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UNIQUE STUDY POINT
NOTES: CLASS X
LIGHT: REFLECTION AND REFRACTION

Introduction

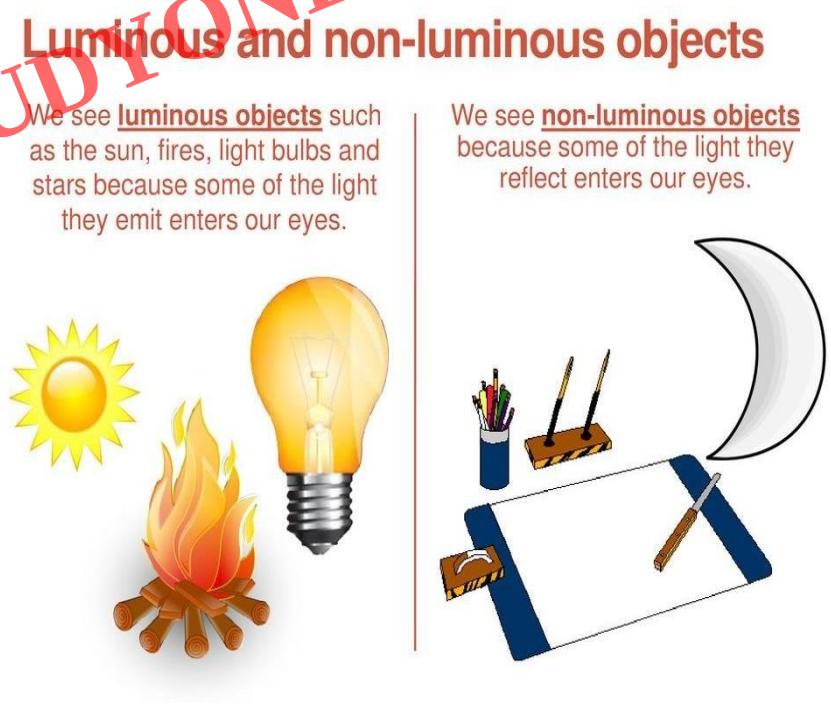
We all are familiar with light and its importance. Light is such an important source that without it all colorful things would have been black for us. So let us see how we can define such an important source.Light is a form of energy that enables us to see around us or we can say that it is an electromagnetic wave that can travel through any medium as well as through vacuum.

Types of objects

There are two types of objects as follows -

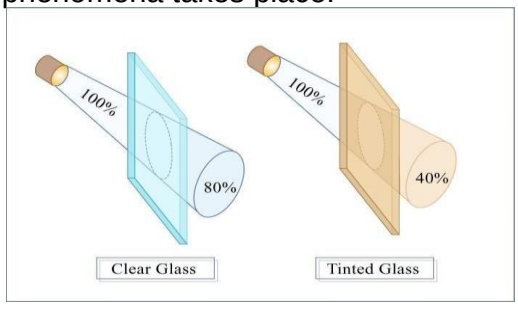
i. Luminous objects
ii.Non Luminous objects

Luminous Objects: They are those which have their own light. We can see them as they have their own light. When their light reaches our eyes that is the time when we cansee them. For example we have sun, tube light, etc. It is not necessary that it should possess light naturally. If any substance glows on passing current, that also falls under the same category.



Non Luminous Objects: They are those which do not have their ownlight. So, if there is no light, we can't see them. To see, we need a luminous object around it. For example: furniture, walls, moon, etc.If we talk about the tendency of light that how it gets affected when it falls on any surface, then we conclude that when light falls on any surface, either of these phenomena takes place:

Light falling on a surface: It may get absorbed. The surface that absorbs all the light falling on it appears tobe black in color, or in other words we say that black isa good absorber and emitter of light.



i. When light falls on the surface it may pass through it. But it isnot that all light rays would pass. Certain substances allow allrays to pass and few substances allow only certain rays to pass. Those substances which allow all rays to pass appear to be transparent. The process of allowing rays to pass through is called transmit process. For example: glass is transparent as it allows all rays to pass through it. In this figure we have tinted a plane glass. You can easily notice that tinted glass allows only a few rays to pass and on the other hand, plane glass allows all rays to pass through it.

Light falling on a surface may strike the surface and bounce back. This striking and bouncing back of light rays is called reflection. For example: we all often look in the mirror at home when we dress up. We can look at ourselves just because of the phenomenon of reflection.

In this unit we are going to consider the important phenomenon of light that is reflection.

Reflection

i. As we have discussed about reflection so now we are going to define it. "Reflection is the bouncing backof light rays on striking the surface". As you can see the picture given below, that in it the ray is striking the surface and then it bounces back.

There are many surfaces that show reflection but not all surfaces show reflection. To show reflection,there are certain characteristics that must be fulfilled as given below.

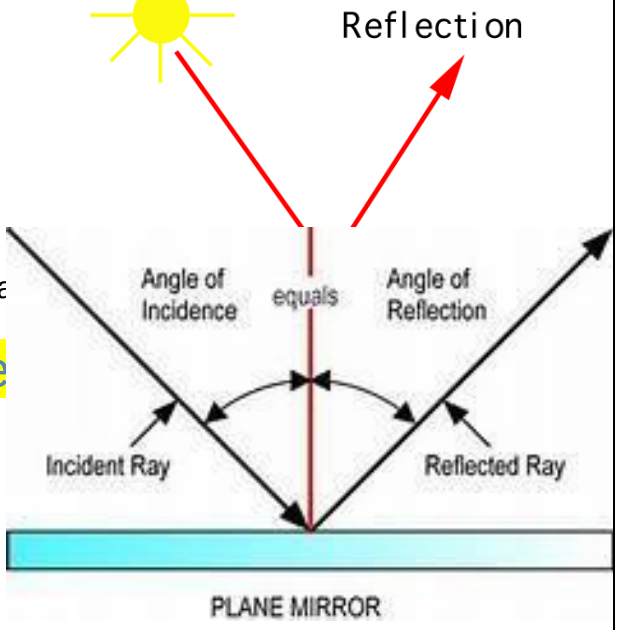
Characteristics of Best Reflector

1. It should have a shiny surface

2. It should have a polished surface

3. It should have a smooth surface

Out of all, silver metal is the best reflector as it fulfills all the a



Terminology involved in case of refle

Look at the figure to understand this in a better way.

