CLASS X : NOTES : CHAPTER-9 : LIGHT-REFLECTION AND REFRACTION : SCIENCE (PHYSICS)

Light-

(i) Form of energy

(ii) Enables us to see objects

(iii) Travels in a straight line

(iv) Produces the sensation of vision in us.

(v) Type of EM radiation (radiant energy), does not require material medium.

(vi) Velocity of light in vacuum is 3×10^8 m/s.

(vii) Wavelength of visible light lies b/w 4×10^{-7}m to 7×10^{-7}m.

Object and image:

Object: Anything which gives out light rays is called an object.

Image: An image is formed when light rays coming from an object meet at a point after reflection from the mirror.

Types of images:

Real image	Virtual image
Real image is inverted.	Virtual image is erect.
Real image is formed, when rays actually meet at a point.	Virtual image is formed when rays appear to meet at a point.
Real image can be obtained on a screen.	Virtual image cannot be obtained on a screen.
For example: image formed on cinema hall is real.	For example: Image formed on a plane mirror.

Mirror: A highly polished surface which is smooth enough to reflect a good fraction of light incident on it. Types: (i) plane mirror (ii) spherical mirror

REFLECTION OF LIGHT BY MIRRORS

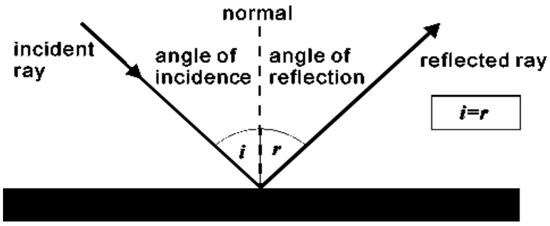
Laws of reflection:

(i) According to this law, angle of incidence is equal to angle of reflection. i.e, i =r. i = angle of incidence, r = angle of reflection

(ii) Incident ray, reflected ray and normal all lie on the same plane.

Note: If a ray falls perpendicularly (normally) on the mirror, then it will reflect back along the same path.

Reflection by plane mirror:



PLANE MIRROR

Characteristics of image formed by plane mirror:

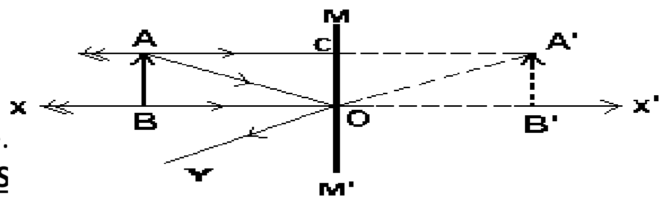
(i) Image is formed as far behind the mirror as the object is in front of it. i.e; OB= OB'=>u=v.

(ii) size of image = size of object, AB =A'B'

(iii) Virtual and erect

(iv) Laterally inverted

Lateral Inversion: Sideways reversal of the image.



SPHERICAL MIRRORS

Definitions:

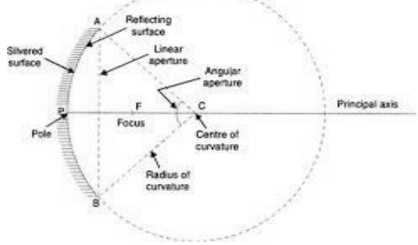
POLE: Centre of the spherical mirror.

APERTURE: That portion of mirror from which the reflection of light actually takes place.

PRINCIPAL AXIS: the straight line passing through the centre of curvature and pole.

CENTRE OF CURVATURE: Centre of the hollow sphere of glass of which mirror is a part.

RADIUS OF CURVATURE, R: Radius of the hollow sphere of glass of which mirror is a part.



- **FOCUS:** Point on the principal axis to which all the light rays which are parallel and close to the axis converge after reflection from the concave mirror.
- **FOCAL LENGTH, f :** distance b/w focus and pole of mirror.

