ICSE
Living Science
Physics

Class 10

Chapter 5 Refraction through Lenses

On Board! BOOKS

As per the guidelines of NEP 2020

On Board! BOOKS

Revised and Updated

Living Science Physics

Based on the latest ICSE syllabus

Dhiren M Doshi

SCAN QR CODE
for ICSE updates and more study material
onboardbooks.in

10

LEARNING OBJECTIVES

Types of Lenses

- ❖ Convex or Converging Lens
- ❖ Converging action of a convex lens
- ❖ Diverging action of a concave lens

Technical Terms Related to Lenses

- ❖ First and second focal points of a convex lens
- ❖ First and second focal points of a concave lens

Refraction of Parallel Beam of Light

Formation of Images by a Lens

Power of a Lens

- ❖ Power of a combination of lenses

Magnifying Glass or Simple Microscope

- ❖ Lens formula
- ❖ Magnification produced by lenses

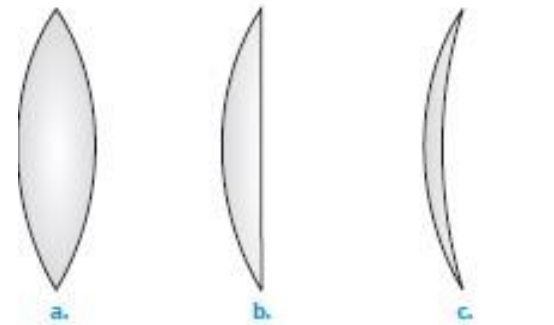
What is a lens?

A lens is a piece of transparent, optical material bounded by two refracting surfaces which are usually spherical, or one surface being spherical and the other plane.

Types of Lenses

Convex or converging lens

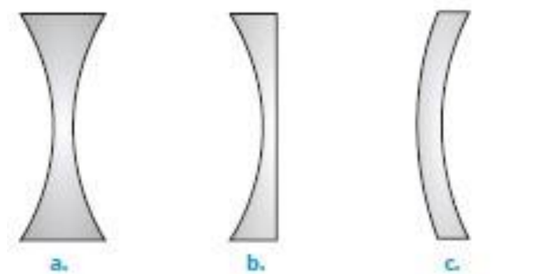
A convex lens is thicker in the middle and thinner at the edges. In other words, a convex lens bulges out at the centre. A convex lens may be of three types:



a. Biconvex b. Plano-convex c. Concavo-convex

Concave or diverging lens

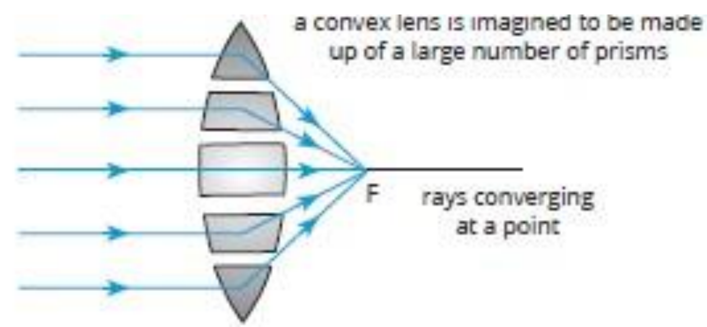
A concave lens is thinner in the middle and thicker at the edges. In other words, a concave lens is bent inwards or depressed at the centre. A concave lens may be of three types:



a. Biconcave b. Plano-concave c. Convexo-concave

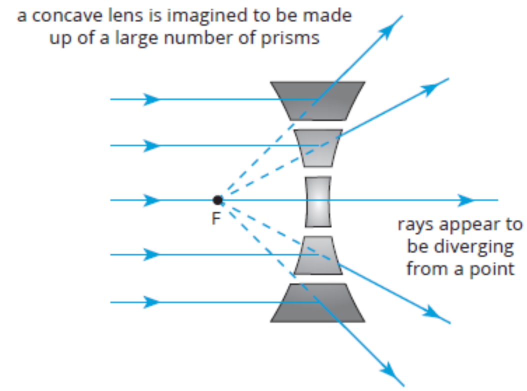
Converging action of a convex lens

The convex lens converges the parallel beam of light at a point. Therefore, a convex lens is also called a converging lens.