1. Incident Ray: It is the ray that strikes the surface.

2. Point of Incidence: It is the point at which theincident ray strikes the surface.

3. Reflected Ray: The ray that bounces back onstriking the surface.

4. Normal Ray: The perpendicular drawn to surface.

5. Angle of Incidence: The angle between the incident ray and the normal ray.

6. Angle of Reflection: The angle between the reflected ray and the normal ray.

7. Plane of Reflection: Plane where incident ray reflected ray and normal ray lies.

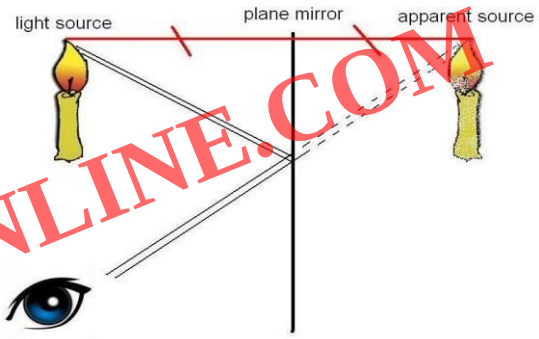
Laws of Reflection: These are certain sets of laws that are obeyed by all surfaces that show reflection.
1st law of reflection: Incident ray, reflected ray and normal ray all lie on the same plane.
2nd law of reflection: Angle of incidence is always equal to the angle of reflection.

Types of Sources of Light

As we know, there are different objects that emit light so, depending upon the size of object; we havetwo types of sources of light:

1. Point Sources

2. Finite Sources

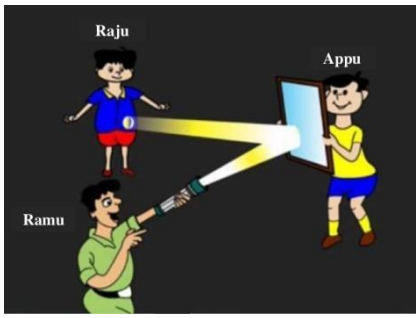


Point Sources: These are those sources that aretoo small in size.

Finite Sources: These are the sources that have certain height as shown in figure. The given diagram candle has certain length and is regardedas a finite source.

Types of Mirror

Mirrors show the phenomenon of reflection so, depending upon the type of reflecting surface of mirrors; we have two types of mirrors, as follows:



1. Plane mirror

2. Spherical mirror

1. Plane Mirror: Plane mirrors are those that have plane reflecting surface as shown in the figure.

2. Spherical Mirror: Spherical mirrors are the other types that have a curved reflecting surface. They aregenerally of two types i.e., one with a bulge and other with a depression.

i. The depression one is concave mirror and bulged one is convex mirror

Types of spherical mirrors

1. Concave mirror

2. Convex mirror

Concave mirror: It is that in which the reflection occurs through inner surface of mirror.
Convex mirror: It is that in which the reflection occurs through outer surface of mirror.

Types of Images

An image is formed when the reflected rays actually meet or appear to meet at a certain point. Accordingly, two types of images are formeddepending upon whether the reflected rays meet or not. We have two types of images:

1. Real images

2. Virtual images

Real Image:

1. It is that which is formed when reflected raysactually meet at a certain point.
2. It is always inverted.
3. It can be obtained on screen.

Virtual Image:

1. It is that which is formed when reflected rays do not meet actually but appear to meet at a

certainpoint.

2. It is always erect.

3. It can’t be obtained on a screen.

Image formed by plane mirror when point object is kept in frontof it

In this many light rays are emitted by the candle flame but in order to make a ray diagram, we have to consider at least two rays. We consider the two rays that are striking the mirror at different angles. Let'ssay, one striking at normal to mirror and the other at a certain angle. The normal ray retraces its path and the other ray striking at a certain angle is reflected by the same angle. When we produce both the reflected rays, they appear to meet at a certain point and there the image is formed.

Characteristics of Image

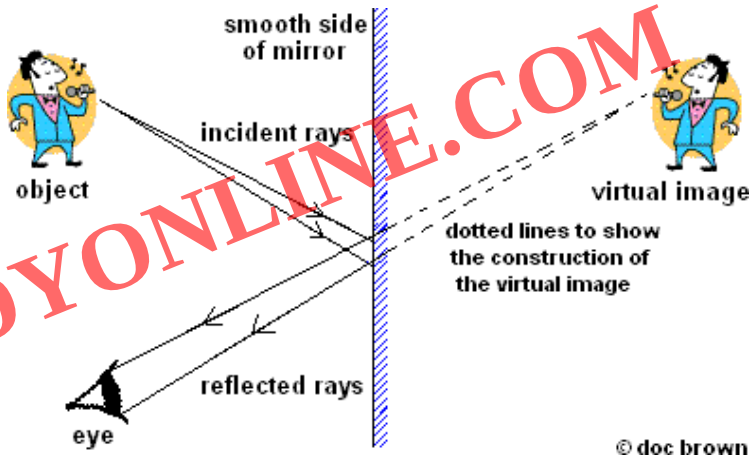
1. Virtual

2. Erect

3. Same Size

4. Distance of Object = Distance of Imagefrom Mirror

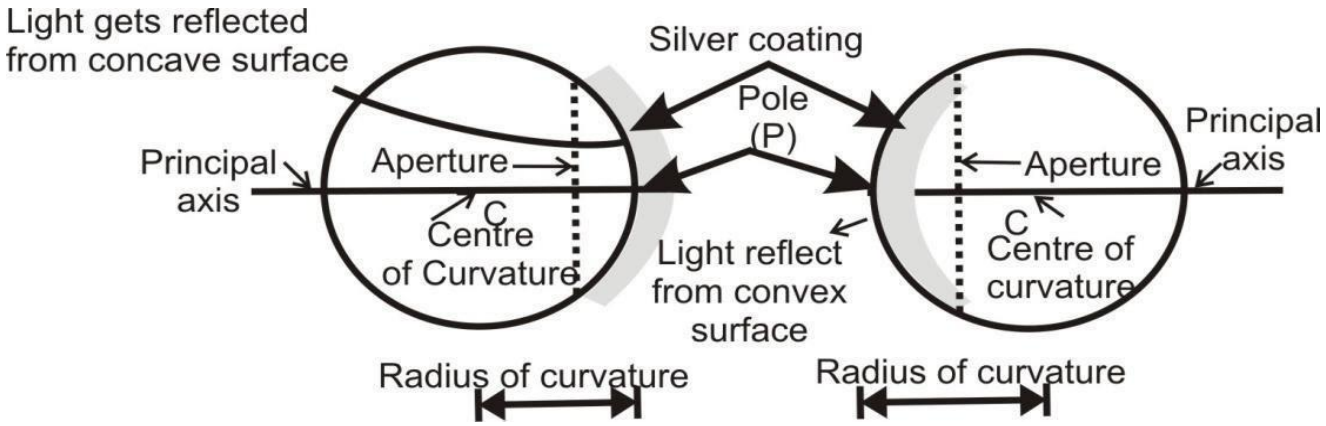
5. Laterally Inverted



Lateral Inversion

It is the phenomenon when LHS becomes RHS or vice-versa, when an object is exposed to a planemirror.