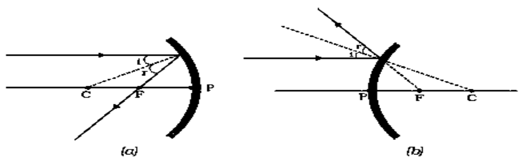
Relation between focal length and radius of curvature: f= R/2

Types of spherical mirror:

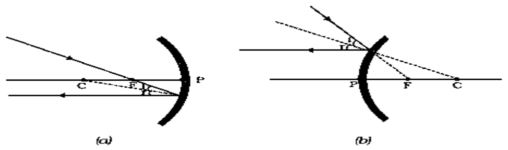
(i) Concave Mirror (ii) Convex Mirror

Reflection by spherical mirror:

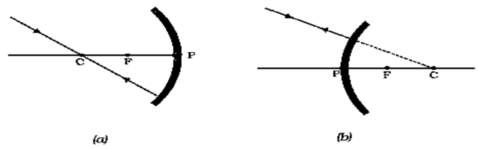
Rules:



Rule-1: A ray of light parallel to principal axis passes through focus after reflection.



Rule-2: A ray of light passing through focus of a mirror is parallel to principal axis after reflection.



Rule-3: A ray of light passing through the centre of curvature is reflected back along the same path.

Rule-4: A ray incident obliquely to the principal axis, towards pole is reflected obliquely.

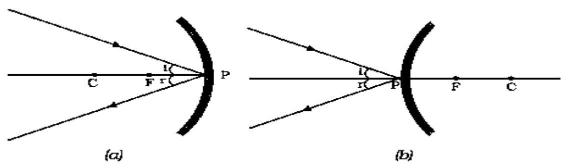
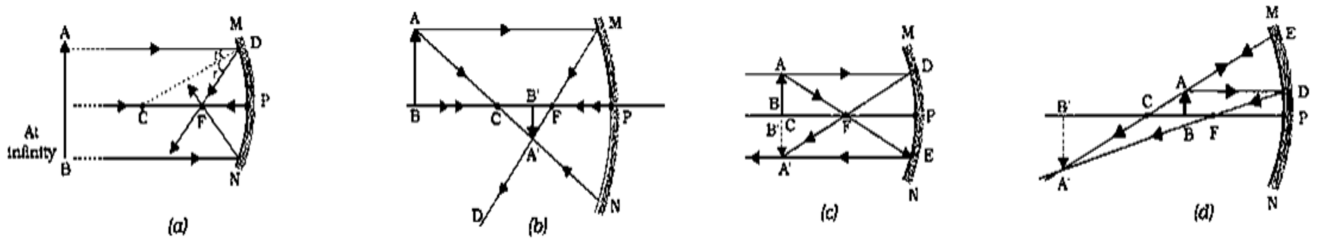
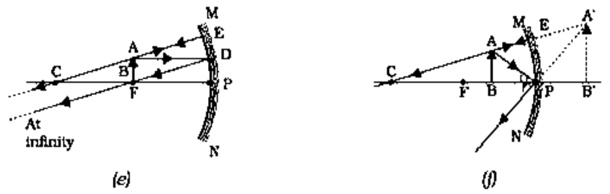


Image formation by Spherical Mirrors:

1. Concave mirrors

S.No	*POSITION OF OBJECT*	*POSITION OF IMAGE*	*NATURE OF IMAGE*	*SIZE OF IMAGE*
1.	Between pole and focus	Behind the mirror	Virtual and erect	Larger than the object
2.	On focus	At infinity	Real and inverted	Highly enlarged
3.	Between focus and centre of curvature	Beyond Centre of curvature	Real and inverted	Enlarged
4.	At Centre of curvature	At Centre of curvature	Real and inverted	Same as the object
5.	Beyond the centre of curvature	B/w focus and centre of curvature	Real and inverted	Diminished
6.	At infinity	At focus	Real and inverted	Highly diminished, pt sized

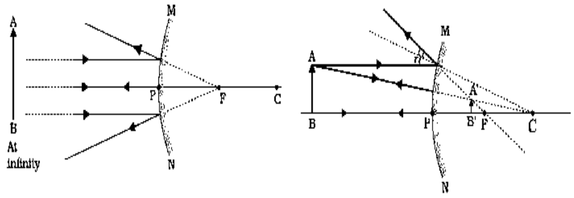




(e) (f)

2. Convex mirrors:

S.No.	POSTION OF OBJECT	POSITION OF IMAGE	NATURE OF IMAGE	SIZE OF IMAGE
1.	At infinity	At focus, behind the mirror	Virtual and erect	Highly diminished, pt sized
2.	Between pole and infinity	b/w pole and focus, behind the mirror	Virtual and erect	Diminished



(a) (b)

USES OF SPHERICAL MIRRORS

(i) Uses of concave mirrors: used in torches, search lights, vehicles' headlights, to concentrate sunlight to produce heat in solar furnaces, shaving mirrors.

