

Light (Part 1)

Light is an important factor that decides whether we would be able to see an object or not. We see an object only when light from the object reaches our eyes.

Light is the form of energy which gives us the sensation of sight. It is invisible in itself but makes the object falling in its path visible.

Luminous objects are the ones which are able to produce their own light while others like chairs, tables, sofa etc are illuminated objects and get lightened up by other sources of light like bulb, tube, sun. These illuminated objects then reflect light coming from some light source into them into our eyes.

Uses of Light...

Its uses are seen in looking mirrors, spectacles, telescopes, periscopes, driving glasses, cameras...the list is endless

Properties of Light

RECTILINEAR PROPAGATION OF LIGHT

- Light travels in a straight line in a uniform transparent medium like air. This mode of travel of light in a straight line in a uniform transparent medium is called **Rectilinear Propagation of light**. Rectilinear means straight line and propagation means movement.

REFLECTION OF LIGHT

- Light travels in a straight line but we can change the path of the light by making it fall on a surface.
- The change in the direction of light after falling on a surface or the bouncing back of light on striking a given surface is called Reflection.
- For example, direction of light changes when it falls on a shiny surface like a mirror, a metal pencil box, shiny surface like a steel plate or a spoon.

How do we see things due to reflection??

- When a ray of light hits an object it gets bounced back from the object and this reflected light reaches our eyes and hence we are able to see the surface.



SOME IMPORTANT TERMS

When light strikes a surface, and gets bounced away from it, there are certain terms which are used.

- **RAY**

This is the path traced by a beam of light.

- **INCIDENT RAY (\vec{i})**

It is the ray of light moving towards the reflecting surface (such as a mirror).

- **POINT OF INCIDENCE (O)**

It is the point of the surface where the incident ray strikes the surface.

- **REFLECTED RAY (\vec{r})**

On striking the surface, the ray of light bounces off and moves away from the surface. This ray of light moving away from the surface after reflection is called the reflected ray.

- **NORMAL (N)**

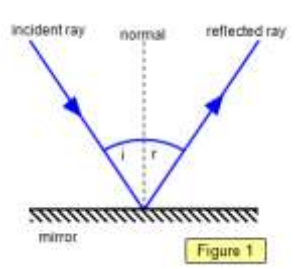
It is an imaginary straight line at the point of incidence drawn perpendicular to the surface.

- **ANGLE OF INCIDENCE ($\angle i$)**

It is the angle between the normal and the incident ray.

- **ANGLE OF REFLECTION ($\angle r$)**

It is the angle between the normal and the reflected ray.



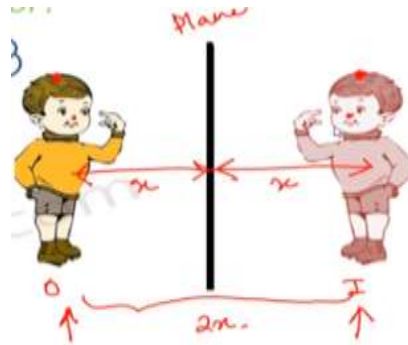
LAWS OF REFLECTION

- The angle of incidence is equal to the angle of reflection.
- The incident ray, normal, and the reflected ray all lie in the same plane.

