Light, Shadows and Reflections

Transparent, Translucent and Opaque Objects

What is the difference between the nature of the materials used to make the lenses of sunglasses and spectacles? And what is the difference between the nature of the materials used to make a carton of juice and a cold drink bottle?

Therefore, we can easily classify materials into three categories according to their optical properties.

Transparent objects	**Translucent objects**	**Opaque objects**
These objects allow light to pass through them.	These objects allow light to pass through them partially.	These objects do not allow light to pass through them.
One can clearly see through transparent objects.	One can see through translucent objects but not very clearly.	One cannot see through opaque objects.
Transparent objects do not cast shadows because they do not block light.	Translucent objects cast faint shadows as they block light partially.	Opaque objects cast dark shadows as they block light completely.

Curtains and Windows

One afternoon, after coming home from school, Ravi goes inside his room and notes that the room is dark. Ravi draws the curtains, allowing sunlight to enter the room through the window. As a result, the room is lit up. **Now, can you identify the types of materials the curtain and windowpanes are made of?**

You can classify a variety of objects as transparent, translucent, or opaque by observing the shadows they cast and by trying to observe other objects through them. The following table lists some common substances as transparent, translucent, and opaque.

Substance	**See-through**	**Shadow cast**	**Classification**
Pencil	Not at all	Dark	Opaque
Paper	Not at all	Dark	Opaque
Glass	Fully	No shadow	Transparent

Water	Fully	No shadow	Transparent
Smoke	Partially	Light	Translucent
Butter paper	Partially	Light	Translucent

Collect various materials from your daily life (for example, eraser, ruler, book, bottle, cup, chalk, duster, glass, tissue paper, paper bag, sunflower oil, coconut oil, kerosene, etc.). Now, observe the shadows cast by these objects and classify them as transparent, translucent, or opaque.

Light: Nature and Properties

Have you already figured out the answer to the last question asked in the animation?

You are not able to see the ball through the curved pipe because the reflected light rays coming from the surface of the ball do not reach your eyes. This happens because light always travels in a straight line.

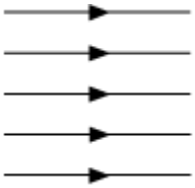
Light rays travelling outward in straight line

After emanating from a source, light travels only in a straight line in all directions. This phenomenon is called the **rectilinear propagation of light**. The straight lines are also called rays of light. The collection of rays of light is known as beam of light.

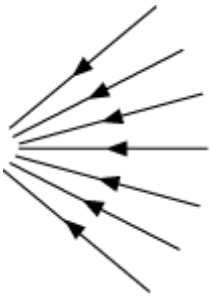
Have you seen a lighthouse from a distance? The light beam that comes out from it travels in a straight path because of the property of rectilinear propagation of light.

The light rays emitting from a source can be either parallel, convergent or divergent.

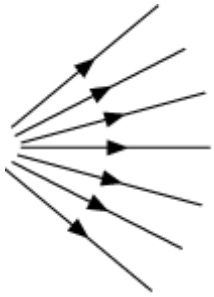
Parallel- the rays of light which are equidistant from each other at all places and do not meet are called parallel rays of light.



Convergent- the rays of light which come from different directions and meet or appear to meet at a point are called convergent rays of light.



Divergent- the rays of light which emit from a common source or point of light and travel in different directions after emitting are called divergent rays of light.