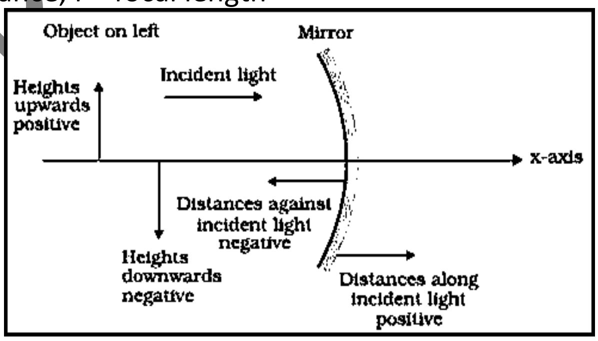
(ii) Uses of convex mirrors: as rear-view mirror in vehicles because they give erect though diminished image and they have wider field of view as they are curved outwards.

MIRROR FORMULA

Mirror Formula:

$1/v + 1/u = 1/f$ where, v= image distance, u= object distance, f = focal length

Sign convention:



MAGNIFICATION: Magnification produced by spherical mirrors gives the relative extent to which the image of an object is magnified w.r.t. the object size. Mathematically, it is defined as the ratio of the size of image to the size of object. It is generally denoted by 'm'.

m = size (height) of image/ size (height) of object

$m = h'/h = -v/u$

if m = -ve : real image   if m = +ve : virtual image

If |m|>1 : Image is magnified   If |m|<1 : Image is reduced   If |m| = 1 : Image is of same size as the object

REFRACTION OF LIGHT

Refraction of light: The change in the direction of light when it passes from one transparent medium to another, at the surface of separation, is called refraction of light.

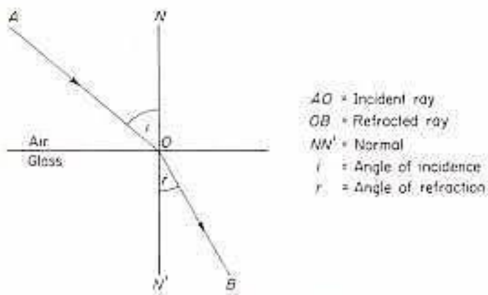


Fig. 23.1. Refraction of light

Cause: The refraction of light takes place because speed of light is different in different media.

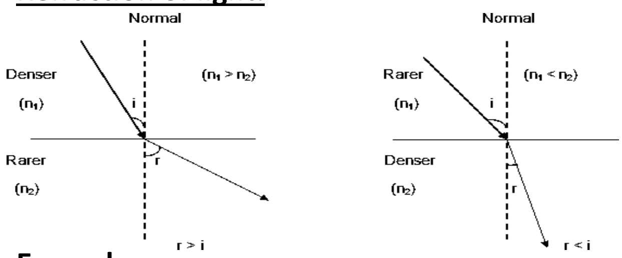
Thus, when light goes from one medium to another, its speed changes. And, this change in speed causes refraction of light.

Optically Rarer Medium and Optically Denser Medium:

Optically Rarer Medium: A medium, in which speed of light is more, is known as optically rarer medium. It has low refractive index.

Optically Denser Medium: A medium, in which speed of light is less, is known as optically denser medium. It has high refractive index.

Refraction of light:



Refraction of light when it goes from a denser to a rarer medium: When a ray goes from a denser to a rarer medium, it bends away from normal. i<r.

Refraction of light when it goes from a rarer medium to denser medium: When a ray goes from a rarer to a denser medium, it bends towards normal. i> r.

Examples:

(i) When a pencil is partly immersed in water in a glass tumbler, it appears to be displaced and short at the interface of air and water.

(ii) To a fish under water viewing obliquely, a fisherman standing on the bank of the lake, the man looks taller.

(iii) Coin placed at the bottom of a bucket filled with water appears to be slightly raised above its actual position.

