JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

LIGHT - 4

LENSES

A lens is an optically transparent medium bounded by two spherical refracting surfaces or one plane and one spherical surface.

Lens is basically classified into two types. They are:

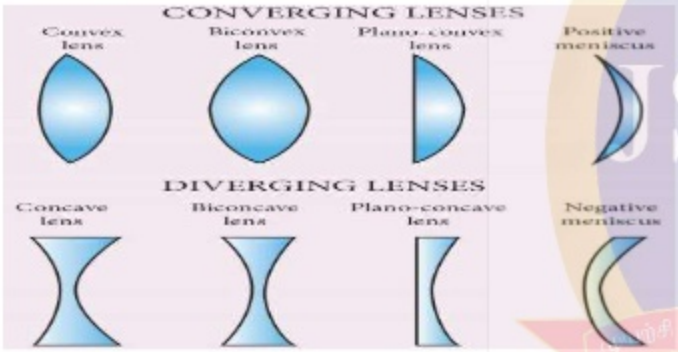
(i) Convex Lens (ii) Concave Lens

(i) Convex or bi-convex lens:

- It is a lens bounded by two spherical surfaces such that it is thicker at the centre than at the edges.
- A beam of light passing through it, is converged to a point. So, a convex lens is also called as converging lens.

(ii)Concave or bi-concave Lens:

- It is a lens bounded by two spherical surfaces such that it is thinner at the centre than at the edges.
- A parallel beam of light passing through it, is diverged or spread out. So, a concave lens is also called as diverging lens.



APPLICATIONS OF CONVEX LENSES

1. Convex lenses are used as camera lenses

2. They are used as magnifying lenses

3. They are used in making microscope, telescope and slide projectors

4. They are used to correct the defect of vision called hypermetropia

APPLICATIONS OF CONCAVE LENSES

1. Concave lenses are used as eye lens of 'Galilean Telescope'

2. They are used in wide angle spy hole in doors.

3. They are are used to correct the defect of vision called 'myopia'

LENS FORMULA

Like spherical mirrors, we have lens formula for spherical lenses.

The lens formula gives the relationship among distance of the object (u), distance of the image (v) and the focal length (f) of the lens. It is expressed as

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

It is applicable to both convex and concave lenses.

MAGNIFICATION OF A LENS

Spherical lenses produce magnification and it is defined as the ratio of the height of the image to the height of an object.

Magnification is denoted by the letter 'm'. If height of the object is h and height of the image is h′, the magnification produced by lens is,

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

Also it is related to the distance of the object (u) and the distance of the image (v) as follows:

$$m = \frac{Distance\ of\ the\ image}{Distance\ of\ the\ object} = \frac{v}{u}$$

If the magnification is greater than 1, then we get an enlarged image. On the other hand, if the magnification is less than 1, then we get a diminished image.

LENS MAKER'S FORMULA

For a maker of any lens, knowledge of radii of curvature of the lens is required.

The lens maker's formula is one such equation. It is given as

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

where μ is the refractive index of the material of the lens; R1 and R2 are the radii of curvature of the two faces of the lens; f is the focal length of the lens.

The lens formula and lens maker's formula are applicable to only thin lenses. In the case of thick lenses, these formulae with little modifications are used.

POWER OF A LENS

- From the above activity, it is clear that when a ray of light falls on a lens, the ability to converge or diverge these light rays depends on the focal length of the lens.
- This ability of a lens to converge (convex lens) or diverge (concave lens) is called as its power.
- Hence, the power of a lens can be defined as the degree of convergence or divergence of light rays.

$$P = 1/f$$

- The SI unit of power of a lens is dioptre. It is represented by the symbol D.
- If focal length is expressed in 'm', then the power of lens is expressed in 'D'.
- By convention, the power of a convex lens is taken as positive whereas the power of a concave lens is taken, as negative.

S. No	Convex Lens	Concave Lens
1	A convex lens is thicker in the middle than at edges.	A concave lens is thinner in the middle than at edges.
2	It is a converging lens.	It is a diverging lens.
3	It produces mostly real images.	It produces virtual images.
4	It is used to treat hypermeteropia.	It is used to treat myopia.

MICROSCOPE

This is an optical instrument, which helps us to see tiny (very small) objects.

Simple Microscope

- Simple microscope has a convex lens of short focal length.
- It is held near the eye to get enlarged image of small objects.

Uses of Simple microscope

Simple microscopes are used

a) by watch repairers and jewellers.

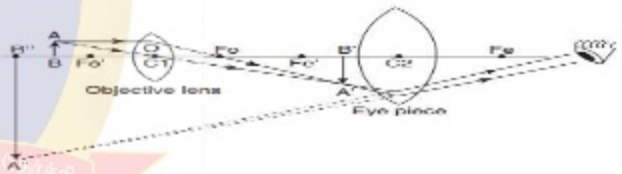
b) to read small letters clearly.

c) to observe parts of flower, insects etc.

d) to observe finger prints in the field of forensic science.

Compound microscope

- Magnification power of microscopes can be increased by decreasing the focal length of the lens used.
- Due to constructional limitations, the focal length of the lens cannot be decreased beyond certain limit.
- This problem can be solved by using two separate biconvex lenses. Construction A compound microscope consists of two convex lenses.
- The lens with the shorter focal length is placed near the object, and is called as 'objective lens' or 'objective piece'.
- The lens with larger focal length and larger aperture placed near the observer's eye is called as 'eye lens' or 'eye piece'.



It works based on the principle of vernier. Its least count is 0.01 mm.

TELESCOPE

Telescope is an optical instrument to see the distant objects.

Jan Lippershey

The first telescope was invented by **Jan Lippershey** in 1608.

Galileo

- Galileo made a telescope to observe distant stars.

Kepler

Kepler invented Telescope in 1611 which was fundamentally similar to the astronomical telescope.

Types of Telescope

i) refracting telescope

- In refracting telescope lenses are used.
- Galilean telescope, Keplerian telescope, Achromatic refractors, Apochromatic refractors are some refracting telescopes.

ii) reflecting telescope

parabolic mirrors are used Gregorian, Newtonian, Cassegrain telescope, Ritchey–Chrétien telescope are some Reflecting telescopes

According to the things which are observed, Astronomical Telescope and Terrestrial Telescopes are the two major types of telescope.

Astronomical Telescope

An astronomical telescope is used to view heavenly bodies like stars, planets galaxies and satellites.

Terrestrial Telescopes

- The image in an astronomical telescope is inverted. So, it is not suitable for viewing objects on the surface of the Earth.
- Therefore, a terrestrial telescope is used. It provides an erect image.
- The major difference between astronomical and terrestrial telescope is erecting the final image with respect to the object.