LIGHT – REFLECTION AND REFRACTION

LIGHT

Light is a form of energy, which induces the sensation of vision in our eyes and makes us able to see various things present in our surrounding.

UNITS OF LIGHT

Any object which has an ability of producing light energy at its own is called as the source of denoted by letter "d".

SOURCE OF LIGHT

Any object which has an ability of producing light energy at its own is called as the source of light. e.g., Sun, Firefly, Battery, Cell Candle, Bulb etc.

KINDS OF SOURCES OF LIGHT

There are two main kinds of sources of light *viz*:

1) **Natural Sources:-** These include all those sources which are natural and possess their own light for example stars, firefly etc.
2) **Artificial sources:-** These include all those sources which are man-made or artificial but possess the ability of emitting light for example candle, lantern, moon etc.

REFLECTION

It is a phenomenon of light in which a ray of light form one medium strikes a smooth polished surface and returns back into the same medium.

LAWS OF REFLECTION

The two laws of reflection of light are:-

1. The incident ray, the normal and the reflected ray lie in the same plane.
2. The angle of incidence is equal to the angle of reflection of a ray of light striking a smooth polished surface i.e., $\angle i = \angle r$.

REFRACTION

When a ray of light travelling in a homogenous medium, strikes a surface of separation between the two media, passes through it and goes into the second medium. The phenomenon is referred to as refraction.

LAWS OF REFRACTION

The two laws of refraction of light are:

The incident ray, the refracted ray and the normal to the refracting surface at the point of incidence all lies in the same plane. The ratio of sine of angle of incidence of the sine of the angle of refraction is a constant for a given pair media i.e,.

$$\frac{\text{Sin.i}}{\text{Sin.r}} = \text{Constant}$$

REFRACTIVE INDEX

Refractive index of a medium is defined as the ratio of velocity of light in vacuum to the velocity of light in medium, i.e.,

$$u = \frac{\text{Velocity of light in vacuum or air}}{\text{Velocity of light in the given medium}}$$

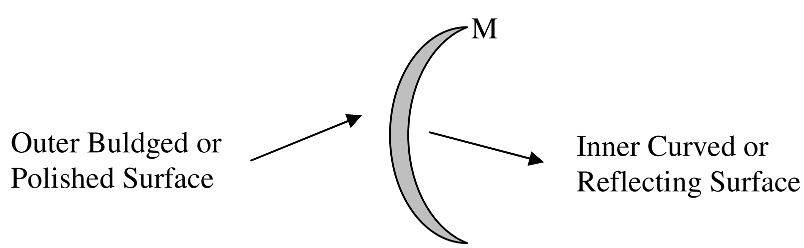
MIRROR

A mirror is a piece of glass having at least one polished surface and one reflecting surface.

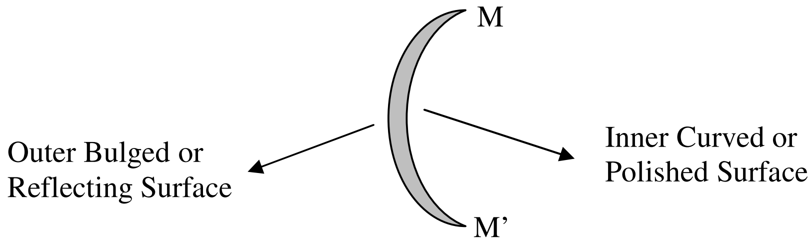
SPHERICAL MIRROR

Spherical mirror is that mirror whose reflecting surface is a portion of a hallow sphere of glass. It is of two main types, concave mirror and convex mirror.