REFRACTIVE INDEX:

Refractive Index: The refractive index of a medium gives an indication of light bending ability of that medium.

Or, it is defined as the extent of the change in the direction of light in given pair of media.

The value of the refractive index for a given pair of media depends upon the speed of light in the two media.

Let v_1 be the velocity of light in medium 1 and v_2 be the velocity of light in medium 2.n_{21} is the refractive index of medium 2 w.r.t. medium 1.n_{12} is the refractive index of medium 1 w.r.t. medium 2.

Relative refractive index: Refractive index of a medium w.r.t another medium is called relative refractive index.

$$n_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$$

$$n_{12} = \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{v_2}{v_1}$$

Absolute refractive index: Refractive index of a medium w.r.t. air is called Absolute refractive index.

$$n_m = \frac{\text{Speed of light in air/vacuum}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

Factors on which the refractive index of a medium depend: nature of the medium, nature of the surrounding medium, wavelength of light used and temperature.

Note: for the light refracted, frequency remains unchanged but wavelength and speed get changed.

Velocity = frequency X Wavelength

LAWS OF REFRACTION

(i) Incident ray, refracted ray and normal all lie on the same plane.

(ii) **Snell's law of refraction:** The ratio of sine of angle of incidence to the sine of angle of refraction is a constant.

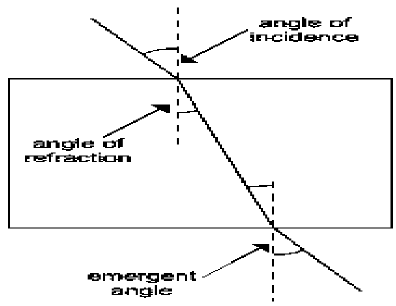
$$\text{Sin } i/\text{Sin } r = n_{21}(\text{constant})$$

$$n_{21} = \text{Sin } i/\text{Sin } r = v_1/v_2 = 1/n_{12} = n_2/n_1$$

Note: When a ray of light strikes the surface of separation normally, it passes undeviated from one medium to another. i = r =0°.

REFRACTION THROUGH GLASS SLAB:

Note:



- The line under the glass slab appears to be bent at the edges due to refraction of light from glass to air.
- The part of the line beneath the glass slab appears to be raised due to refraction of light rays.
- The part of the line under the glass slab does not appear bent. This is because, light rays incident

normally at the interface of glass and air do not suffer refraction or bending at the interface.

Lateral displacement: the emergent ray is shifted sideward slightly by a perpendicular distance w.r.t. the incident ray. This lateral shift in the path of light on emerging from a medium with parallel faces is called Lateral Displacement.

Lateral displacement depends upon the:

Angle of incidence, thickness of the glass slab, refractive index of the slab material.

SPHERICAL LENSES:

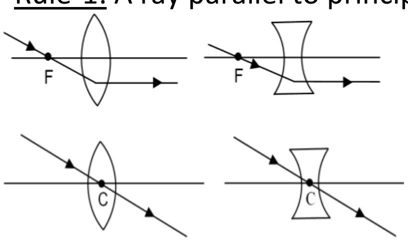
(i) **Concave or Diverging Lens:** thin in the middle and thicker at edges, diverges a parallel beam of light. It has virtual focus.

(ii) **Convex or Converging Lens:** thick at centre and thinner at edges, converges a parallel beam of light. It has real focus.

REFRACTION BY SPHERICAL LENSES:

RULES:

Rule-1: A ray parallel to principal axis passes through principal focus after refraction.



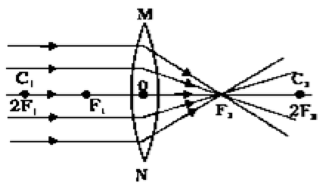
Rule-2: A ray of light passing through focus is parallel to principal axis.

Rule-3: A ray of light passing through optical centre O; emerges without any deviation after refraction.