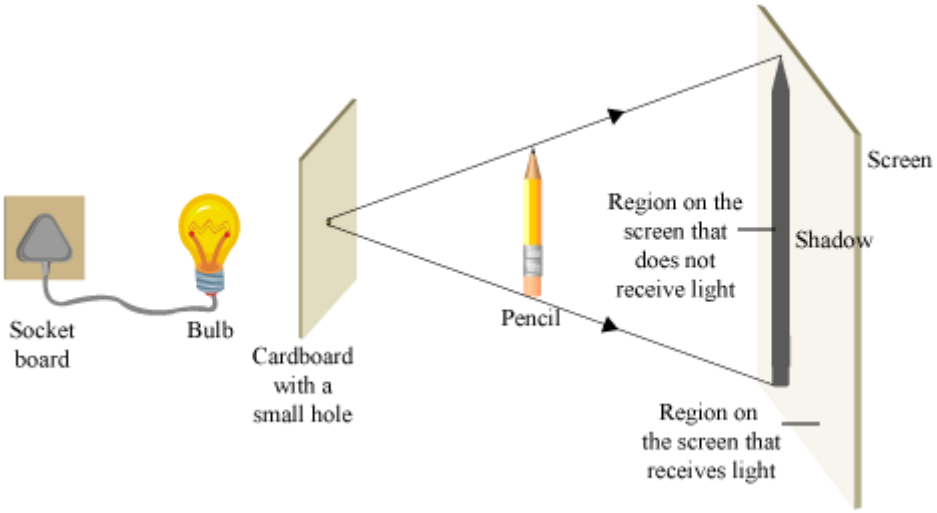


The light rays propagate in different media with different speeds, the maximum being in air or vacuum.

Medium	Speed of light (in m/s)
Air/ Vacuum	$3\times\times10^{8}$
Water	$2.25\times\times10^{8}$
Glass	$2\times\times10^{8}$

Shadow and Its Formation

Here is the graphical representation of the experiment you have just seen in the animation.



Shadow of a pencil in a point source of light

Remember, a screen is must to obtain a shadow.

What happens to the size of the shadow when the pencil is moved towards the screen?

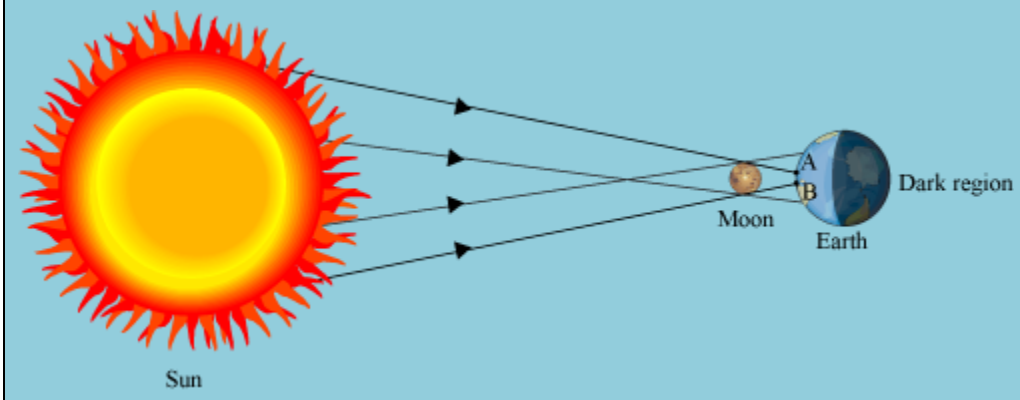
What happens when it is moved towards the source?

When the cardboard and the bulb are moved vertically upwards, the shadow of the pencil will move downwards on the screen. Why?