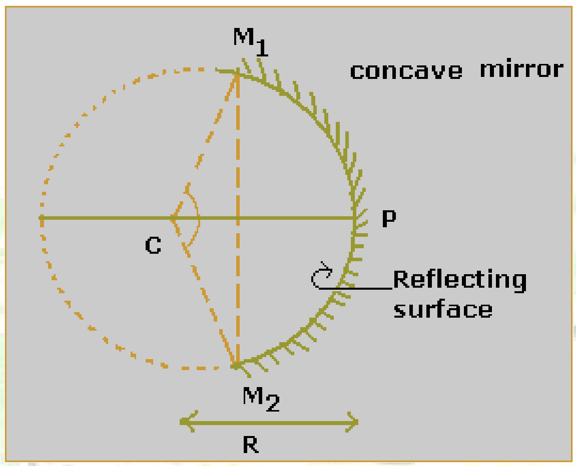
1) **Concave Mirror:-** A concave mirror is that spherical mirror in which the process of reflection takes place at the concave or curved surface as shown under:



2) **Convex Mirror:-** A convex mirror is that s M’ al mirror in which the process of reflection takes place at the convex or bulging out surface as shown under:



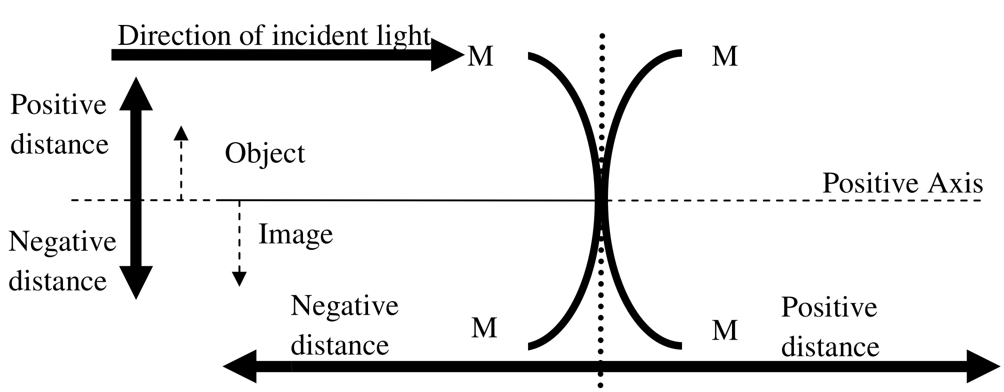
Terms associated with spherical mirrors:-



The various terms associated with spherical mirrors are:

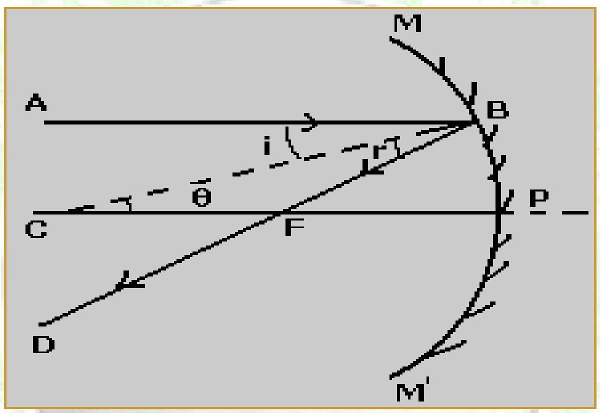
1) **Center of curvature:-** The centre of curvature of a spherical mirror is the central point of the hallow sphere of which the mirror is a part.
2) **Radius of curvature:-** The radius of curvature of a spherical mirror is the radius of the hallow sphere of which the mirror is a part, in other words, it is the distance between the centre of curvature and pole of a mirror. It is represented by letter R.
3) **Pole:-** The pole of spherical mirror is the centre or middle point of a spherical mirror. It is represented by letter P.
4) **Principle axis:-** Principle axis of a spherical mirror is the line passing through the centre of curvature and its pole. In other words, it is the line joining the pole and centre of curvature of a mirror.
5) **Secondary axis:-** Any straight line other than the principal axis passing through the centre of a spherical mirror is referred to as secondary axis. It is usually represented by letters SS’.
6) **Aperture of a mirror:-** Aperture of a mirror is the portion of a mirror from which reflection of light takes place. In other words it is the maximum size of a mirror. It is usually represented by letter M and M/.