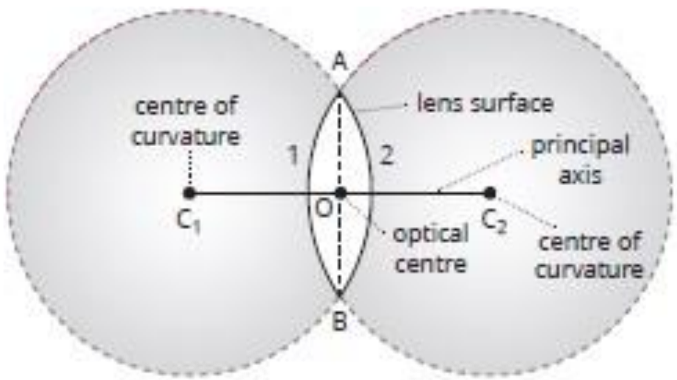


Diverging action of a concave lens

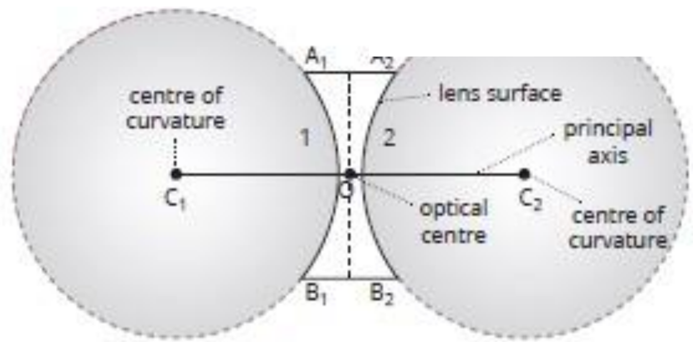
The concave lens diverges the parallel rays of light and the diverged rays appear as if they are coming from a point. Therefore, a concave lens is also called a diverging lens.



Technical Terms Related to Lenses



a. Convex lens



b. Concave lens

Centre of curvature: The centre of curvature of a lens is defined as the centre of the spherical surface from which the lens has been cut.

Aperture: The maximum portion of the spherical surfaces from which refraction takes place is called the aperture of the lens.

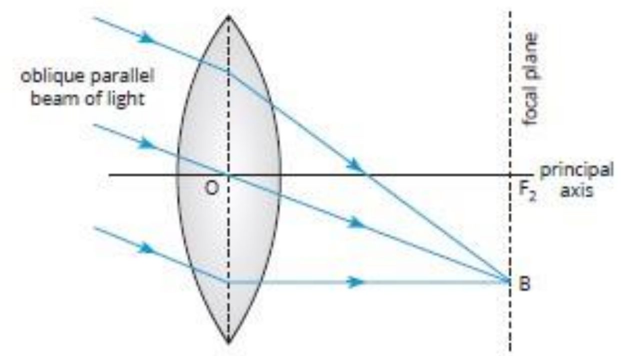
Radius of curvature: The radius of curvature of a lens is the radius of the sphere of which the lens surface is a part.

Principal axis of a lens: The line joining the centres of curvature of two refracting surfaces of the lens is called the princip

Optical centre: The geometrical centre of the lens is called its optical centre.

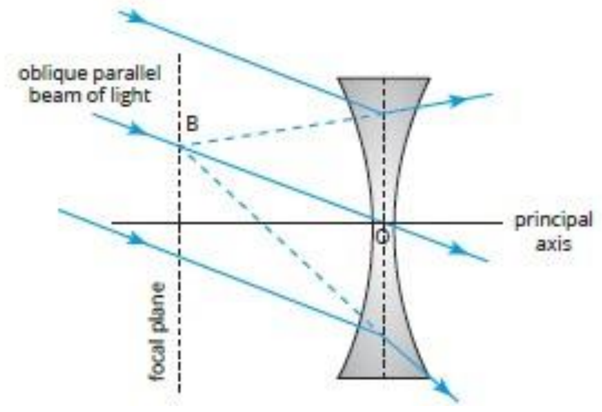
Principlal foci: There are two principal foci at equal distances from the optical centre of the lens, provided the medium on either side of the lens is same. These are known as the first focal point (or first focus) F1 and the second focal point (or second focus) F2.

