23

OPTICAL INSTRUMENTS

MICROSCOPE

Near point is the distance from the eye for which the image of an object placed there is formed (by eye lens) on the retina.

(i) The near point varies from person to person and with the age of an individual.

(ii) Least distance of distinct vision is the distance upto which the human eye can see the object clearly without any strain on it. For a normal human eye, this distance is generally taken to be 25 cm.

(iii) Angular magnification is the ratio of the angle subtended by the image at the eye (when the microscope is used) to the angle subtended by the object at the unaided eye when the object is placed at the least distance of distinct vision. It is also called the **magnifying power** of the microscope.

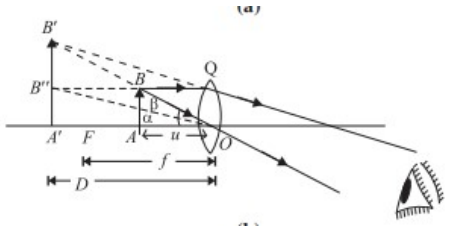
(iv) When the image is formed at infinity, least strain is exerted on the eye for getting it focused on the retina. This is known as **normal adjustment**.

(v) **Linear magnification** is the ratio of the size of the image to the size of the object.

(vi) **Visual angle** is the angle subtended by the object at human eye

A Simple Microscope

When a convex lens of short focal length is used to see magnified image of a small object, it is called a simple microscope.

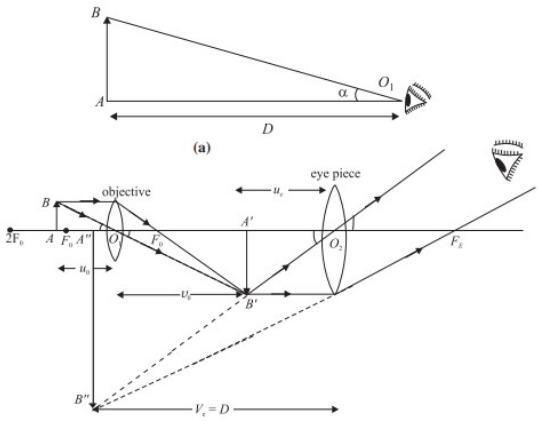


$$M = 1 + \frac{D}{f}$$

A Compound Microscope

- A compound microscope consists of two convex lenses.
- A lens of short aperture and short focal length faces the object and is called the **objective**.

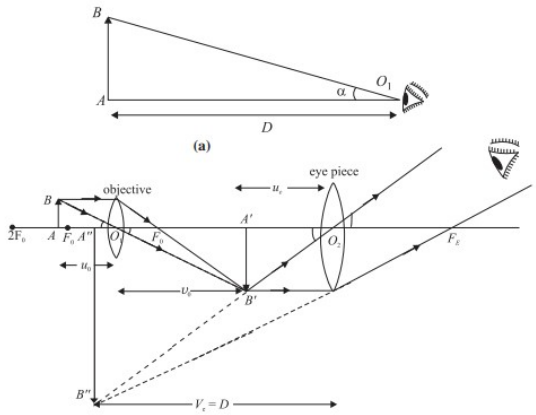
Another lens of short focal length but large aperture facing the eye is called the **eye piece**. The objective and eye piece are placed coaxially at the two ends of a tube.



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

Magnifying Power of a compound microscope

The ratio of the angle subtended by the final image at the eye to the angle subtended by the object at unaided eye, when both are placed at the least distance of distinct vision

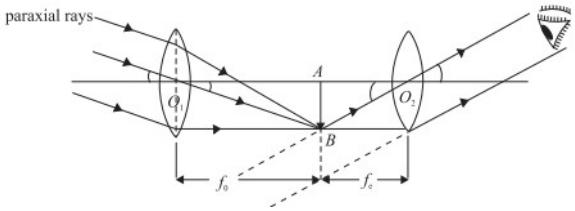


$$M = m_o \times m_e$$
$$= \frac{v_o}{u_o}\left(\frac{D}{f_e}\right)$$

TELESCOPES

Telescopes are used to see distant objects such as celestial and terrestrial bodies

The use of a telescope increases the visual angle and brings the image nearer to the eye



Refracting Telescope

Astronomical telescopes are used to observe heavenly or astronomical bodies.

Terrestrial telescopes are used to see distant objects on the earth. So it is necessary to see an erect image. Even Galilean telescope is used to see objects distinctly on the surface of earth.

Reflecting telescope

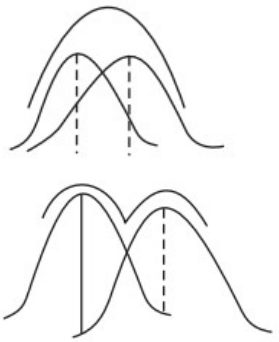
A reflecting telescope is used to see distant stars and possesses large light-gathering power in order to obtain a bright image of even a faint star deep in space. The **objective** is made of a **concave mirror**, having large aperture and large focal length. This concave mirror, being parabolic in shape, is free from spherical aberration.

RESOLVING POWER :

THE RAYLEIGH'S CRITERION

The resolving power of an optical instrument is its ability to resolve (or separate) the images of two point objects lying close to each other.

Rayleigh suggested that two images can be seen as distinct when the first minimum of the diffraction pattern due to one object falls on the central maximum of the other. This is called Rayleigh's criterion.



The resolving power of a telescope

The resolving power of a telescope is its ability to form separate images of two distant point objects situated close to each other.

It is measured in terms of the angle subtended at its objective by two close but distinct objects whose images are just seen in the telescope as separate.

This angle is called the limit of resolution of the telescope.

If the angle subtended by two distinct objects is less than this angle, the images of the objects can not be resolved by the telescope

The smaller the value of this angle, higher will be the resolving power of the telescope.

$$(R.P)_T = \frac{1}{\theta} = \frac{D}{1.22\lambda}$$

Resolving Power of a Microscope

The resolving power of a microscope is measured in terms of the smallest linear separation between the two objects which can just be seen through the microscope as separate.

This smallest linear separation between two objects is called the limit of resolution of the microscope.

$$(R.P)_m = \frac{2n\sin\theta}{\lambda}$$

Check Yourself

1. Magnifying power of a simple microscope having a focal length 2.5cm
   A. 10
   B. 11
   C. 12
   D. 1.0
2. Nature of image formed by simple microscope is
   A. Virtual erect and magnified
   B. Virtual inverted and magnified
   C. Real inverted and magnified
   D. Real erect and magnified
3. If the focal length of the objective of a telescope is 50 cm and that of the eye piece is 2cm.Magnification is
   A. 20
   B. 25
   C. 30
   D. None of the above

4. Resolving power of light microscope is
   A. 2mm
   B. 0.2 mm
   C. 0.1 mm
   D. 1mm
5. The minimum distance for the eye to focus any object is
   A. 10cm
   B. 25 cm
   C. 32cm
   D. 42 cm

Stretch Yourself

1. Why should the objective and the eye piece of a compound microscope have short focal length?
2. Derive an expression for the magnification of compound microscope?
3. State difference between refracting microscope and reflecting microscope?

Hint to Check Yourself

1 A 2A 3A 4A 5B