Eclipse

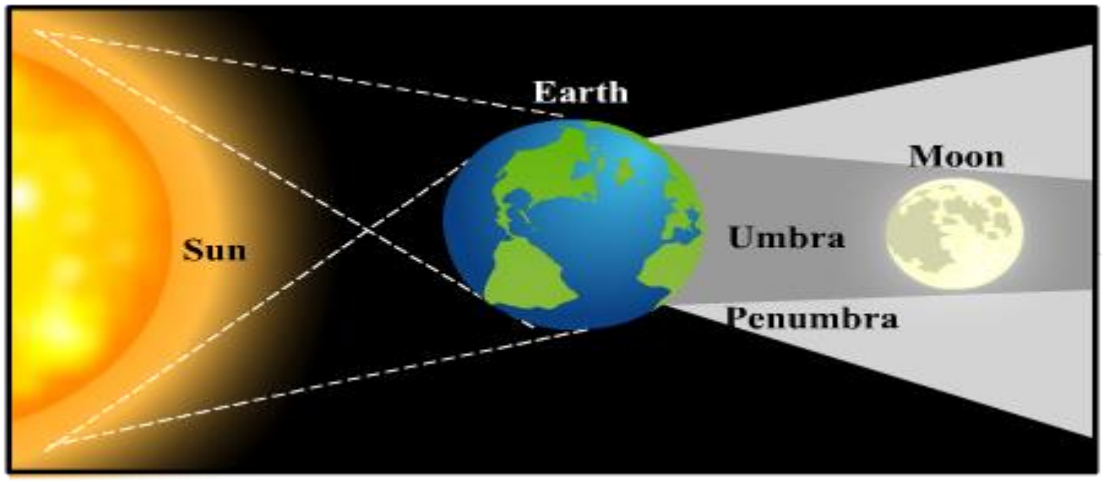
Why are we talking about eclipse when we are discussing shadows?

Can you identify the regions **umbra** and **penumbra** in the following figure of solar eclipse?



Why do the regions of umbra and penumbra occur on earth?

What happens when Earth comes between Sun and Moon?



Lunar eclipse occurs when Earth comes in between Moon and Sun and Earth's shadow falls on the Moon. The lunar eclipse occurs on the full night moon.
Total lunar eclipse: When the total moon comes under the shadow of the earth.
Partial lunar eclipse: When partial moon or some part of moon comes under the shadow of the earth.

Can we see lunar eclipse from anywhere on the night side of the earth?

Identifying Objects from their Shadows

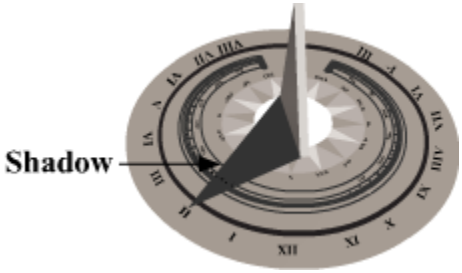
Is it possible to identify an object from its shadow?

So far you have learned that

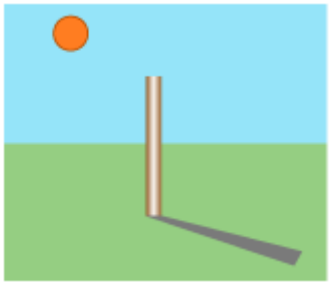
- the size and nature of the shadow of an object depend upon its position from the source of light. Hence, **actual size of an object cannot be determined by its shadow.**
- a shadow can provide some information about the shape of the object that casts the shadow. Therefore, **sometimes it is possible to identify the shape of an object by observing its shadow.**
- whatever be the color of an object, the color of the shadow cast by the object is always black. Therefore, **the color of an object cannot be identified by its shadow.**

Do you know how time was measured in early days?

In ancient times, people used to measure time by the shadow of an object cast by the sun. A device, named **Sundial** was invented for this purpose. This device used to tell the time of a day by casting of the shadow of a triangular blade on a reference plane with markings.



The largest sundial is situated at Jantar Mantar, Jaipur, India.

Fix an iron rod in an open ground and observe its shadow. Now, rotate the rod about its axis by some angle and observe its shadow again. **Will the shape or the size of the shadow change because of the rotation of the rod?**	

Shadows can also be used for fun. Several artists create shadows of different birds and animals using their hands. Some examples of such shadows are shown in the given figure.

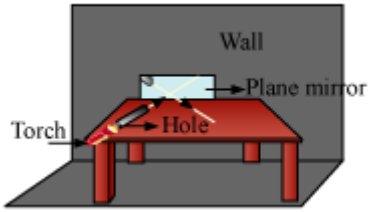
Reflection of Light by Plane Mirror

Reflection from a plane mirror

Is it possible to find the direction of a reflected ray? Let us perform an activity to find out.

Activity:

Place a plane mirror on a table. Take a sheet of paper and make a small hole in it. Make sure that the light in the room is not bright. Hold the sheet normal to the table. Now, light a torch and allow its light to fall on the mirror through this small hole.



