bottom. This step requires some patience, because you want it to be a tiny, smooth hole. (If you are using a cardboard tube, place a piece of aluminum foil between two index cards and gently turn the pin through the layers. Then tape the aluminum foil to the end of the tube, with the hole in the center.)

3. Cut a circle out of waxed paper and tape it over the top of the short part of the can. This will be your viewing screen or "film."

4. Put the long part of the can back on top of the short part and tape the two pieces together so they form a single tube again.



5. For a pinhole camera to work, light must enter through the pinhole. Make your camera "light-tight" by wrapping it with aluminum foil.

6. Roll the piece of black construction paper into a tube and insert it part-way into the open end of the can. This will act as a light-shielding eyepiece for your camera.

Now you are ready to use your camera! Place an object such as a flower or pencil (or even your hand!) under a bright lamp so it is well lit. Point the pinhole end of the camera at it and look through the black paper eyepiece. You should see an image of the object on the waxed paper screen; move your camera to and fro until the object is in focus. The image is upside-down and reversed, so you will have to move the camera in the opposite direction from what you expect. Remember, practice makes perfect!