Refraction of Parallel Beam of Light by Lens



In case of convex lens

- Rays incident obliquely to the principal axis converge at point B on the focal plane

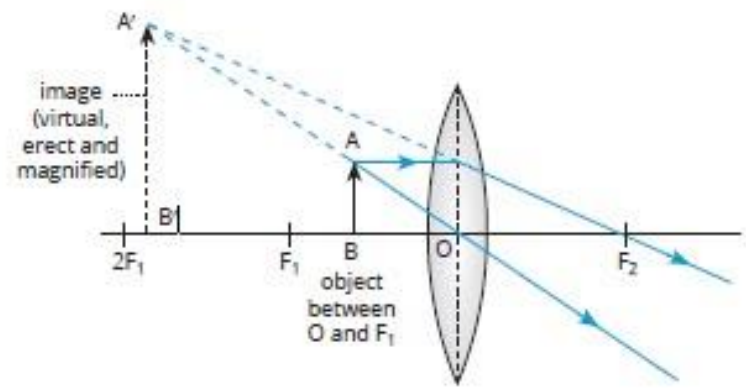


In case of concave lens

- Rays incident obliquely to principal axis appear to diverge from a point B in the focal plane

Formation of Images by a Convex Lens

Case I: When the object is placed between the optical cenre and the principal focus:

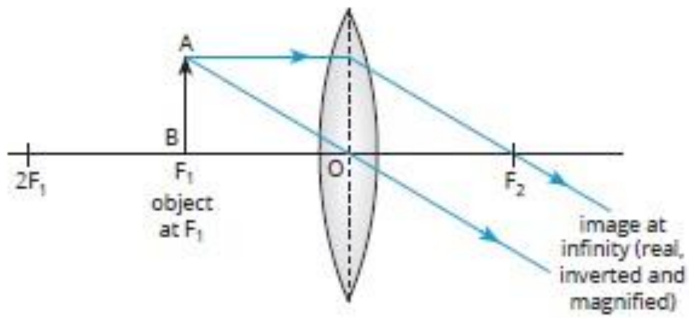


Characteristics and location:

•The image formed is virtual, erect, enlarged (or magnified) and on the same side of the lens, behind the object.

Applications: It is used as a magnifying glass (or simple microscope) etc.

Case II: when the object is placed at the focus of a convex lens:

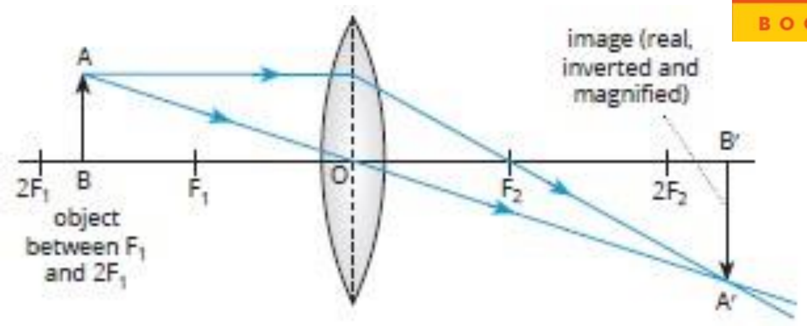


Characteristics and location:

•The image formed is virtual, erect, enlarged (or magnified) and on the same side of the lens, behind the object.

Applications: The above case is used in making searchlights and spotlights in theatres.

Case III: When the object is placed between F_1 and $2F_1$

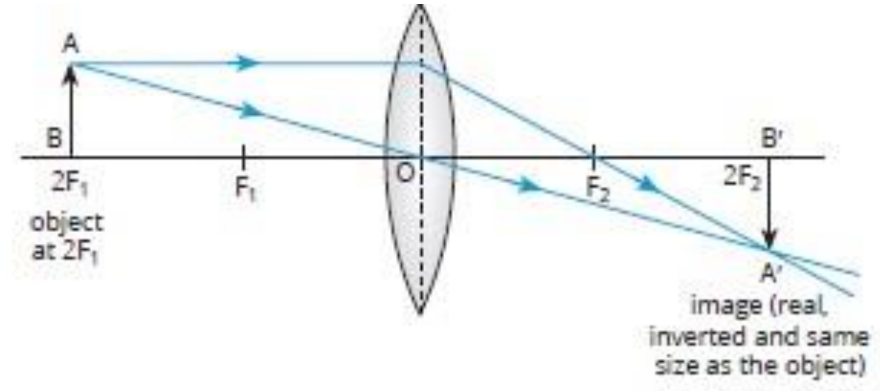


Characteristics and location:

•The image formed is real, inverted, enlarged (or magnified) and beyond $2F_2$ on the other side of the lens

Applications: This type of image formation is used in film and slide projectors, when enlarged image of a small slide (or film) is formed on a screen.