Spherical Mirrors: We have two types of spherical mirrors as discussed - concave and convex.



1. Aperture: It is the part of a spherical mirror from which the reflection actually occurs.

2. Centre of curvature: It is the centre of the spherical mirror.

3. Principal Axis: The line passing straight through C.

4. Pole: It is the point where Polar axis strikes the mirror.

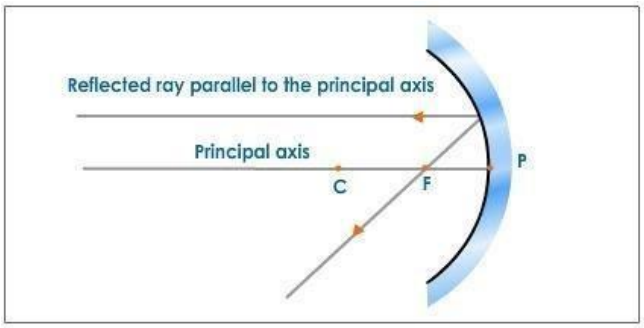
5. Focus: It is the point where all reflected rays meet or appear to meet.

6. Focal Length: The distance between focus and pole.

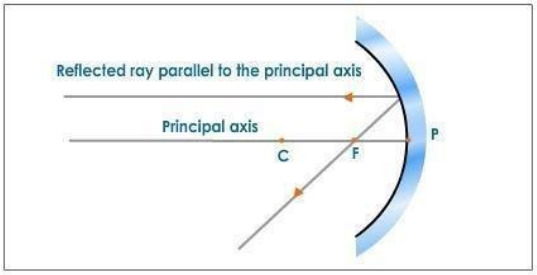
7. Relation between focal length and radius of curvature.

F = R/2 (focal length is always half of radius)

Rules to obtain image fromconcave mirror

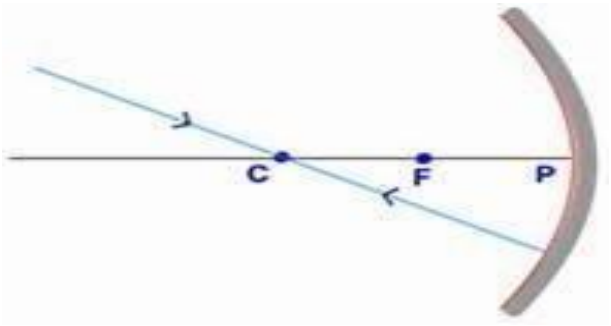


1st rule: The incident ray that comes parallel to thepolar axis after reflection passes through the focus as shown.

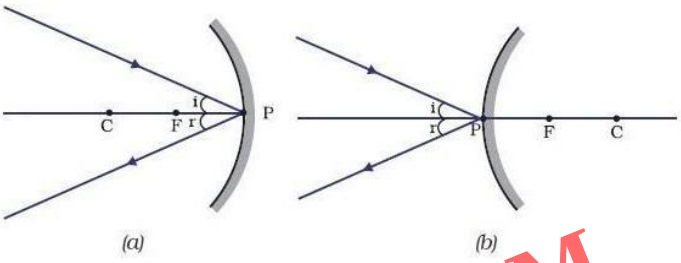


2nd rule: The incident ray coming from focus afterreflection becomes parallel to the polar axis.

3rd rule: The incident ray coming through ‘C’ retracesits path.

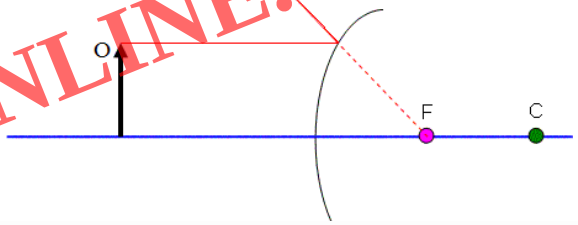


4th rule: The Incident ray striking at pole by a certain angle is reflected through the same angle

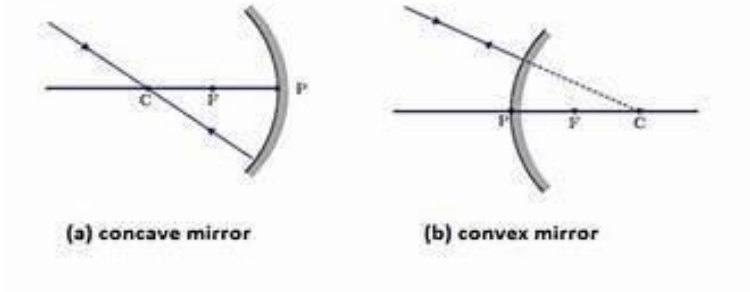


Rules to obtain Image from Convex Mirror

1st rule: The incident ray coming parallel to the polaraxis diverges but appears to pass through the focus.

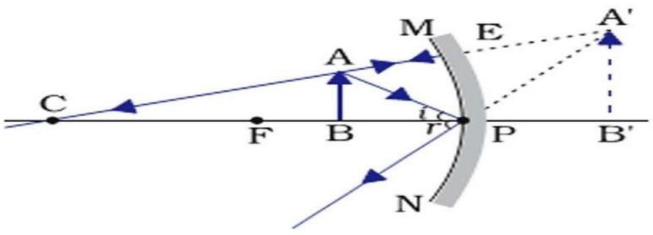


2nd rule: The incident ray appears to becoming from ‘C’ but rebounds back.