Sign conventions for spherical mirrors:-



The various sign conventions employed for measuring distances in case of spherical mirrors are:
For the measurement of all the distances, the pole of the mirror is taken as origin.
All the distances measured in the same direction as that of light are taken as positive for example the focal length of a convex mirror is taken as positive. Object is placed on L.H.S.
All he distances measured against the direction of incident light are taken as negative for example the focal length of a concave mirror is taken as negative.
All the distances measured upward and perpendicular to the principle axis are taken as positive, i.e., height of an object, or image formed above principle axis.
All the distances measured downward and perpendicular to the principal axis are taken as negative i.e., image of an object below principle axis.

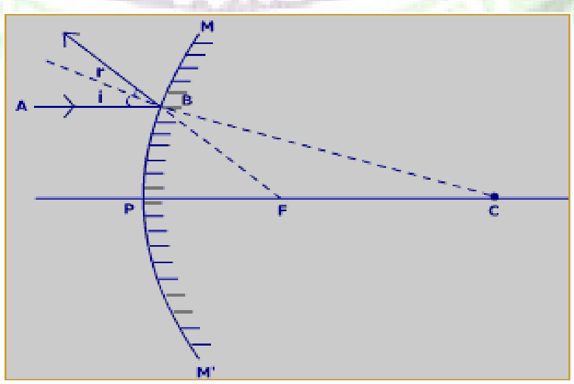
Terms associated with concave mirror:-



The various terms associated with the concave mirror are:

1) **Principal focus:-** The principal focus of a concave mirror is defined as the point on its principle axis to which all the incident rays parallel and close to the axis converge after reflection through the mirror. It is represented by letter 'F' and lies always in front of a concave mirror, thus a real focus.
2) **Focal length:-** The focal length of a concave mirror is defined as the distance between the pole and principle focus of a concave mirror. It is represented by letter 'f' and is always taken as negative.

Terms associated with convex mirror:



The various terms associated with a convex mirror:

1) **Principal focus :** The principle focus of a convex mirror is the point on its principal axis to which a beam of light rays, initially parallel and close to the axis, appears to diverge after being reflected from the mirror. A convex mirror has a virtual focus and lies always behind the mirror. It is represented by letter F.
2) **Focal length :** The focal length of a convex mirror is the distance between its pole and principle focus, it is represented by letter f, and is always taken as positive.

OPTICLA IMAGE

If a beam of light emitted by an illuminated object suffers a change in the direction due to reflection or refraction, the reflected or refracted rays of light converge or appear to diverge from another point. This second point is referred to as optical image of the first point. The optical images formed by the spherical mirrors are of the following types:

(i) **Real image:** Those images, which can be transferred or formed on a screen, are called as real images. These images are formed by the actual intersection of reflected or refracted light rays.

(ii) **Virtual Images:** Those images, which can be seen only by looking into a mirror, but cannot be transferred or formed on a screen, are called as virtual images. These images are formed by the apparent intersection of the reflected or refracted light rays.

(iii) **Erect Images:** Those images, which lie or are formed above the principle axis, are referred to as erect images.

(iv) **Inverted Images:** Those images, which lie or are formed below the principle axis, are referred to as inverted images. These images are upside down in appearance.

(v) **Magnified Image:** Those images, which are larger in size than the size of the object, are referred to as magnified images.

(vi) **Diminished Image:** Those images, which are smaller in size than the size of the object , are referred to as magnified images.