When the ray of light from the hole hits the mirror, it gets reflected in a certain direction. Measure the angle of incidence (i) and the angle of reflection (r) with the help of a protractor. Now, change the orientation of the paper with respect to the mirror. Then, measure the angle of incidence and the angle of reflection again. Make sure that the paper is perpendicular to the table in each observation. Perform this activity four or five times and record the observations in tabular form.

What do you observe? Is the angle of incidence equal to the angle of reflection? Through different experiments, it has been proved that the angle of incidence is always equal to the angle of reflection. This is known as the **first law of reflection**.

We can take the **incident ray**, the **reflected ray**, and the **normal** on the same piece of paper. This shows that these **lie in the same plane**. This is the **second law of reflection**.

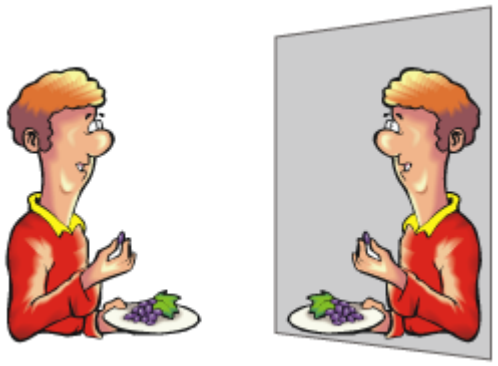
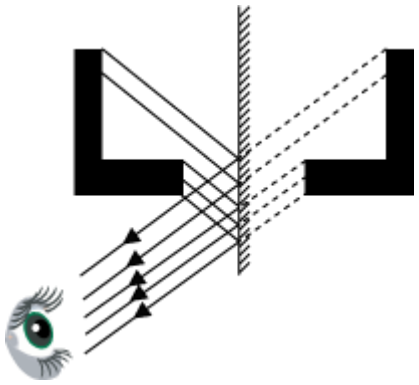
Reflection on Plane Mirrors

Image formed by a plane mirror is at the same distance from the mirror as the object is from the mirror.

A mirror forms images by the reflection of light. Images formed by plane mirrors are termed as **virtual** because they cannot be touched or captured on a screen. These images have the **same size** as the object and are **laterally inverted**.

Laterally inverted? What is that? Some properties of the images formed by a plane mirror are discussed below.

The orientation of the image formed by a plane mirror is such that the object on the left appears to be on the right and vice-versa. This phenomenon is known as the **left-right reversal or lateral inversion.**

Take some fruit in a plate. Hold this plate with your left hand and eat the fruit using your right hand. Now, stand in front of a plane mirror and observe your image in it. Why does it appear in the mirror that you are eating with your left hand and holding the plate with your right hand?	
The distance between the mirror and the image is the same as that between the object and the mirror.	

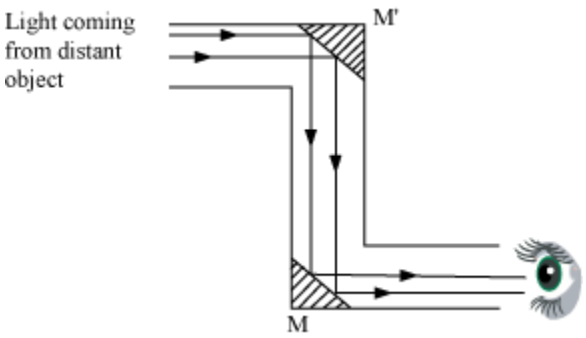
Mirror writing is an art of writing texts in the reverse order such that they appear as the mirror image of the original text. Such words can be read through their mirror images.

In mirror writing, the word MUM remains MUM.