PLANE MIRROR

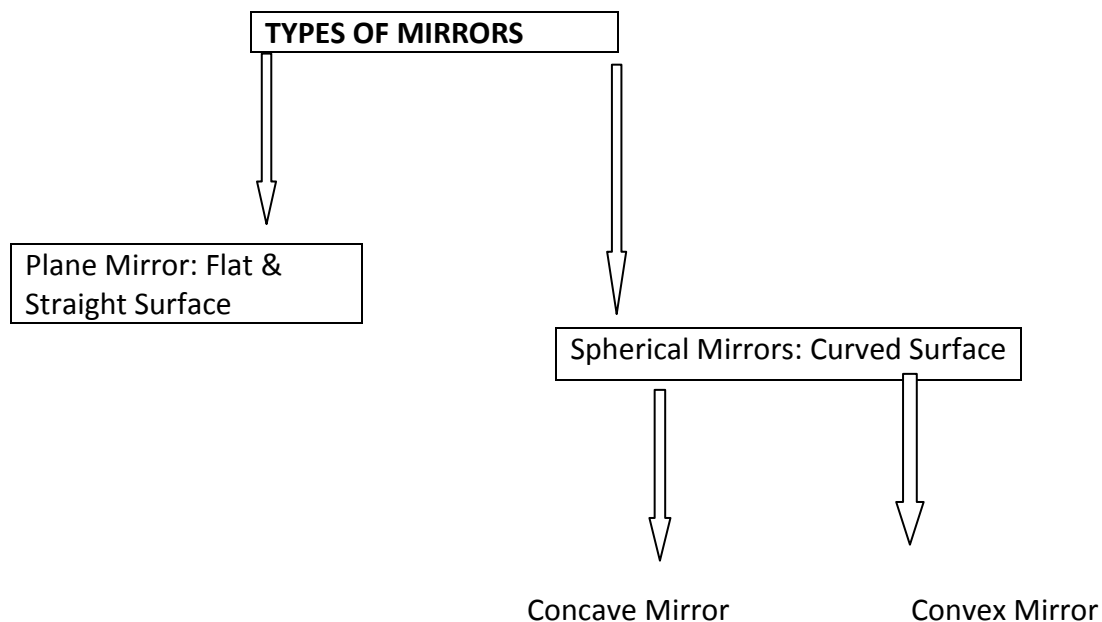
A plane mirror is a smooth polished surface that acts as a reflecting surface. It also has a painted surface.

When light falls on an object, say a flower vase, falls from the vase and hits the mirror. As soon as it falls on the mirror, the mirror has a shiny surface and reflects these rays back. These reflected rays when extended backwards meet at a point where the image is formed. Hence this image is called a virtual image since the rays actually don't meet but appear to meet.



REAL AND VIRTUAL IMAGES

- The image form by a projector (similar to the images formed in a cinema hall) is called a REAL IMAGE. This is because this image is formed by actual meeting of the rays and hence can be formed on a screen.
- However, in case of plane mirror the image seems to be formed behind the mirror and if we move away from the mirror the image also moves away from us. However, this image is visible only through a mirror and will vanish the moment the object is moved away from the mirror. Since, this image cannot be formed on a screen it is called a VIRTUAL IMAGE.



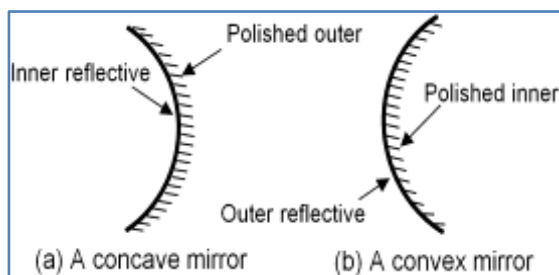
PLANE MIRROR

The image formed by a plane mirror shows certain characteristics:

1. Is of same size as that of the object.
2. The distance of the object in front of the mirror is same as the distance of the image behind the mirror
3. If the object moves away or come closer to the mirror, the image also seems to move away or come closer to the mirror.
4. The image formed is always erect and virtual
5. The image formed is of the same size , colour and same details.
6. LATERAL INVERSION – When an image is formed by a plane mirror, the left appears as the right and the right appears as the left. This is known as lateral inversion.

SPHERICAL MIRRORS

- Mirrors with curved surfaces are called spherical mirrors.
- Spherical mirrors can be thought of as a portion of a sphere that was sliced away and then silvered on one of the sides to form a reflecting surface. **Concave mirrors** were silvered on the inside of the sphere and **Convex mirrors** were silvered on the outside of the sphere
- Spherical mirror with a concave reflecting side is called a concave mirror.
- Concave mirror is called Converging Mirror as when a beam of light falls on it the reflected rays converge at a point
- Spherical mirror with a convex reflecting side is called a convex mirror.
- Convex mirror is called Diverging Mirror as when a beam of light falls on it , the reflected rays diverge away from it.