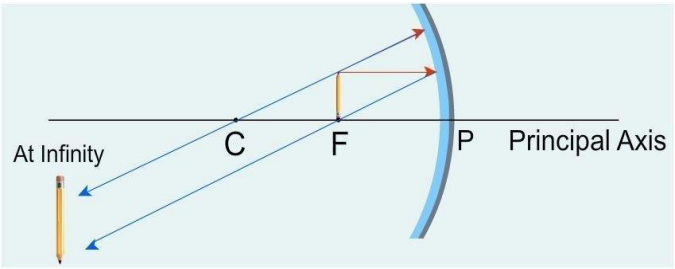


Nature and Position of Image Formed by Concave Mirror

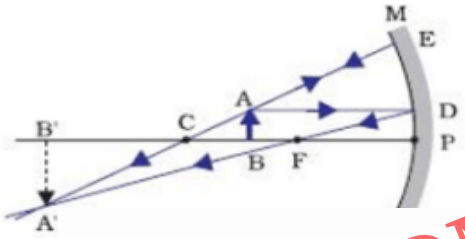
Let us draw the ray diagram for the concave mirror:1st Case: Object between P & F



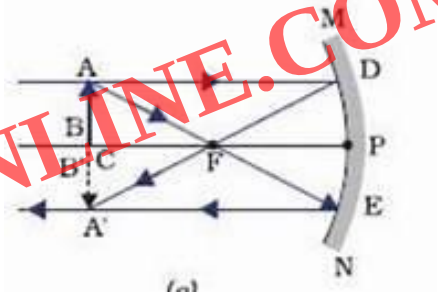
2nd Case: Object at F



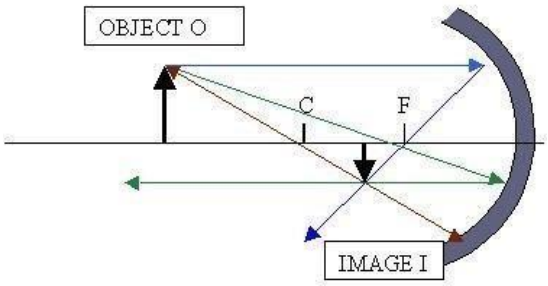
3rd case: Object between F and C



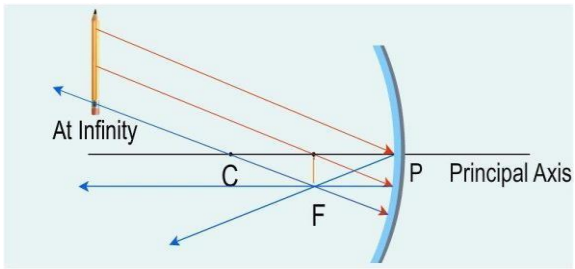
4th case: Object at C



5th case: Object beyond C



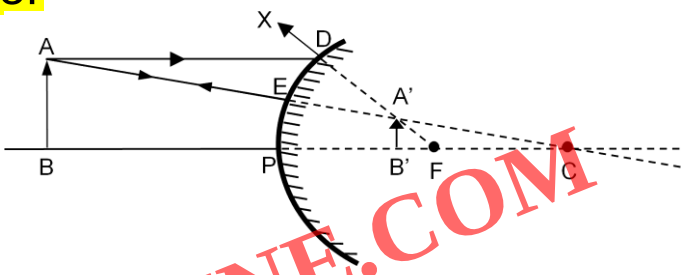
6th case: Object at infinity



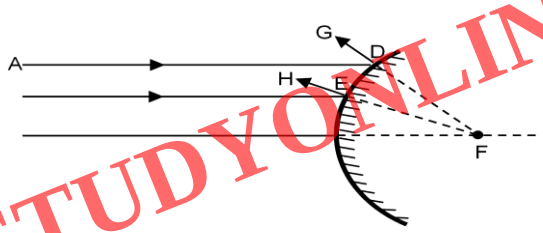
Object position	Image position	Size of image	Nature of image
At infinity	Focus (**F**)	Point sized	Real
Beyond C	Between **F** and C	Small	Real and inverted
At C	At C	Same as that of the object	Real and inverted
Between C and **F**	Behind C	Enlarged	Real and inverted
At **F**	At infinity	Highly enlarged	Real and inverted
Between **F** and **P**	Behind mirror	Enlarged	Virtual and erect

Images formed by Convex Mirror

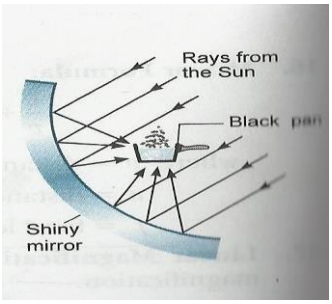
1st Case: Object anywhere at p. axis



2nd case: object at infinity



Uses of concave Mirror



- It is used in torches: It produces a powerful beam of light rays thatconverge at infinity.
- It is used in making solar devices: It converges all the rays so when solarrays converge, they increase the temperature at that converging point.

- It is used as shaving mirror: When face is placed between the pole andthe focus, it gives virtual, erect and magnified image.

It is used by dentist to see cavities: When the tooth is placed within the focus it gives virtual and erect image.

Uses of Convex Mirror

- It is used as rear view mirror: It gives virtual and diminished image. It covers a wide view and theimage formed is within the focus.

Differentiate between Planemirror, convex mirror and Concave mirror

Mirror Formula

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

where,

$f \rightarrow$ *focal length*

$v \rightarrow$ *distance of image*

$u \rightarrow$ *distance of object*

Linear Magnification is defined as the height of image to the height of the object.

Linear Magnification, m

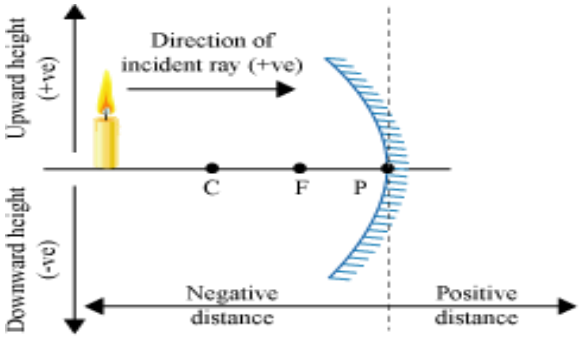
$$m = \frac{\text{height of image}}{\text{height of object}} = \frac{h'}{h}$$

or

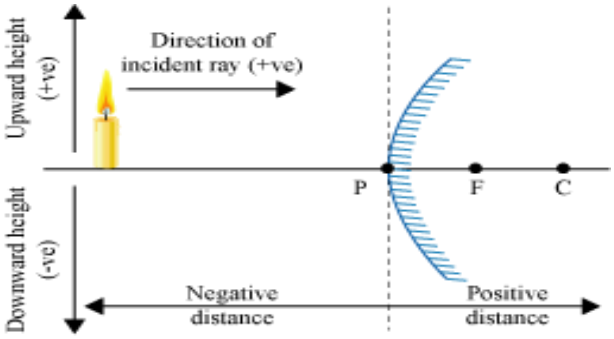
$$m = -\frac{\text{image distance}}{\text{object distance}} = -\frac{v}{u}$$

$$m = \frac{h'}{h} = -\frac{v}{u} \quad \text{or} \quad m = \left|\frac{v}{u}\right|$$