Rules for Image formation on a concave mirror:

When an object is placed in front of a concave mirror, and image is formed at a point where at least two reflected rays intersect each other. The various rules employed for obtaining images on a concave mirror are:

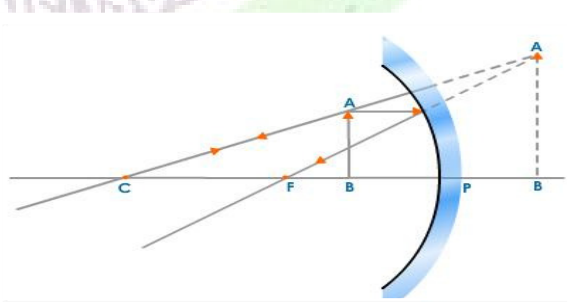
A ray of light parallel to the principle axis of a concave mirror passes through its principle focus after reflection from the mirror.

A ray of light passing through the centre of curvature of a concave mirror is reflected back along the same path. A ray of light passing through the focus of a concave becomes parallel to the principle axis after reflection from the mirror.

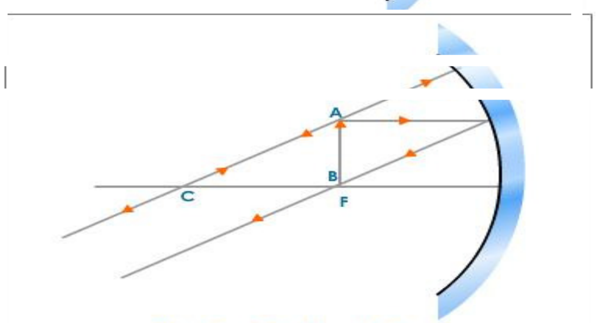
Formation of Images on a concave mirror:

When an object is placed at different positions in front of a concave mirror, various types of images are formed, which can clearly understood by considering following situations:

1) **Object place in between pole and focus:** When the object is placed in between the pole and principle focus of a concave mirror, the image is formed behind the mirror, the image formed is virtual , erect and magnified i.e., larger in size than those of the object as shown under:-



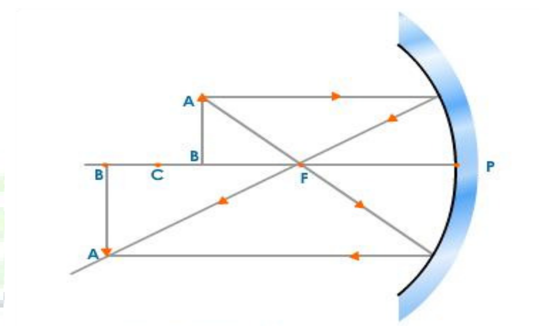
2) **Object at focus:** When the object is placed at the focus of a concave mirror, the image formed is at infinity highly



When the Object is at the Focus

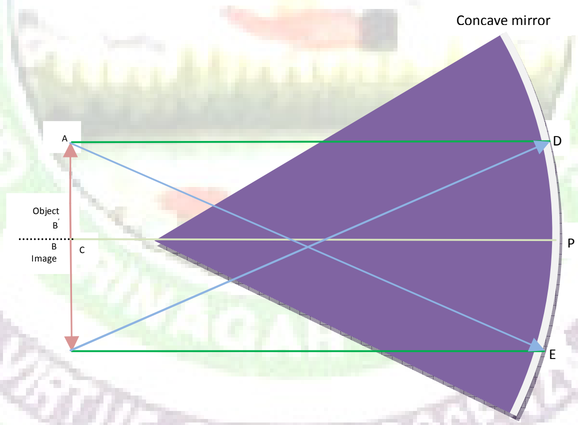
magnified, real and inverted as shown under:-

3) **Object between focus and center of curvature:-** When the object is placed between the focus and centre of curvature of a concave mirror, the image is formed beyond the centre of curvature. The image formed is real, inverted and magnified in size of the object as shown under:-