CONCAVE MIRRORS

SOME TERMS OF CONCAVE MIRRORS:

PRINCIPAL AXIS :If a concave mirror were thought of as being a slice of a sphere, then there would be a line passing through the center of the sphere and attaching to the mirror in the exact center of the mirror. This line is known as the **principal axis**. (It is perpendicular to the mirror at its vertex or pole.)

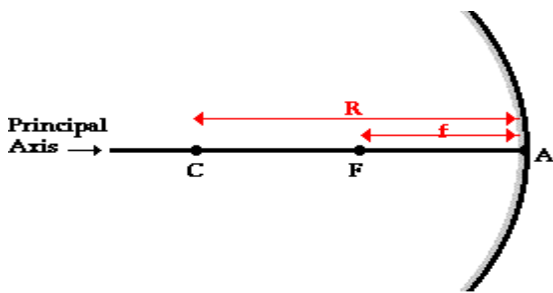
CENTER OF CURVATURE: The point in the center of the sphere from which the mirror was sliced is known as the **center of curvature** and is denoted by the letter **C** in the diagram below.

VERTEX OR POLE: The point on the mirror's surface where the principal axis meets the mirror is known as the **vertex** OR the **Pole**, and is denoted by the letter **A Or P** in the diagram below. The vertex is the geometric center of the mirror.

RADIUS OF CURVATURE: The distance from the vertex to the center of curvature is known as the **radius of curvature** (represented by **R**). The radius of curvature is the radius of the sphere from which the mirror was cut.

FOCAL POINT :Midway between the vertex and the center of curvature is a point known as the **focal point**; the focal point is denoted by the letter **F** in the diagram below.

FOCAL LENGTH: Finally, the distance from the mirror to the focal point is known as the **focal length** (represented by **f**). Since the focal point is the midpoint of the line segment adjoining the vertex and the center of curvature, the focal length would be one-half the radius of curvature.



IMAGES FORMED BY CONCAVE MIRRORS WHEN THE OBJECT IS PLACED AT DIFFERENT LOCATIONS

Different types of images can be formed by a concave mirror by changing the position of the object from the concave mirror. Therefore different types of images are formed when the object is placed

1. At the infinity
2. Beyond the centre of curvature
3. At the centre of curvature
4. Between centre of curvature and principal focus
5. At the principal focus
6. Between the Principal Focus and Pole

CONSTRUCTING THE DIAGRAMS/ RAY DIAGRAMS

1). To determine the location of an image using a ray diagram, at least two sets of incident and reflected rays must be constructed. The image of an object is at the location where light rays from that object meet after reflecting from a mirror. By constructing at least two sets of incident and reflected rays, this image location can easily be found. We can also construct 3 sets of line. The choice between 2 or 3 lines is ours (there is no difference)

2). Of all the rays which emanate from the top of the object and fall on the mirror, there are 3 rays whose behavior at the mirror surface can be easily predicted. Following are the two incident rays which are used in the ray construction :

- One of the rays moves parallel to the principal axis and reflects through the focal point.
 - The second ray passes through the focal point on the way to the mirror and reflects parallel to the principal axis.
- All concave and convex mirror ray diagrams can be constructed from knowledge of the behavior of these two rays.
- If a ray passes through the centre of curvature, then it retraces back on the same line. (i.e. it gets reflected back on the same path)

DIFFERENT LOCATIONS OF AN OBJECT AND THE SUBSEQUENT LOCATION OF THE IMAGE IN CASE OF A CONCAVE MIRROR

1). Object Located Beyond the Center of Curvature

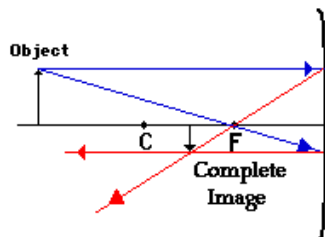
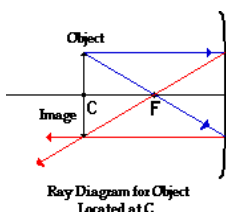


