PHYSICS CLASSES *by* JATIN KHERA

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1. The human eye is a remarkable optical instrument.

(i) The ability of the eye to focus on objects at different distances is called power of accommodation of the eye.

(ii) The most distant point that the eye can see clearly is called far point of the eye. For normal eye the far point is at infinity.

(iii) The closest point at which an object is seen most clearly without strain is called the near point of the eye. This limiting distance is known as least distance of distinct vision (*D*). For normal eye, this distance is taken to be 25 cm (by convention).

2. The two important defects of the eye are (i) Short-sightedness or Myopia (ii) Farsightedness or Hypermetropia.

(i) A person who can see the near objects clearly but cannot focus on distant objects is short sighted. The far point of a short sighted person may be a few metres rather than at infinity. To correct short sighted vision, a diverging lens (concave lens) of suitable focal length is placed in front of the eye so that virtual image of far off object is formed at the far point of the short sighted eye.

(ii) A person who can see distant objects clearly but cannot focus on near objects is farsighted. Whereas the normal eye has a near point of about 25 cm, a farsighted person may have a near point of several metres from the eye. To correct farsighted vision, a converging lens (convex lens) of suitable focal length is placed in front of the eye. When an object is held at the normal near point (*i.e.* 25 cm from the eye), a virtual image is formed at the actual near point of the farsighted person's eye.

3. The angle which an object/image subtends at the eye is called visual angle. The greater the visual angle, the larger is the apparent size of the object/image.

4. The angular magnification (or magnifying power) of an optical instrument is given by;

Angular magnification, $M = \frac{\beta}{\alpha}$

where β = angle subtended at the eye by the image

α = angle subtended at the unaided eye by the object

5. A simple microscope or magnifying glass is a single converging (convex) lens.

(i) When the object is placed within the focus of the convex lens, a virtual, erect w.r.t. object and magnified image is formed behind the object. The lens is adjusted so that the image is formed at the near point. This is the *normal* use of microscope.

Angular magnification, $M = 1 + \frac{D}{f}$

D= least distance of distinct vision (=25 cm)

f = focal length of the lens

The smaller the value of *f*, the greater will be the magnifying power. Since the image formed is erect w.r.t. object, *M* is positive.

(ii) When the object is placed at the focus, a virtual, erect w.r.t. object and magnified image is formed at infinity. This is not the normal use of microscope.

Angular magnification, $M = \frac{D}{f}$

Note that this arrangement produces a slightly smaller angular magnification that when the image is at the near point. However, the advantage is that the eye is relaxed.

6. A compound microscope uses two converging lenses. Therefore, its magnifying power is much greater than that of simple microscope or magnifying glass. The lens nearer to the object is called objective lens and the lens through which final image is viewed is called the eye-piece.

(i) The object *AB* is placed between F_0 and $2F_0$ where F_0 is the focal point of objective lens. The objective forms a real, inverted and enlarged image A'B' of the object *AB*.

(ii) The lenses are so arranged that the image *A'B'* is inside the focal point F_e of the eyepiece. Therefore further magnification takes place. The adjustments are so made that the final image is formed at the near point.

(iii) Magnification produced by objective lens, $M_0 = \frac{L}{f_0}$

Here *L* is the length of microscope tube and f_0 is the focal length of objective lens.

Magnification produced by eyepiece, $M_e = 1 + \frac{D}{f_e}$

∴ Magnification of compound microscope, $M = M_0 \times M_e$

$$= \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

If f_0 and fe are small, *M* is large. Note that final image formed is inverted w.r.t. the object so that *M* is negative.

7. An astronomical telescope is used for seeing heavenly bodies e.g. moon, sun, starts etc. It uses two converging convex lenses called objective lens and eyepiece lens.

(i) The telescope is said to be in *normal adjustment* when the final image is at infinity. The objective lens collects parallel rays from the distant object and forms an intermediate image at its focus F_0. The separation of lenses is so adjusted that F_0 *(* focus of objective) and F_e (focus of eyepiece) coincide. Therefore, eye-piece forms the final image at infinity.

(ii) The final image can be formed at the near point. The objective lens forms an intermediate image of the object at its focus F_0. The eyepiece is moved so that the intermediate image is inside the focus F_e of the eyepiece. The telescope is adjusted so that the final image is a the near point.

Magnifying power, $M = \frac{f_0}{f_e}$

F_0 = focal length of objective; f_e = focal length of eyepiece.

In order to have large *M*, f_0 should be large while f_e should be small. Note that final image formed is inverted w.r.t. object so that *M* is negative.

(iii) The final image can be formed at the near point. The objective lens forms an intermediate image of the object at its focus F_0. The eyepiece is moved so that the intermediate image is inside the focus F_e of the eyepiece. The telescope is adjusted so that the final image is at the near point.

Magnifying power, $M = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

Note that magnifying power is increased when the final image is formed at the near point. Again the final image formed is inverted w.r.t. the object so that the magnification (*M)* is negative.

8. A terrestrial telescope forms an erect image of distant object and is used for viewing objects on the earth (e.g. distant trees, building etc.).

Magnifying power, $M = \frac{f_0}{f_e}$ ….. final image at infinity

$M = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$ …. Final image at near point

(i) A terrestrial telescope uses three convex lenses- objective, eyepiece and one convex lens (called erecting lens) between them. The erecting lens is placed at a distance $2f$ (f= focal length of erecting lens) in front of the inverted real image I_1 of the objected formed by the objective lens. The erecting lens forms an image *I of* I_1 at a distance $2f$ from it. The image I is of the same size as I_1 and is erect w.r.t. the object. The eyepiece is so adjusted that image is at the focus of the eyepiece. Therefore, the eyepiece forms the final image at infinity which is virtual, erect w.r.t. object and highly magnified.

(ii) The presence of erecting lens does not affect the magnitude of the angular magnification produced by the telescope.

9. In a reflecting telescope, the objective lens is replaced by a concave parabolic mirror. Magnifying power of a reflecting telescope is

$$M = \frac{f_o}{f_e} = \frac{(R/2)}{f_e}$$

10. The resolving power of an optical instrument is its ability to produce distinctly separate images of two objects very close together.