LIGHT - REFLECTION AND REFRACTION

SPHERICAL LENSES

SPHERICAL LENSES :

A lens is a piece of transparent refracting material bounded by two spherical surface or one spherical and other plane surface.

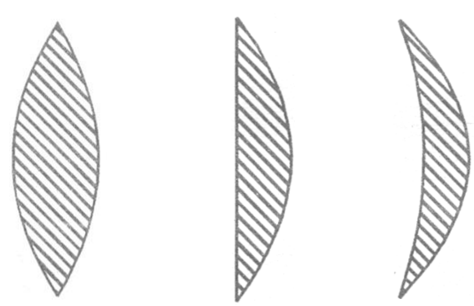
A lens is the most important optical component used in microscopes, telescopes, cameras, projectors etc.

Basically lenses are of two types :

(i) Convex lens or converging lens (ii) Concave lens or diverging lens

(a) Convex lens and its type :

A lens which is thick at the centre and thin at the edges is called a convex lens. The most common form of a convex lens has both the surfaces bulging out ta the middle. Some forms of convex lens are shown in the figure.



Double- Cojnvex   Plano- Convex   concavo - Convex

(b) Concave lens and its type :

A lens which is thin at the middle and thick at the edges is called a concave lens. The most common form of a concave lens has both the surfaces depressed inward at the middle. Some forms of concave lenses are shown in the figure.

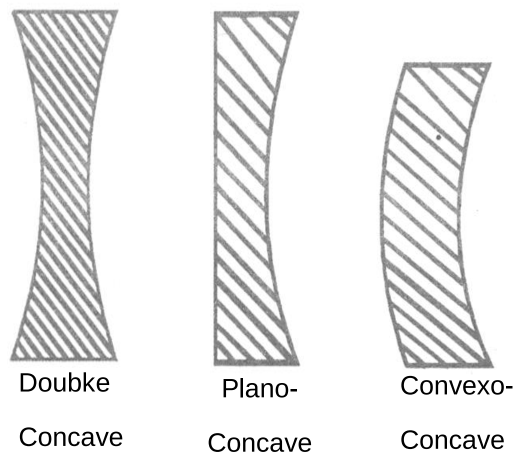


Figure : Different types of concave lens

Definitions in connection with spherical lens :

(i) Centre of curvature (C) :

The centre of curvature of the surface of lens is the centre of the sphere of which it forms a part, because a lens has two surfaces, so it has two centers of curvature. In figure (a) & (b) points C_1 & C_2 are the centers of curvature.

(ii) Radius of curvature (R) :

The radius of curvature of the surface of a lens is the radius of the sphere of which the surface forms a pat. R_1 & R_2 in the figure (a) & (b) represents radius of curvature.

(iii) Principle axis (C_1 C_2) :

It is the line passing through the two centers of curvature (C_1 & C_2) of the lens.