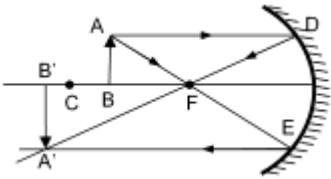
Image Beyond 'C' is : Between 'C' and 'F'
Real, Inverted, Diminished

2). Object Located at 'C'



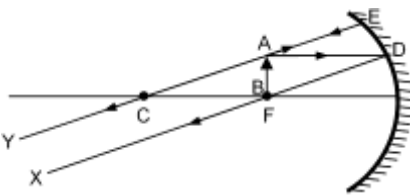
So the image at 'C' is : At 'C'
Real, Inverted, Same size as the object

3).Object Located Between 'C' and 'F'



So the image between 'C' & 'F' is : Beyond 'C', Real, Inverted, Enlarged

4). Object Located at 'F'



So the image at 'F' is : At Infinity, Real, Inverted , Highly Enlarged

5).Object Located Between 'F' and Pole

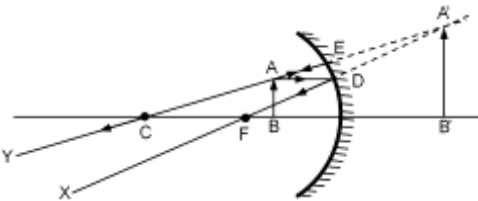


Image between 'F' & 'Pole P' is : Behind the Mirror
 Virtual, Erect, Enlarged

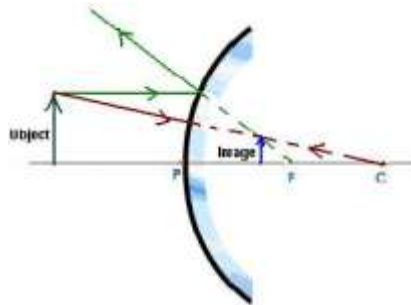
Table: Summary of images formed by a concave mirror

S No.	Position of Object	Position of Image	Size of Image	Nature of Image
1.	Beyond the centre of curvature C	Between F and C	Diminished	Real and inverted
2.	At the centre of curvature C	At C	Same size	Real and inverted
3.	Between C and F	Beyond C	Enlarged	Real and inverted
4.	At focus F	At infinity	Highly enlarged	Real and inverted
5.	Between F and P	Behind the mirror	Enlarged	Virtual and Erect

CONVEX MIRROR

According to the behavior of the convex mirror, it can produce only virtual images. It does not depend upon the size or position of an object. **The image formation by a convex mirror is described below:**

When an object is placed in front of the convex mirror, a ray parallel to the principle axis gets reflected back and is produced backwards as if it is coming from the focus (F) behind the mirror. Other ray moving towards the center of curvature (C) of the mirror gets reflected back on the same path. The reflected rays meet at a point between the center and focus. The virtual image formed behind the mirror is erect and diminished.



So the image formed in a convex mirror is : Behind the Mirror
Virtual, Erect, Diminished

USES OF SPHERICAL MIRRORS

Concave mirrors

1. Used by dentists to obtain a large virtual image of the teeth
2. Used in headlights of cars /torches
3. Used as makeup and shaving mirrors
4. Used in concentrator type solar cookers - This is because a concave mirror focuses sunlight at its focus and this point becomes very hot, hence this heat generated is used to cook food.
5. Used in reflector type telescopes – Here a large concave mirror is used to form an image of the star or the planet. This image is then magnified in the telescope.

Convex mirrors

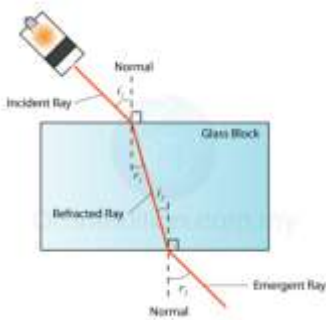
1. Used in vehicles as rear view mirrors, since they form the image of objects spread over a large area
2. Used in shops / malls for surveillance.