Case IV: When the object is at $2F_1$:



Characteristics and location:

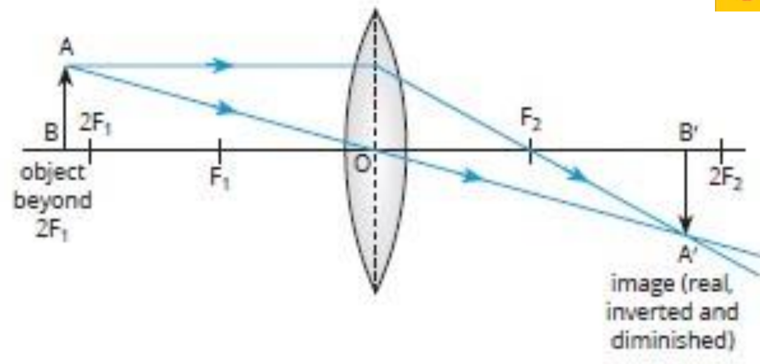
•The image formed is real, inverted, of the same size as the object and at $2F_2$ on the other side of the lens.

Applications: This type of image formation is used in terrestrial telescope, for erecting the inverted image formed by the objective lens of the telescope..

Case V: When the object is beyond $2F_1$:

Characteristics and location:

•The image formed is real, inverted, diminished and formed between F_2 and $2F_2$ on the other side of the lens.

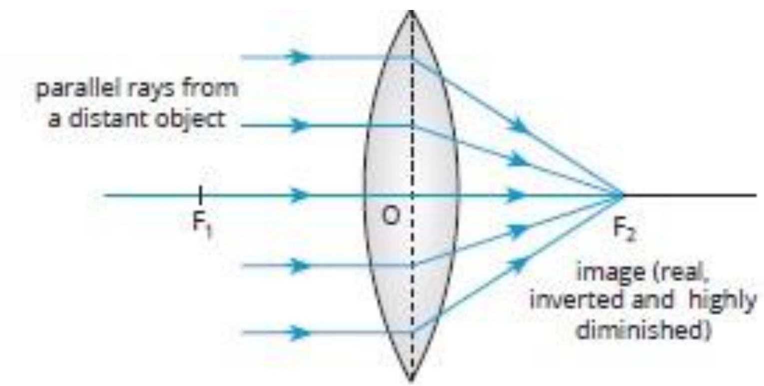


Applications: This type of image formation is used in a photographic camera, where a small, real and inverted image of an object is formed on the film.

Case VI: When the object is at infinity (such that the rays coming from it are parallel to the principal axis of the convex lens) :

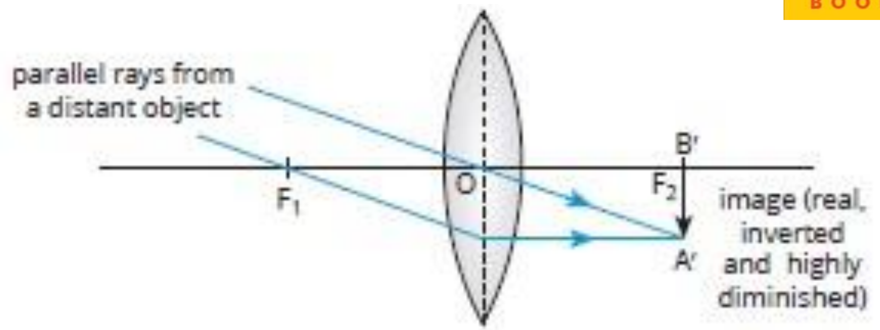
Characteristics and location:

•The image formed is real, inverted, diminished to a point and formed at F_2 on the other side of the lens.



Applications: This type of image formation is used in a burning glass.

Case VII: When the object is at infinity (such that the rays coming from it are not parallel to the principal axis of the convex lens)