Sign convention for concave and convex mirror



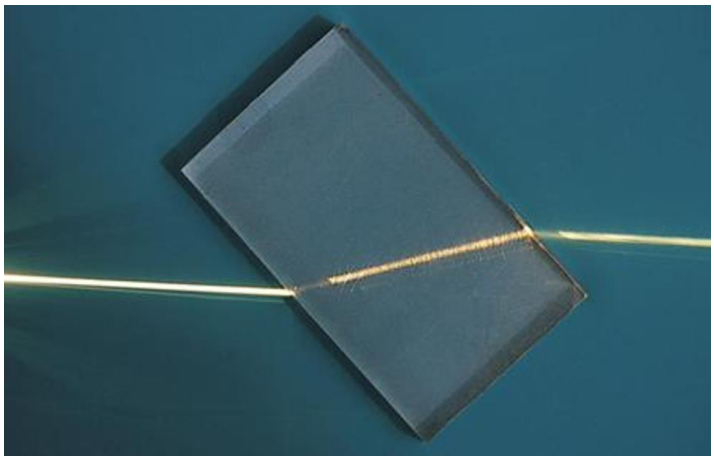
Concave mirror



Convex mirror

Type of Mirror	u	v		f	R	Height of the Object	Height of the Image	
		Real	Virtual				Real	Virtual
Concave mirror	-	-	+	-	-	+	-	+
Convex mirror	-	No real image	+	+	+	+	No real image	+

Refraction



We know the nature of light and we have also learnt about one of its applications as reflectionin part one. Now we are going to study anotherapplication of light that is refraction. To understand it, let's look at how light passes through air, water, glass, etc. You will notice that whenever light moves in one medium, it follows a straight line path as shown in figure. But when it travels from one substance to another substance, its path doesn't remain a straight line. It is deviated from the straight linepath as shown in figure. These substances are regarded as medium or we can say that medium refers to any substance or material from which lightcan pass.

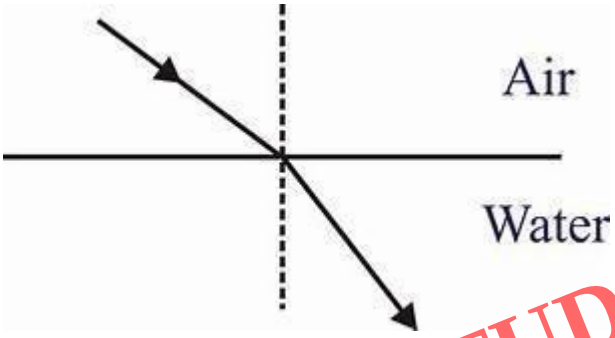
Types of medium

We have two types of mediums:

- Rarer medium- We can define rarer medium as the medium which hasless density and speed of light is more. Example: air is rarer than water.

- Denser Medium- It is that which has more density and speed of light islesser in it. Example: water is denser than air.

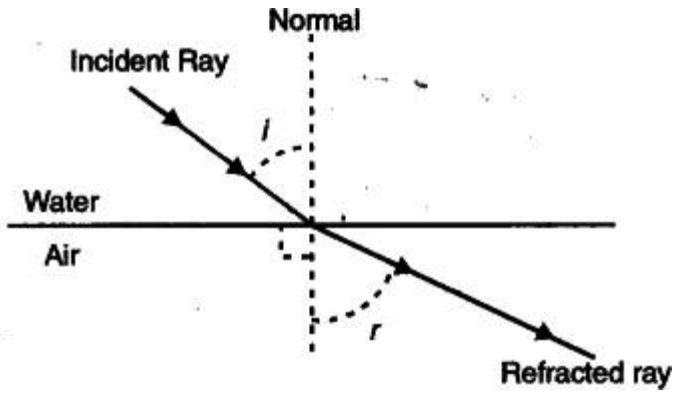
Please note the type of medium is comparative study as one medium can be rarer in one case and can be denser in another case. For example: water is denser than air but water is rarer in comparison to glass. This change in the path of light while travelling from one medium to another causes a change in the speed of light and is called refraction or we can say that the bending of light ray when it passes fromone medium to another is called refraction.



Like in the figure above, the speed of light decreases when it passes from air to water because water is denser than air.

Important Terms

Look at the figure carefully then you will understand the terminology involved:



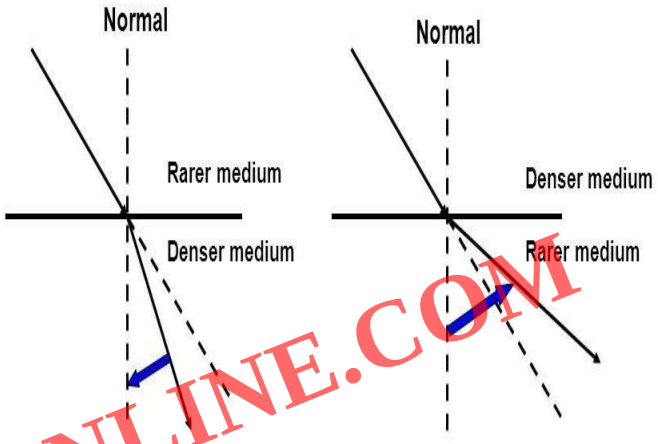
Incident Ray: The ray that strikes the surface.
Point of Incidence: Point where the incident ray strikes the surface.
Refracted Ray: he ray that changes its path when it travels from one medium to another.Normal Ray: The perpendicular drawn to the point of incidence.
Angle of Incidence: Angle between incident ray and the normal ray.
Angle of Refraction: Angle between refracted ray and the normal ray.

Law of Refraction

These are the laws obeyed by the surface from wherever the refraction takes place:

- Incident ray, normal ray and the refracted ray all lie in the same plane.
- The ratio of sine of angle of incidence to the sine of the angle of refraction is always constant for aparticular pair of media.

i.e.: sin i/sin r = constant (Snell's law)



Refraction when light passesfrom denser to rarer medium

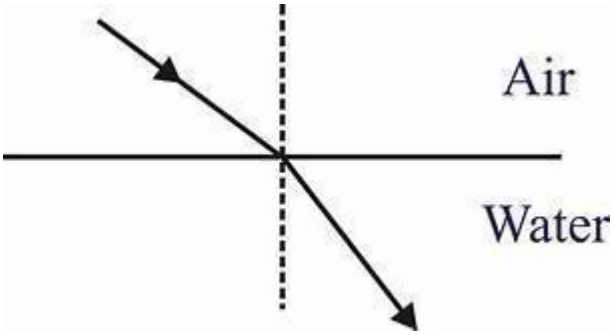
When light passes from a denser to a rarer medium, it gets deflected away from the normal and in this case the angle of refraction is greaterthan the angle of incidence.