REFRACTION

Refraction, in physics is the change in direction of a wave passing from one medium to another caused by its change in speed.

Similarly, the change of direction of light because of change of medium resulting in a change of its speed is known as Refraction of Light. The light travels at faster speed in rare medium and at slower speed in denser medium.

CONCEPT OF REFRACTION IN 2 DIFF MEDIUMS



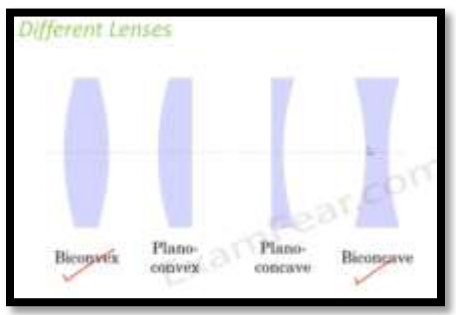
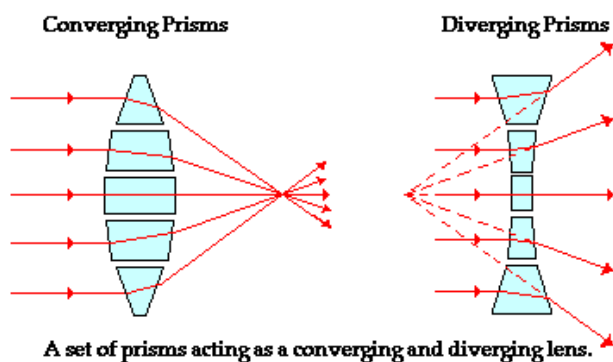
- 1). When a ray of light from one medium, strikes a surface as incident ray, and enters another different medium, it changes its path and this is called refraction.
- 2). The point at which it strikes forms an angle with the Normal (or Perpendicular) to that surface and this is called the angle of incidence. (i_1)
- 3). If the light enters a denser medium then this light gets deflected towards the normal in the new medium and the new angle at which it bends is called the angle of refraction. (r_1) This angle is less than the angle of incidence.
- 4). Once the light passes through the medium and then exits out of it again into a less dense medium, it again strikes as a new incident ray (i_2) and then gets refracted away from the normal at a greater angle r_2 . This time since it is travelling to a less dense medium, $r_2 > i_2$

LENSES

Lens is a transparent medium bound by two curved surfaces for concentrating or dispersing light rays. It refracts light rays in such a way as to form an image

- A lens allows light to pass through it.
- The light rays passing through a lens may either converge or diverge depending upon the type of lens.
- There are two types of lenses:
 1. Convex lens = Converging lens
 2. Concave lens = Diverging lens

NOTE2



SOME IMPORTANT TERMS

PRINCIPAL AXIS

The line joining the centres of the 2 spheres C_1C_2 of which the lens forms a part is called the principal axis of the lens

OPTICAL CENTRE

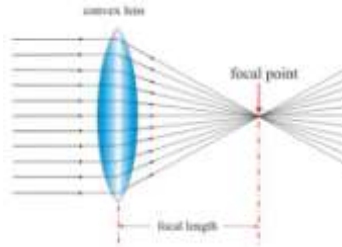
The Optical Centre "O" is the centre of the Lens. A ray of light passing through the optical centre of a lens emerges undeviated.

PRINCIPAL FOCUS AND FOCAL LENGTH

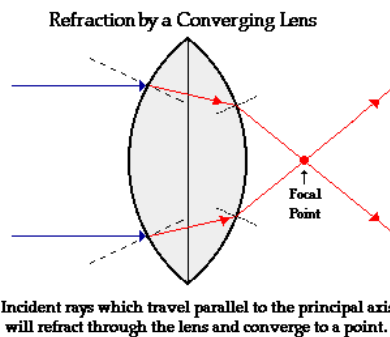
The principal focus on a convex lens, is where all the light that passes through the lens is refracted to a single point. The distance between the lens and the principal focus is what they call the focal length.