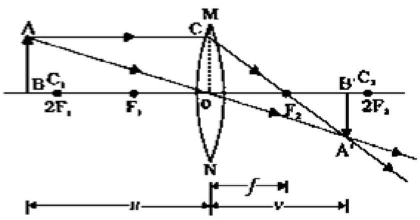
IMAGE FORMATION BY SPHERICAL LENSES:

(i) Convex Lens:

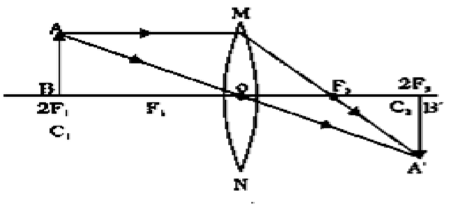
S.No.	*POSITION OF OBJECT*	*POSITION OF IMAGE*	*NATURE OF IMAGE*	*SIZE OF IMAGE*
1.	At infinity	At focus	Real and inverted	Highly diminished, point sized
2.	b/w optical centre& focus	Same side of the lens as object	Virtual and erect	Enlarged
3.	At focus	At infinity	Real and inverted	Highly enlarged
4.	b/w focus &centre of curvature	Beyond centre of curvature	Real and inverted	Enlarged
5.	At centre of curvature	At centre of curvature	Real and inverted	Same size
6.	Beyond Centre of curvature	b/w focus and centre of curvature	Real and inverted	diminished



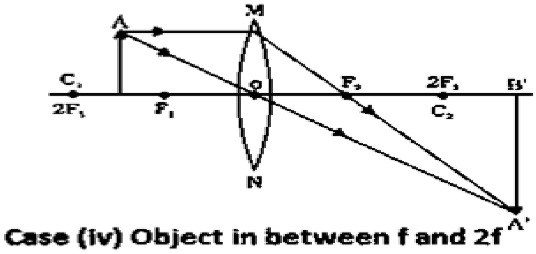
Case (i) Object at infinity



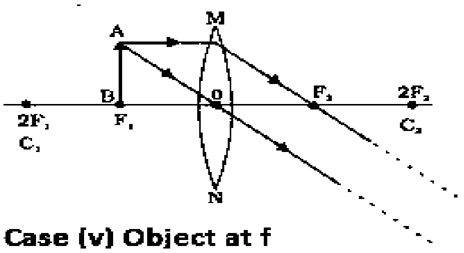
Case (ii) Object at beyond 2f



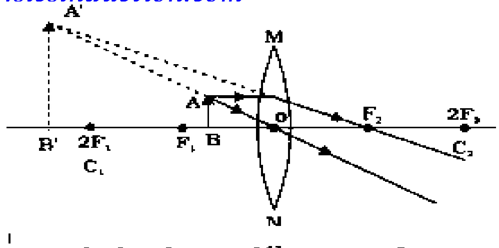
Case (iii) Object at 2f



Case (iv) Object in between f and 2f



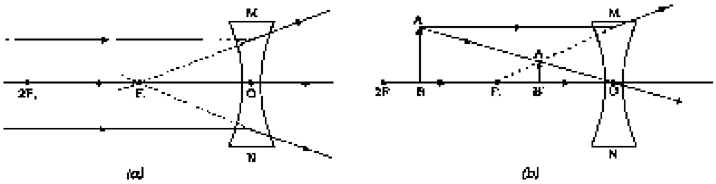
Case (v) Object at f



Case (vi) Object distance < f

(ii) **ConcaveLens:**

S.No.	POSITION OF OBJECT	POSITION OF IMAGE	NATURE OF IMAGE	SIZE OF IMAGE
1.	At infinity	At focus	Virtual and erect	Highly diminished, point sized
2.	b/w infinity & optical centre	b/w optical centre and focus	Virtual and erect	diminished



LENS FORMULA

lens formula: $1/v - 1/u = 1/f$

Where, v: Image distance, u: object distance, f: focal length.

Magnification: $m = h'/h = v/u$

POWER OF A LENS

Power of a Lens: The power of a lens is a measure of the degree of convergence or divergence of light rays falling on it. It is the reciprocal of focal length and is generally denoted by P.

$$P = 1/f$$

Unit of power is 'Dioptre', denoted by D.

1 Dioptre: 1 Dioptre is the power of a lens whose focal length is 1m. $1\ D = 1\ m^{-1}$.

Power of convex lens is +ve and that of concave lens is –ve.

Power of the combination of lenses: $P = P_1 + P_2 + P_3 + P_4 + \ldots\ldots\ldots\ldots\ldots\ldots$