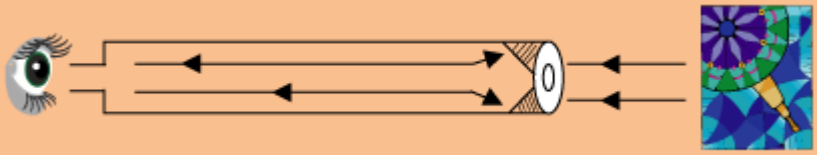
Leonardo Da Vinci wrote most of his secret thoughts using mirror writing.

Write your name on a cardboard and try reading it by looking at its image in a mirror.

Periscope is an optical instrument that is used to see an object that is out of the direct line of sight. It consists of two plane mirrors, which are placed parallel to each other. The light coming from the object reaches the viewer after it is reflected by the mirrors M′ and M respectively. Hence, **a virtual** image having the **same orientation and size** as the object is seen by the viewer.



Kaleidoscope is an optical device that is used to see **beautiful coloured symmetric patterns**. It is a tube that consists of some plane mirrors and a few coloured beads such as pieces of glass bangles. **Virtual** coloured images of these pieces can be seen because of the reflection of light by the mirrors onto the coloured pieces.



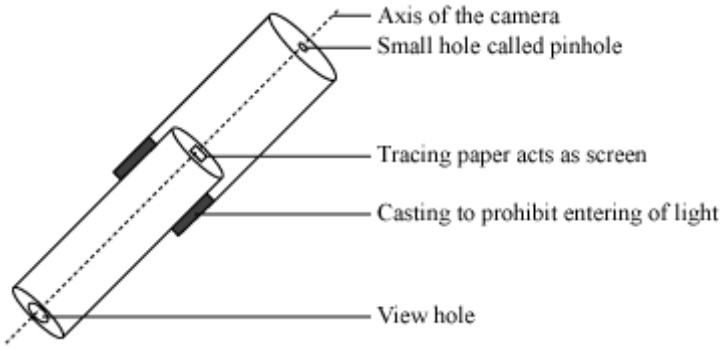
Pinhole Camera

Now, we will summarise what we have learned so far.

- A pinhole camera is a simple optical device that forms an image without using a lens or a mirror.

Construction of a Pinhole Camera

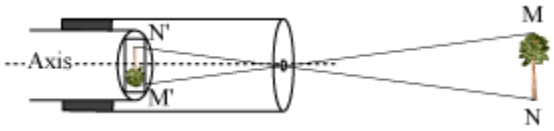
Here is a graphical representation of a simple pinhole camera.



Did you know that a pinhole camera does not require a lens or a mirror for image formation?

A Chinese scholar invented the pinhole camera in 400 B.C.

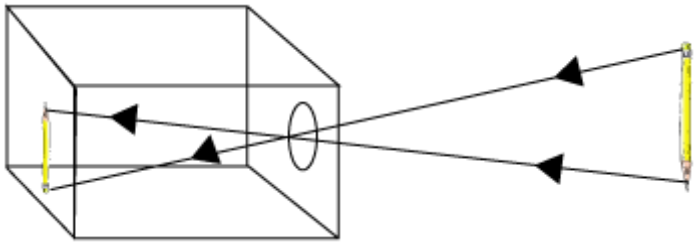
Working principle of a Pinhole Camera



The size and contrast of the formed image can be changed by sliding the smaller cylinder. In addition, the image also depends on the size of the pinhole; the smaller the pinhole, the sharper will be the image and vice-versa.

Try looking at your own hand through a pinhole camera. You will observe an upside down image of your hand. Now, move your hand downwards slowly. **What do you observe on the screen?** You will observe that the image of your hand is moving upwards.

A pinhole camera creates a real image of an object because the image can be captured on a screen. The image formed by a pinhole camera is **inverted** and **smaller** than the object.



Construct your own pinhole camera and look at the sun during a solar eclipse. Avoid looking at the sun directly.

Does the size of the image formed in the pinhole camera remain same?

The following factors affect the size of the image:

- **Distance between the pinhole and the screen:** The size of the image increases with the increase in distance between the screen and the pinhole and vice-versa.
- **Distance between the pinhole and the object:** The size of the image increases when the object is moved towards the pinhole and vice-versa.