1. **CONVEX LENS**

- It is thicker in the middle and thinner at the edges.
- It is a converging lens, it is able to focus or converge light rays at a point.



REFRACTION BY A CONVEX LENS



Any incident ray traveling parallel to the principal axis of a converging lens will refract through the lens and travel through the focal point on the opposite side of the lens.

CONCAVE LENS

- The lens is broad / thicker at the edges & thinner in middle.
- The concave lens makes the light rays appear to diverge. Therefore it is known as a diverging lens.

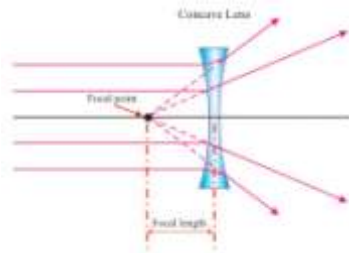
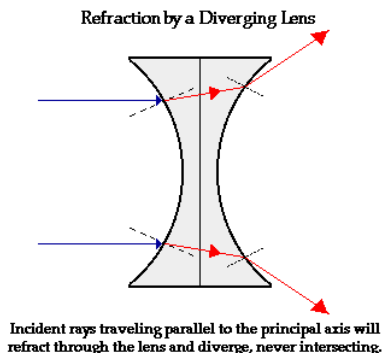


IMAGE FORMED BY A CONCAVE LENS

- If the concave lens is placed very close to an object, the image formed is diminished & virtual.
- As the lens is moved away from the object, the image remains diminished in size.

REFRACTION IN A CONCAVE LENS



Any incident ray traveling parallel to the principal axis of a diverging lens will refract through the lens and travel in a direction such that its extension will pass through the focal point).

IMAGES FORMED BY DIFFERENT LENSES

A CONVEX LENS

This can produce enlarged as well as diminished images depending on the position of the object .

- If a convex lens is placed very close to the object, then the image formed is magnified, virtual & erect. This is used in instruments like the magnifying lens, digital cameras etc.
- If the object is far away from the lens, then the image is inverted, real & it is obtained on the screen, but on the other side.

-Though there are various diff options of the object being placed at different positions in front of a convex lens, the most important location of the object where the convex lenses are used is that when ' the object is placed between the focus and the Optical centre', "say O" of a lens.

-When an object is placed b/w the principal focus, F_1 & Optical Centre, O,

A virtual, erect and enlarged image is formed at the same side of lens, when an object is placed between principal focus, F_1 and optical centre, O of a convex lens.

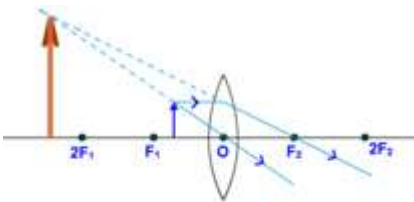


Fig: Object between F and O

Properties of Image: Image is enlarged, virtual and erect.

Q. What happens when sunlight is focused on a sheet of paper with a magnifying glass?

Ans.

A magnifying glass is a convex lens.

The convex lens, causes the sun's rays to converge & meet / concentrate at a point, on the sheet of paper.

This causes the paper to burn at the point where the sun's rays get focused. (Focal point / Focus)

IMAGES FORMED BY CONCAVE LENS

It can produce only erect & diminished images.

COLOURS OF LIGHT



- White light is made up of seven colors. The phenomenon of splitting of white light is called **dispersion** and the pattern of this band of colors is called **spectrum**.

- The seven colors in this spectrum of white light are – violet, indigo, blue, green, yellow, orange and red. (VIBGYOR)

NEWTON'S COLOUR DISK

- Newton's color disc is a disc of cardboard or metal which is divided into seven sectors which are painted in the colors of VIBGYOR.
- When the disc is rotated very fast, it appears almost white.
- This is because the image of each color on the retina does not get erased before the image of the other color forms on it due to the fast movement of the disc.
- This phenomenon is called persistence of vision.
- The reason why the color on the disc does not appear exactly white is because the colors on the disc are not exactly like the colors in the natural spectrum of light.