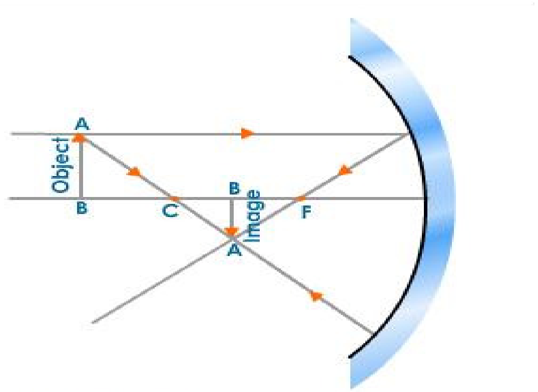


When the Object is Between C and F

4) **Object at center of curvature:-** When the object is placed at the center of curvature of a concave mirror, the image formed is also at center of curvature, same in size, real and inverted as shown under:-

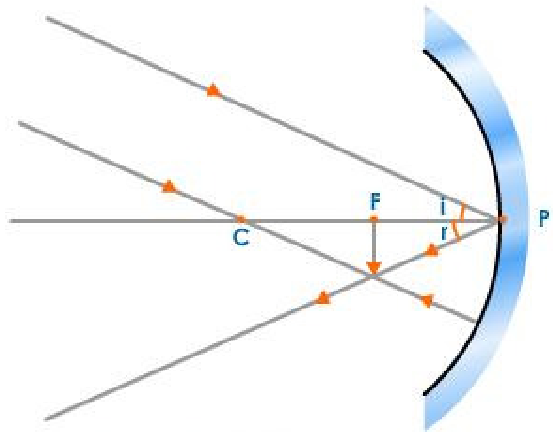


5) **Object beyond center of curvature:-** When the object is placed beyond the center of curvature, the image formed is in between the focus and center of curvature, the image is smaller is size than the object (diminished), real and inverted.



When the Object is Placed Beyond C

6) **Object at infinity:-** When the object is placed at the infinity form the concave mirror , the image formed is at the focus, highly diminished, real and inverted as shown under:



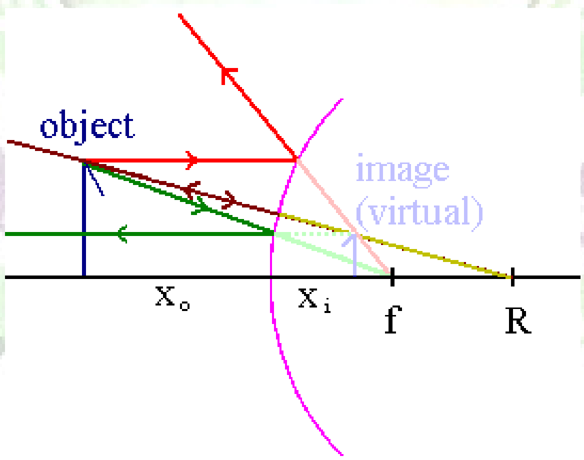
When the Object is at Infinity

Rules for obtaining Images on a convex mirror:- The various rules employed for obtaining images on a convex mirror are:-

A ray of light parallel and close to the principle axis of a convex mirror appears to be coming from its focus after reflection from the mirror.

A ray of light going towards the centre of curvature of a convex mirror is reflected along its own path.

Images formed by a convex mirror: The image formed by a convex mirror does not depends upon the position and size of the object. It always forms the image behind the mirror, and in between the pole and the focus. The image formed is however always virtual, erect and diminished as shown under:-



Mirror formula:- A formula which indicates the relationship between the image distance, object distance and focal length of a mirror is know n as the mirror formula which can be written as under:-

$$\frac{1}{\text{Image Distance}} + \frac{1}{\text{Object Distance}} = \frac{1}{\text{Object Distance}}$$

If the image distance of a mirror be represented by u and the focal length by f, then mirror formula can be represented as under:-

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

Where v = distance of the image from the mirror.
And u = object distance from the mirror.
Also f = focal length of the mirror.