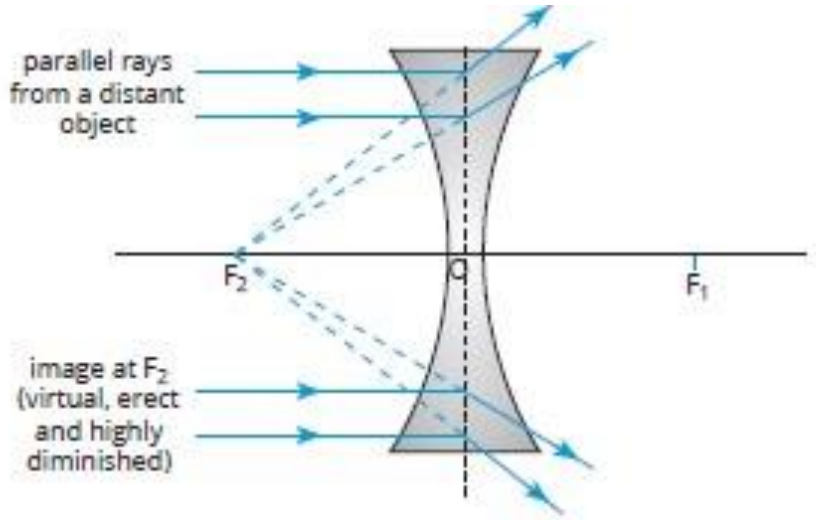
Characteristics and location:

•The image formed is real, inverted, highly diminished and formed on the focal point on the other side of the lens.

Applications: This type of image formation is used for an objective lens in a telescope. It forms small, inverted image of far off objects in the focal plane in front of the eye lens.

Formation of Images by a Concave Lens

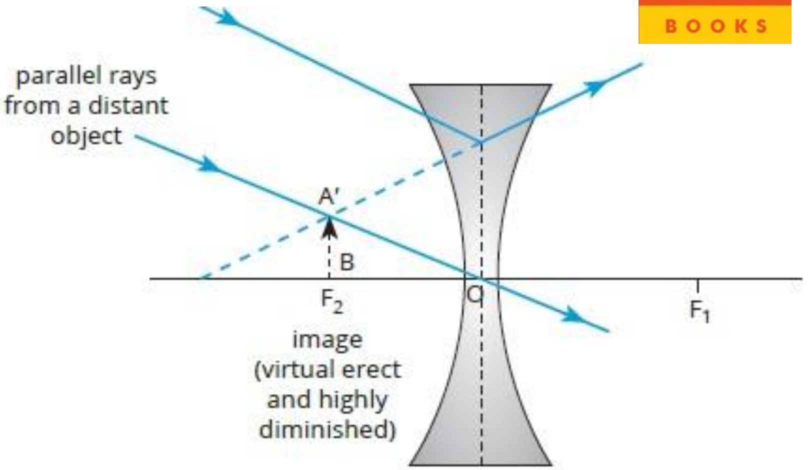
Case I: When the object is located at infinity (such that the rays coming from it are parallel to the principal axis)



Characteristics and location:

•The image formed is virtual, erect, diminished to a point and formed at F_2 on the same side of the lens as the object

Case II: When the object is located at infinity [such that the parallel rays from it are falling obliquely (not parallel) to the principal axis.]

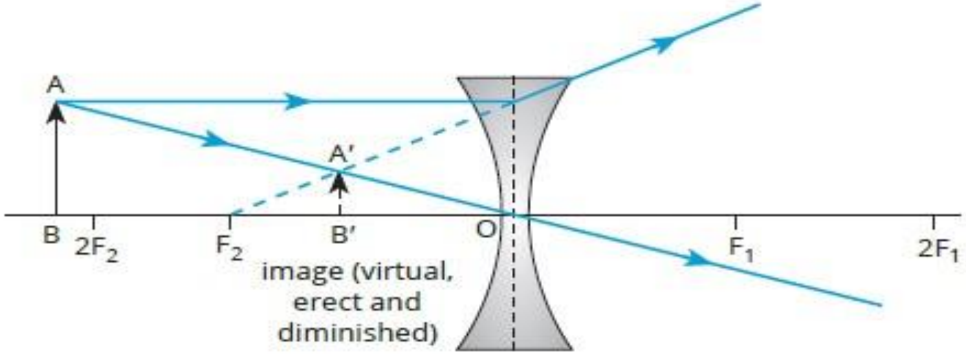


Characteristics and location:

•The image formed is virtual, erect, highly diminished and formed in the focal plane on the same side of the lens as the object.

Applications: This type of image formation is used in Galilean telescope, where concave lens acts as an eye lens.

Case III: When the object is anywhere between the optical centre (O) and infinity.



Characteristics and location:

The image formed is virtual, erect, diminished and is formed between the optical centre (O) and the focus (F2) on the same side of the object

Applications: This type of image formation is used mainly in spectacles for the correction of short-sightedness or myopia.