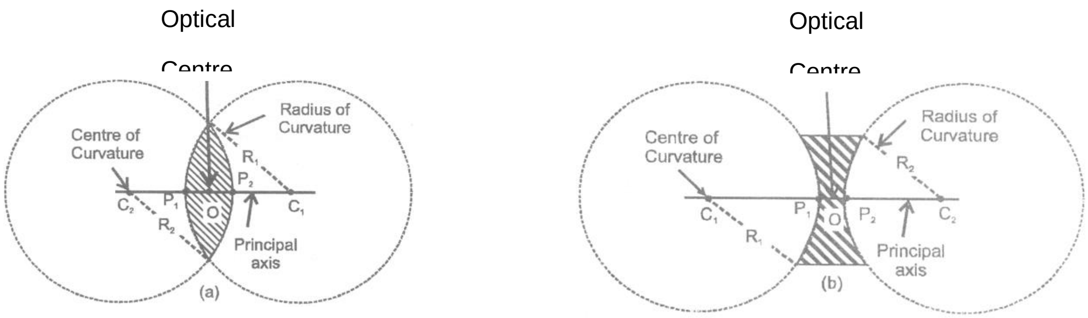


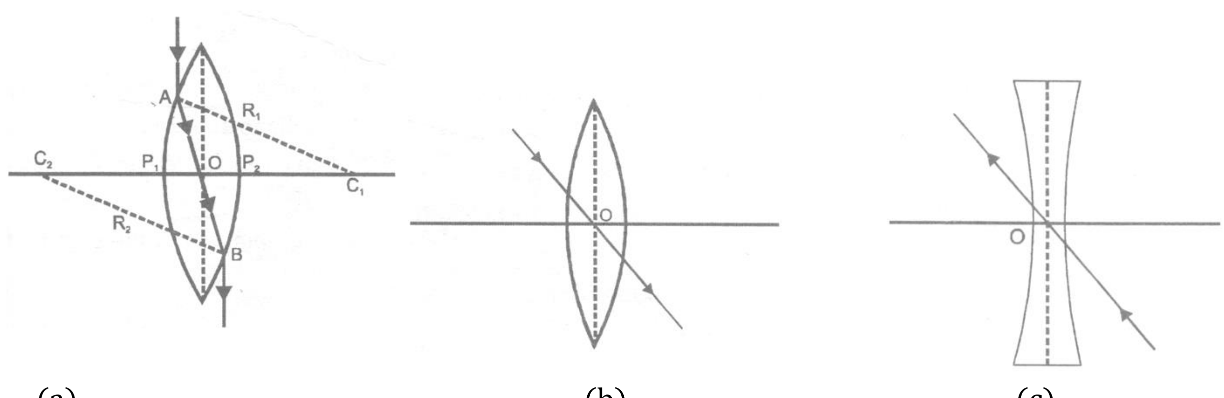
Figure : Characteristics of convex and concave lense

Optical centre :

If a ray of light is incident on a lens such that after refraction through the lens the emergent ray is parallel to the incident ray, then the point at which the refracted ray intersects, the principal axis is called the optical centre of the lens. In the figure O is the optical centre of the lens. It divides the thickness of the lens in the ratio of the radii of curvature of its two surfaces. Thus :

$$\frac{OP_1}{OP_2} = \frac{P_1C_1}{P_2C_2} = \frac{R_1}{R_2}$$

If the radii of curvature of the two surfaces are equal, then the optical centre coincides with the geometric centre of the lens.



(a) (b) (c)

Figure : Ray diavram Showing lateral displacement

For a ray passing through the optical centre, the incident and emergent rays are parallel. However, the emergent ray suffers some lateral displacement relative the incident ray. The lateral displacement decrease with the decrease in thickness of the lens. Hence a ray passing through the optical centre of a thin lens does into suffer any lateral deviation, as shown in the figure (b & (c) above.

(v) Principal foci and focal length :

(A) First principal focus :

It is fixed point on the principal axis such that rays starting from this point (in convex lens) or appearing to go towards this point (concave lens), after refraction through the lens, become parallel to the principal axis. It is represented by F_1 or F'. The plane passing through this point and perpendicular to the principal axis is called the first focal plane. The distance between first principal focus and the optical centre is called the first focal length. It is denoted by f_1 of f'.

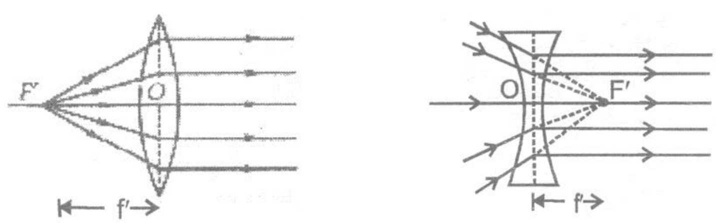


Figure : Ray diagram showing First principal focus

Second principal focus :

It is a fixed point on the principal axis such that the light rays incident parallel to the principal axis, after refraction through the lens, either converge to this point (in convex lens) or appear to diverge from this point (in concave lens). The plane passing through this point and perpendicular to principal axis is called the second focal plane. The distance between the second principal focus and the optical centre is called the second focal length. It is denoted by f_2 or f

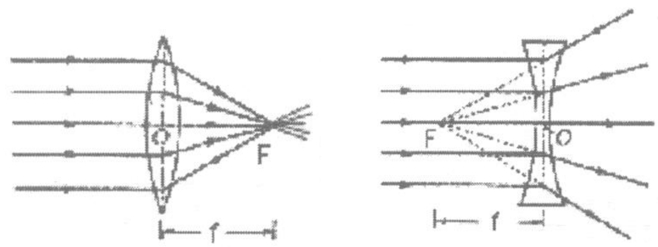


Figure : Ray diavram showing second principal focus

Generally, the focal length of a lens refers to its second focal length. It is obvious from the above figures, that the foci of a convex lens are real and those of a concave lens are virtual. Thus the focal length of a convex lens is taken positive and the focal length of a concave lens is taken negative.

If the medium on both sides of a lens is same, then the numerical values of the first and second focal length are equal. Thus

$f = f'$

(vi) Aperture : It is the diameter of the circular boundary of the lens.