Linear magnification of a mirror:- Linear magnification of a mirror is the ratio of height of the image to the total height of the object, thus,

$$\text{Linear magnification} = \frac{\text{Height of Image}}{\text{Height of Object}}$$

If "h_1" be the height of the object placed in from t of a mirror and if "h_2" be the image formed , the n linear magnification "M" produced by the mirror can be represented as under:-

$$M = \frac{h_2}{h_2}$$

However linear magnification of a mirror is also equal to the ratio between image distance and object distance form a mirror but with negative sign as represented as under:-

M = - v/u

Where v = Image distance
And u = object distance of a mirror.

If the magnification has a positive (plus) sign, the n the image formed will be virtual and erect and if it has a negative (minus) sign, the image formed will be real and inverted.

Uses of a concave mirror:- The various uses of a concave mirror are as under:-

- It is used as shaving and dressing mirror.
- It is used as a reflector in car headlights, torches, table lamps and searchlights etc.
- The opticians to concentrate light on the specific body parts during treatment.
- It is also used in the solar heating devices to focus the solar radiation e.g., solar cookers.
- It is used as object lens in telescopes.

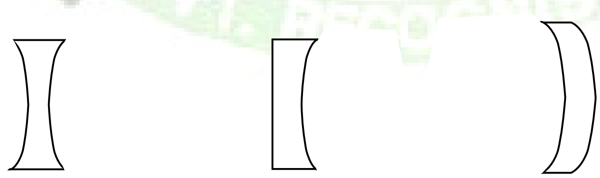
Uses of a convex mirror:- the important uses of convex mirror are:-

It is used in rear view mirrors in motor vehicles to see traffic at the backside, because it always produces and erect and diminished image of the object. It also has a very wide field of view, which helps a driver to have a clear view of the traffic behind.

Lens :- A lens is a piece of transparent glass bounded by two spherical surfaces. It is of two main types viz.

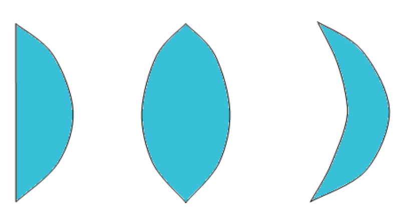
1. **Concave Lens:-** A lens having both of its surfaces curved inwards is called as a concave lens. It is thin in the middle and thicker at the edges. It is also called as a diverging lens as it diverges a parallel beam of light rays incident on it.

Kinds of concave lenses:- these are of three kinds as explained under in the diagram:-



Double concave Lens   Plano - concave Lens   Convexo- concave Lens

2. **Convex Lens:-** A lens having both of its surfaces bulged outwards is called as a convex lens. It is thicker at the middle and thin at the edges as shown under. It is also called as converging lens, as it converges a parallel beam of light rays.



Plano-Convex Lens   Double-Convex Lens   Concavo-Convex Lens

Terms associated with Lenses:- the various terms associated with the lenses (concave and convex) are:-

(i) **Optical centre :-** the central point of a lens (concave or convex) is called as its optical centre. It is represented by letter "C" and has the property that it allows light ray to pass through it without any deviation.

(ii) **Principle Axis:-** The principle axis of a lens is a line that passes through the optical centre of the lens and is perpendicular to both of its faces.

(iii)**Principle focus:-**

(a) **Concave Lens :-** the principle focus of a concave lens is a point on its principle axis from which light rays, originally parallel to the axis, appears to diverge after passing through the lens has a virtual focus represented by letter F'

(b) **Convex Lens :-** The principle focus of a convex lens is a point on its principle axis to which light rays originally parallel to the principle axis converge after passing through it. A convex lens has a real focus represented by letter f.

Sign convention for Lenses:-

The various sign conventions used for measuring distances in the ray diagram of lenses are:-

All distances are measured from the optical centre of a lens.

The distances measured in the same direction of that of incident light are taken as positive.

The distances measured against the direction of the incident light are taken as negative.

The distances measured upwards and perpendiculars to the principle axis are considered as positive.

The distance measured downwards and perpendiculars to the principle axis are considered as negative.