Power of a Lens

The power of a lens is defined as the reciprocal of its focal length (in metres). Thus,

Power of a lens = 1/ focal length of the lens (in m)

$$P = 1/f$$

where, P = power of the lens

f = focal length of the lens (in metres)

The SI unit of the power of a lens is dioptre, which is denoted by the letter D. The focal length of a lens is measured in metres.

Hence, **one dioptre is the power of a lens whose focal length is one metre**. The power of a lens can be measured directly by using an instrument called dioptremeter. It is used by opticians to measure the power of spectacle lenses.

Power of a Combination of Lenses

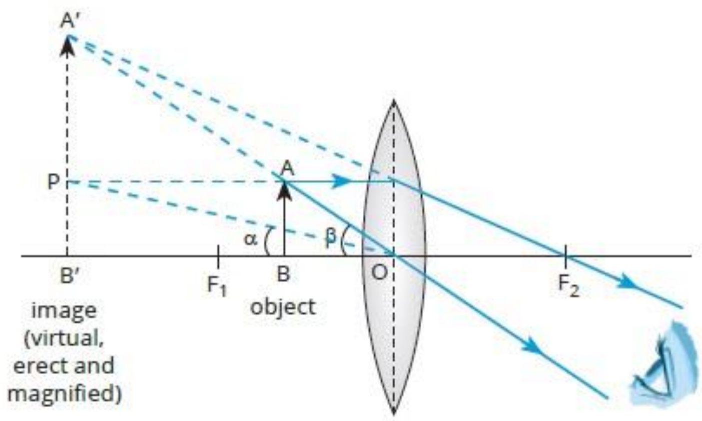
If a number of lenses are placed in close contact with each other, then the power of the combination of lenses is equal to the algebraic sum of the powers of individual lenses. Thus, if two lenses of powers P_1 and P_2 are placed in contact with each other, then their resultant power P is given by the algebraic sum of the individual powers P_1 and P_2 of the two lenses,

i.e. $P = P_1 + P_2$

Magnifying Glass or Simple Microscope

A magnifying glass or simple microscope is an optical instrument, which produces the magnified image of a very small object which cannot be seen with the naked eye.

Principle: A simple microscope (or magnifying or reading glass) is based upon the fact that, if an object is placed between the optical centre and the focus of a convex lens, a virtual, erect and magnified image will be formed on the same side of the lens. In order to get the clear image of the object, the lens is placed at the least distance of distinct vision (25 cm)



Magnifying power

The magnifying power of a simple microscope is defined as the ratio of the angle subtended by the image at the eye to the angle subtended by the object at the eye, when placed at the least distance of distinct vision.

Magnifying power = β/α where α is angle subtended by the object at the eye when the object is placed at the least distance of distinct vision and β is the angle subtended by the image at the eye.

Magnifying power = 1 + D/f (When the image formed by a simple microscope is at the least distance of distinct vision)
Magnifying power = D/*f* (When the image formed by a simple microscope is at infinity) where, D = least distance of distinct vision (which is 25 cm)

Lens Formula

1/f = 1/v - 1/u , where f is the focal length, v is the image distance and u is the object distance.

Magnification produced by lenses = Height of the image /Height by the object
= Image distance / Object distance

Applications of Lenses

1. Lenses are used in spectacles to correct defects of vision. To correct hypermetropia or longsightedness, convex lenses are used in spectacles. Concave lenses are used to correct myopia or shortsightedness. There is a small convex lens in each of our eyes.
2. Convex lenses are used in photographic camera, microscopes, telescopes and film projectors.
3. A convex lens is used as a magnifying glass.
4. A concave lens is used as the eye lens in Galilean telescope.
5. A combination of concave lens with convex lens is used to make high quality lens systems for optical instruments.

SUMMARY

1. **Lens:** A lens is a piece of transparent, optical material bounded by two refracting surfaces.

2. **Convex lens:** It is thinner at the edges and thicker in the middle.

3. **Concave lens:** It is thicker at the edges and thinner in the middle.

4. **Real image:** The image is said to be real if the rays of light after refraction actually meet at a point. It can always be taken on the screen. It is always inverted.

5. **Virtual image:** The image is said to be virtual if the rays of light after refraction appear to meet at some point. It cannot be taken on the screen. It is always erect.

6. **Images by concave lens:** It always produces a virtual and erect image which always lies between the focus and the optical centre of the lens.

7. **Power of a lens:** It is the degree of convergence or divergence produced by the lens of the light rays falling on it.

8. **Simple microscope:** It is an optical instrument to see the small objects as magnified ones.