Refraction when light passes from rarer to denser medium

Likewise when it passes from rarer to denser, it moves towards normal and in this case the angle of refraction is less than the angle of incidence.

Refractive Index

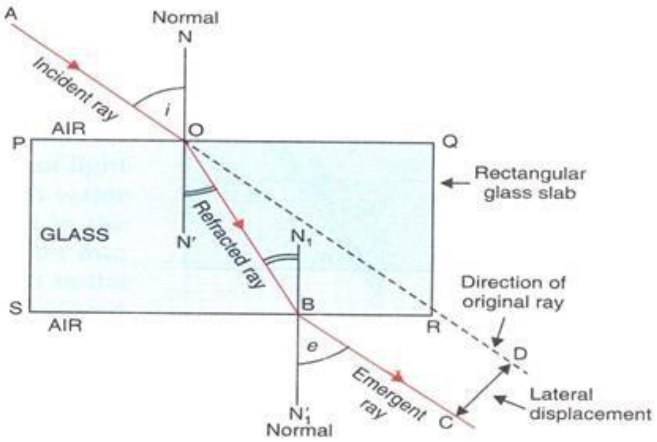
This is another physical quantity that is related to refraction. It is defined as the speed of light in vacuum /speed of light in a given medium or it is the ratio of the sine of the angle of incidence to the sine of the angle of refraction is always constant for a particular pair of media.



Note: The refractive index is denoted by 'n' and it has no units. Also, value of refractive index for one medium with respect to another is the reciprocal of the value of refractive index of the second to the first medium.

Reversibility of path of light

We have noticed that the path of light is reversible.For example: If light enters as shown in the figure, it undergoes refraction as shown and also, if the light enters in the opposite manner, it will follow the same sequence. The ray that moves out to its original medium after passing through certain medium is emergent ray and it can be defined as:

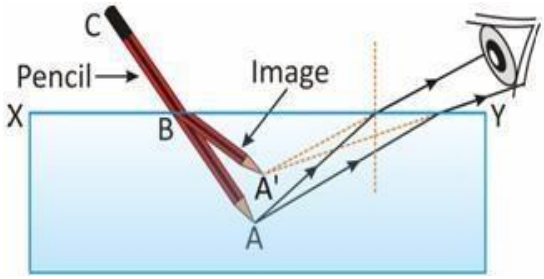


Emergent Ray: The ray that passes through a certain media and then returns to its original mediais known as the emergent ray.
Angle of Emergence: The angle between a normal ray and an emergent ray is known as angle of emergence.

Lateral Displacement

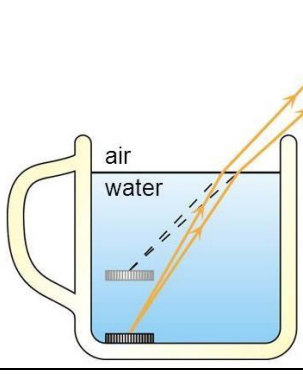
An interesting phenomenon that we notice while studying reversibility of light is lateral displacement. It can be defined as the perpendicular shift in the path of incident ray when it travels through a certain medium and then returns to its original medium.

Consequences of Refraction

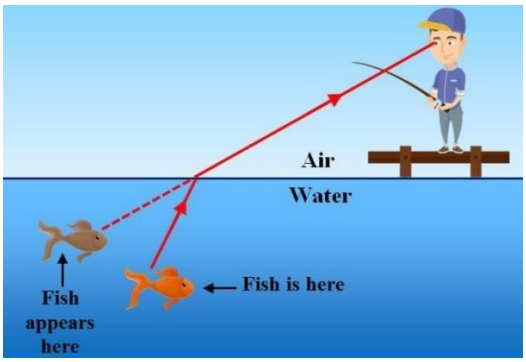


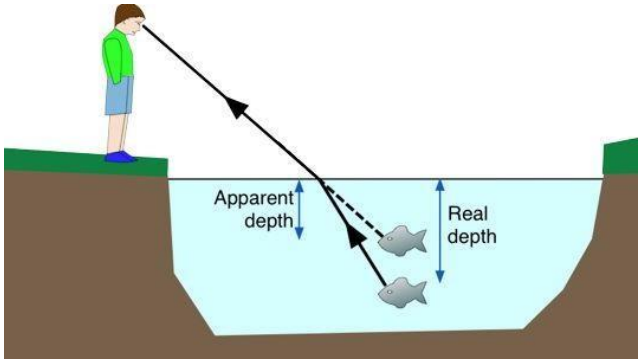
- A stick immersed in water appears to be bent: A stick immersed in water reflects light rays. These rays when travelling in water travel in a straight line path but when they go from water to air, they deviate from their path and
get deflected away from the normal. When these refracted rays are produced,they app ear to meet at point “I” which is higher than the actual point that is ‘O’. Therefore, a stick immersed in water appears to be bent due to refraction.

- The water level appears to be raised: When rays moves out from water to air, they will bend away from normal and when produced, they meet at point “I” which is above actual point ‘O’. So, apparent image is at ‘O’ and actual image is at ‘I’.



The coin appears to be raised in a cup of water.





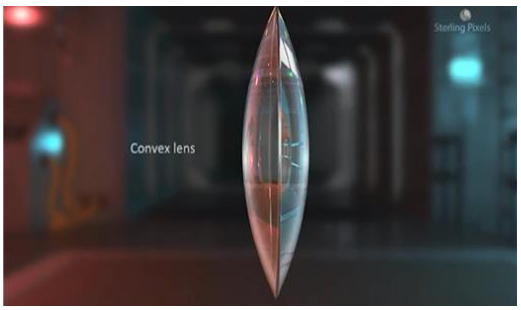
Lens

It is a portion of a transparent optical material having one or two spherical faces.