Rules for Images formed by a convex Lens:- The various rules employed for obtaining images on a convex lens are listed as under:-

An incident ray of light passing through the optical centre of a convex lens emerges undeviated after refraction through the lens.

An incident ray of light parallel to the principle axis of a convex lens passes through the focus after refraction.

An incident ray of the light passing through the focus of a convex lens becomes parallel to the principle axis after refraction.

Formation of Images on a convex Lens:- When an object is placed at the different positions in front of a convex lens, various types of images are formed, which are described as under:

1) **Object placed between C and F:-** When an object is placed between the optical centre and focus of a convex lens, the image formed lies behind the object on the same side. The image formed is virtual, erect and magnified i.e., larger in size than the size of the object as shown under:-
2) Object placed at the focus:- When an object is placed at the focus of a convex lens, the image is formed at infinity , which is real , inverted and highly enlarged i.e., larger in size than the object as shown under:

3) **Object placed between F/ and 2F/:-** When an object is placed between the focus and 2F in from of a convex lens, the image formed lies beyond 2f. the image formed is real, inverted and larger in size than of the object as shown under:-
4) **Object placed at 2f/:-** When an object is placed at 2f/ in form of a convex lens. The image is formed at 2f on the other side of the lens, which is real , inverted and of the same size of the object as shown under:-
5) **Object place beyond 2f:-** When an object is placed beyond 2f in front of a convex lens, the image is formed between F and 2F on the other side of the lens which is real, inverted and diminished i.e., smaller in size than the size of the object as shown under:-
6) **Object at Infinity:-** When an object is at infinity from a convex lens, the image formed lies at the focus, which is real, inverted and highly smaller in size that the size of the object as shown under:-

Power of Lens:- The power of a lens may be defined as the reciprocal of its focal length expressed in maters. It is represented by letter "p". thus

$$\text{Power of lens} = \frac{1}{\text{Focal length in metress}}$$

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

Where P = Power of lens
And F = focal length of the lens.
The S.I unit of power of a lens is dioptre, which is denoted by letter"D". The power of a lens is said to be one dioptre, if its focal length is equal to 1 meter.
However a convex lens has a positive focal length and a concave lens has a negative focal length, thus a convex lens has a positive power and a concave lens ahs a negative power.
Lens Formula:- The formula which gives a relationship between the image distance, object distance and the focal length of a lens is referred to as Lens formula. If "u" be the object distance and "v" as the image distance and "f" as focal length of a lens, then the lens formula can be given as under :-

$$\frac{1}{\text{Image distance}} - \frac{1}{\text{Object distance}} = \frac{1}{\text{Focal length}}$$

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

Linear Magnification of a Lens:- it is defined as the ration between the height of image to the height of object. If "h_2"be the height of object and if "h_1" be the height of image, then the magnification "M" of a lens can be given as :

$$\text{Magnification} = \frac{\text{Height of image}}{\text{Height of object}}$$

Or $$M = \frac{h_2}{h_1}$$

Where h_2 = height of image and h_1 = height of object.
However the ratio of image i\distance to object distance is also knoen as magnification. If "u" be distance of object and "V" as distance of image from a lens, the n magnification "M" of a lens can be given asunder :-

$$\text{Magnification} = \frac{\text{Image distance}}{\text{Height of object}}$$

Or $$M = \frac{V}{U}$$

Where v = Image distance
And U = object distance
However , if M has a positive sign then the image formed is virtual and erect and if it has a negative sign, then the image formed will be real and inverted.

Rules for image formation by a concave lens:-

An incident ray parallel to the principle axis of concave lens appears to be coming from its focus after refraction through the lens.

An incident ray passing through the optical centre of a concave lens goes straight without any deviation from its straight a path.

Image formation by a concave lens:- formation of images on a concave lens does not depends upon position of the object in from of a concave lens. A concave lens always forms a virtual, erect and diminished image i.e., smaller in size than the size of the object, as shown under:

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