Types of Lens are:

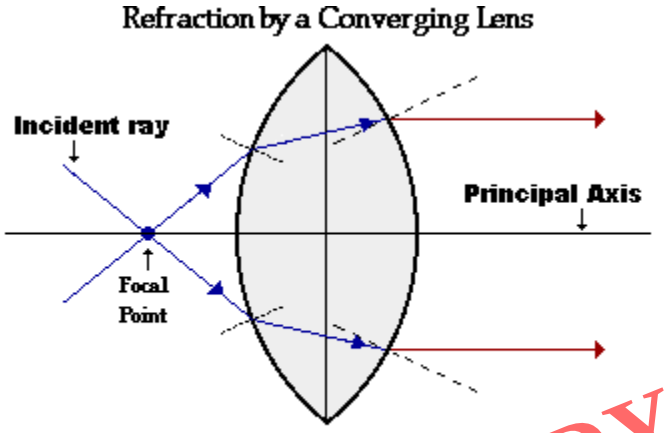
- Concave lens

- Convex len



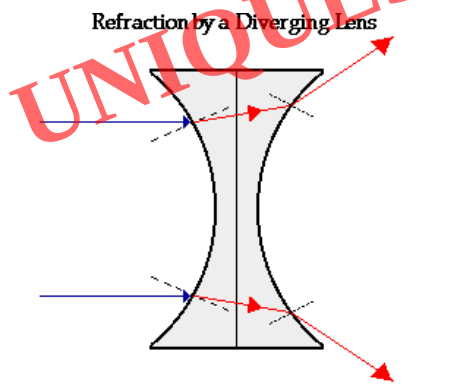
The terminology used for lenses:

Optical Centre: It is the centre of the lens.
Principal Axis: It is the line passing straight through optical centre.
Focus: Point where refracted rays meet or appear to meet.
Focal length: The distance between the focus and the optical centre.
2f: Twice of focal length.
Nature: The rays that fall on convex lens, after refraction, meet at one point so it is a converging lens.



Incident rays which travel through the focal point will refract trough the lens and travel parallel to the principal axis.

On the other hand, a concave lens splits all refracted rays in different directions, so it is a diverging lens.

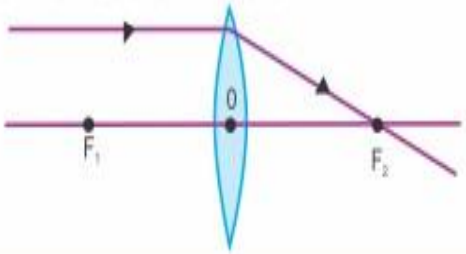


Incident rays traveling parallel to the principal axis will refract through the lens and diverge, never intersecting.

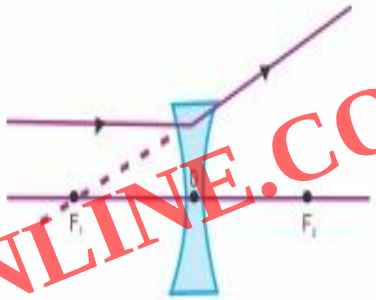
Rules to obtain image from convex lens and concave lens

1) In both the lenses a ray of light passing through the optical center goes without any deviation.

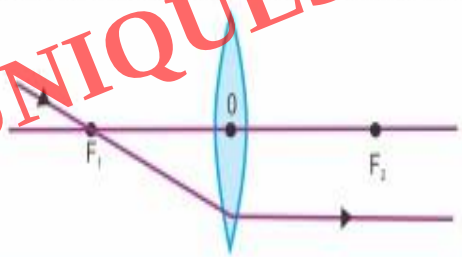
A ray of light parallel to the principal axis after refraction passes through the focus on the other side of the lens.



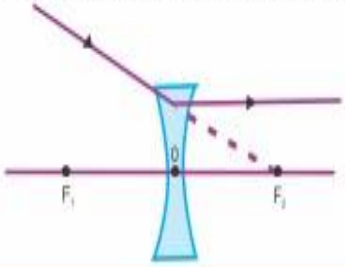
A ray of light appears to diverge from the focus on the same side of the lens.



A ray of light passing through the focus after refraction goes parallel to the principal axis.



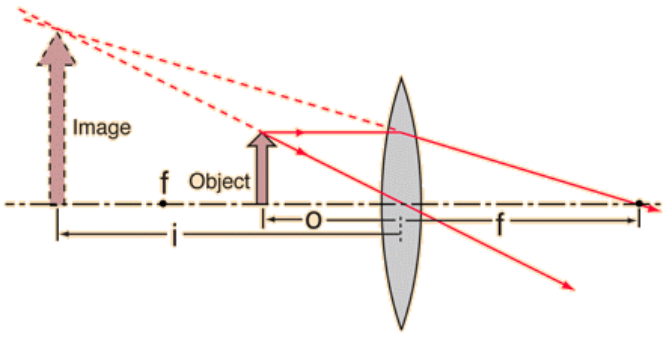
A ray of light directed towards the focus after refraction goes parallel to the principal axis.



Characteristics of image formed by a convex lens:

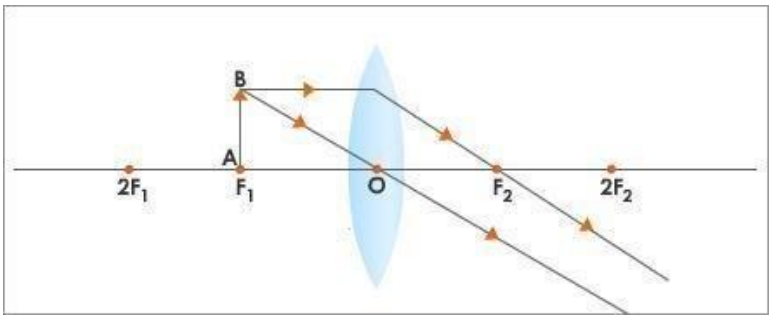
Images formed by convex lens:

1. Object between O and F (used in case of simple microscope)



Characteristics of image: in front of the lens, magnified and virtual-erect.

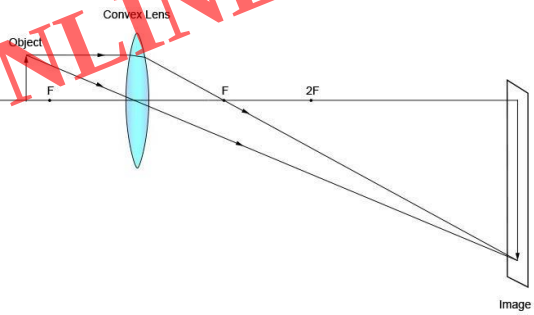
2. Object at F (used in case of search lights)



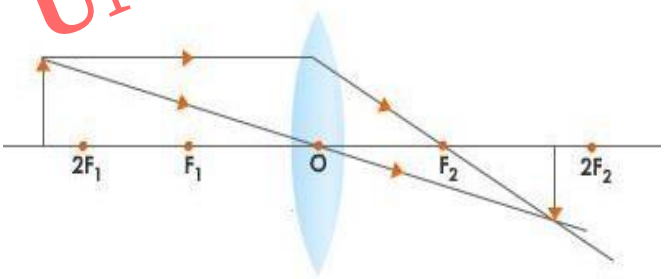
Characteristics of image: formed at infinity, real and inverted and highly magnified.

3. Object between f and 2f (used in case of optical projector).

Characteristics of image: formed beyond 2f, real inverted and magnified

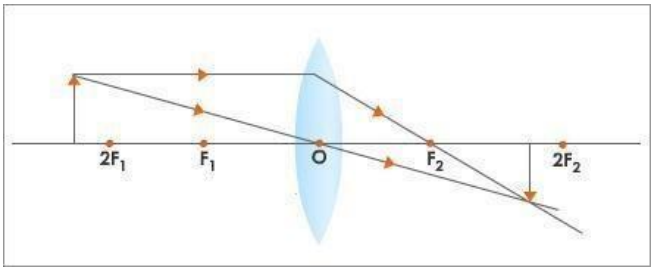


4. Object at 2f (used in case of terrestrial telescope).



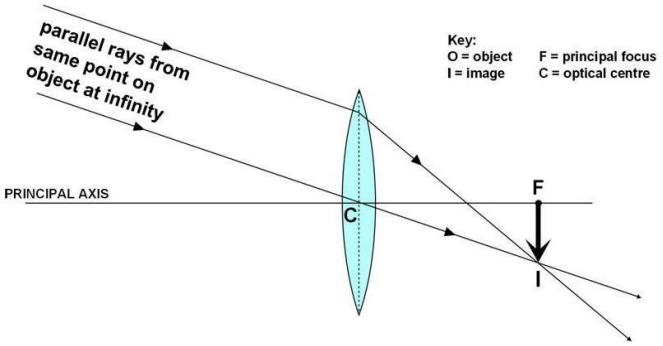
Characteristics of image: image formed at 2f , same size and real inverted.

5. Object beyond 2f (used in case of photographic camera).



Characteristics of image: image is formed between f and 2f , real, inverted and diminished.

6. Object at infinity (used as burning glass)

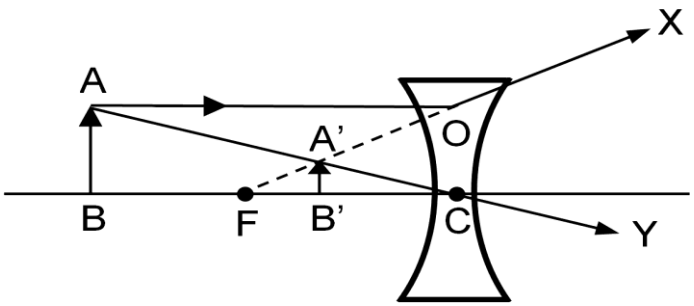


Characteristics of image: formed at f, highly diminished, real and inverted

Object position	Image position	Size of image	Nature of image
At infinity	At F_2	Extremely small	Real and inverted
Behind $2F_1$	Between F_2 and $2F_2$	Small	Real and inverted
At $2F_1$	At $2F_2$	Same as that of the object	Real and inverted
Between $2F_1$ and F_1	Beyond $2F_2$	Enlarged	Real and inverted
At F_1	At infinity	Highly enlarged	Real and inverted
Between F_1 and O	Same side of the lens	Enlarged	Virtual and erect

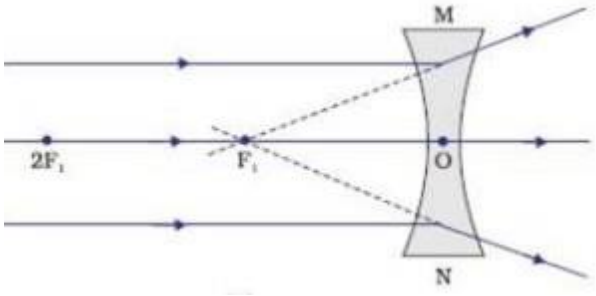
Image formed by concave lens

1. Object anywhere on principal axis (used in case of correcting myopic eye)



Characteristics of image formed: within focus, virtual-erect and diminished.

2. Object at infinity (used in case of Galilean telescope)



Lens Formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Distance of an image (v)

Distance of an object (u)

Focal length (f) of the lens

Sign convention for convex and concave lens

U= negative for both
V= positive for real inverted and negative for virtual erect
F = positive for convex lens and negative for concave lens
M = positive for virtual erect image and negative for real inverted image
H = positive for virtual erect image and negative for real inverted

Distance	Positive value (+)	Negative value (–)
u	Real	Virtual
v	Real	Virtual
f	Convex lens	Concave lens

Calculating magnification with the help of lens formula:

Magnification of a lens is defined as the ratio of the height of image to the height of object. It is also given in terms of image distance and object distance. It is equal to the ratio of image distance to that of object distance.

$$m = \frac{height\ of\ image}{height\ of\ object} = \frac{distance\ of\ object}{distance\ if\ image}$$

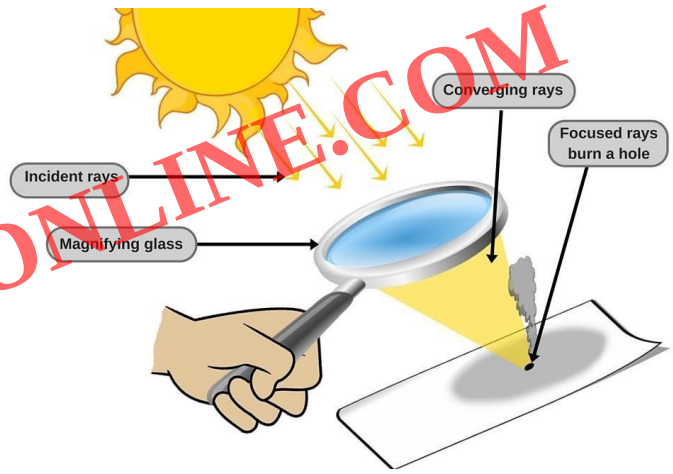
Power of Lens

Simply put, the power of a lens in Ray Optics is its ability to bend light. The greater the power of a lens, the greater is its ability to refract light that passes through it. For a convex lens, the converging ability is defined by power and in a concave lens, the diverging ability.

Power of a Lens Formula

To find the power of a lens in Ray Optics, the following formula can be used.

$$P = \frac{1}{f}$$



If the focal length is given in meters (m), the power of the lens if measured in Diopters (D), as in the unit of power of the lens is diopter. Another thing you should keep in mind is that for a converging lens the optical power is positive and for a diverging lens, it is negative.