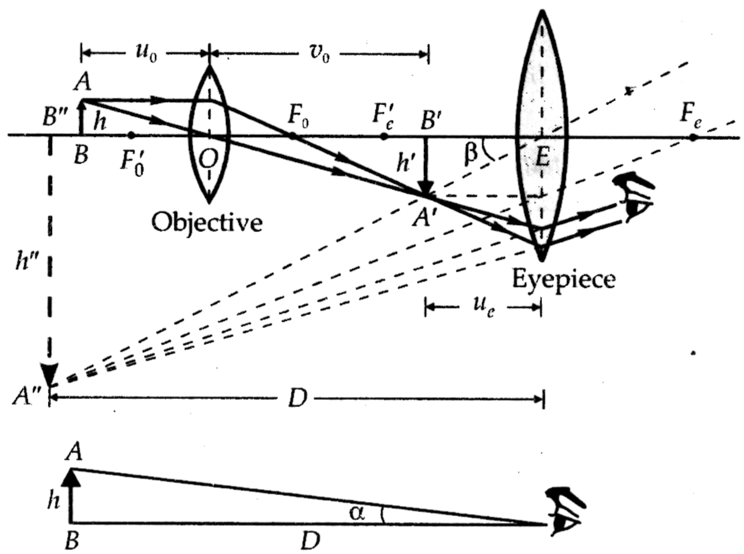
MONTFORT SCHOOL

XII CBSE: PHYSICS - Class Notes

Ray Optics and Optical Instruments: COMPOUND MICROSCOPE

- For much larger magnifications, one uses two lenses, one compounding the effect of the other. This is known as a *compound microscope*.
- The lens nearest the object, called the *objective*, forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the *eyepiece*, which functions essentially like a simple microscope or magnifier, produces the final image, which is enlarged and virtual.

(i) When the final image is formed at the least distance of distinct vision



Magnifying Power: The magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final virtual image to the angle subtended at the eye by the object, when both are at least distance of distinct vision from the eye.

$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} = \frac{h'/u_e}{h/D} = \frac{h'}{h}\cdot\frac{D}{u_e} = m_0 m_e$$

Here $m_0 = \frac{h'}{h} = \frac{v_o}{u_0}$

As the eyepiece acts as a simple microscope, so

$$m_e = \frac{D}{u_e} = 1 + \frac{D}{f_e} \quad \therefore \quad m = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$$

As the object AB is placed close to the focus F_0 of the objective, therefore,

$$u_0 \simeq -f_0$$

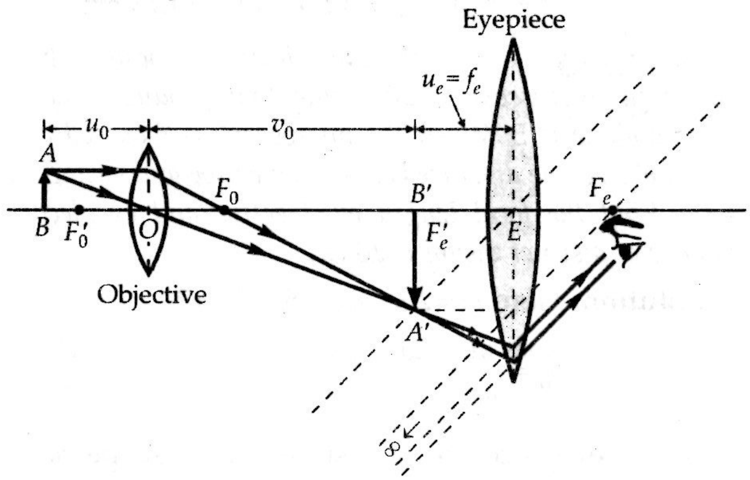
Also image $A'B'$ is formed close to the eyelens whose focal length is short, therefore $v_0 \simeq L =$ the length of the microscope tube or the distance between the two lenses

$$\therefore \quad m_0 = \frac{v_0}{u_0} = \frac{L}{-f_0}$$

$$\therefore \quad m = -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right) \quad \text{[for final image at } D\text{]}$$

(ii) When the final image is formed at infinity

The final image is formed at infinity if the image A'B' is formed at the focus of eye piece.



When the final is formed at infinity,

$$m_e = \frac{D}{f_e}$$

$$\therefore \qquad m = -\frac{L}{f_0} \times \frac{D}{f_e} \qquad \text{[For final image at } \infty\text{]}$$

Obviously, magnifying power of the compound microscope is large when both f_0 and f_e are small.

Numericals:

1. The magnification produced by the objective of a compound microscope is 8. If the magnifying power of the compound microscope be 32, then calculate the magnification produced by eye piece. [Ans: 4]
2. The focal lengths of the objective and eye-piece of a compound microscope are 4 cm and 6 cm respectively. If any object is placed at a distance of 6 cm from the objective, what is the magnification produced by the microscope? Distance of distinct vision = 25 cm. [Ans: 10.33]
3. A compound microscope is made using a lens of focal length 10 mm as objective and another lens of focal length 15 mm as eye piece. An object is held at 1.1 cm from the objective and final image is formed at infinity. Calculate the distance between objective and eyepiece. [Ans: 12.5 cm]

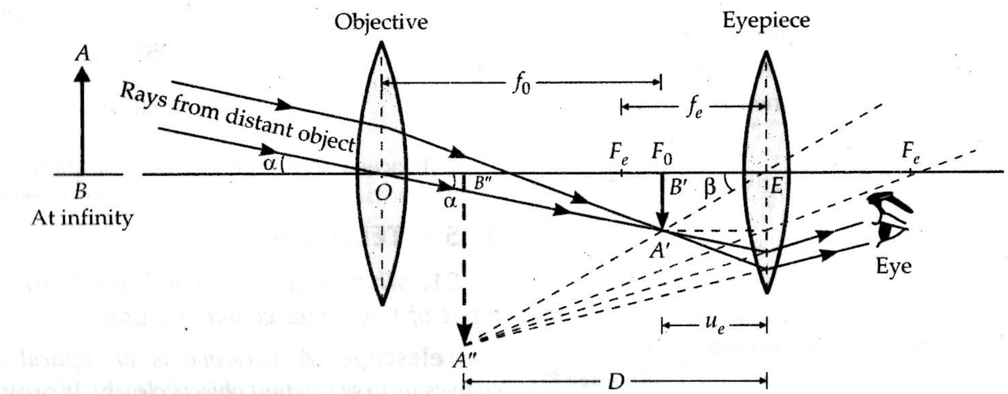
TELESCOPES

Telescope is an optical device which enables us to see distant objects clearly. Types are

1. Refracting type
   a. Astronomical Telescope
      To see heavenly object, image formed is inverted
   b. Terrestrial Telescope
      To see objects on the surface earth, image formed is erect
2. Reflecting type
   Make use of converging mirrors
   Eg. Newtonian and Cassegrain Telescopes

(a)Astronomical Telescopes:

(i) When the final image is formed at the least distance of distinct vision



Magnifying Power: The magnifying power of a telescope is defined as the ratio of the angle subtended at the eye by the final image formed at the least distance of distinct vision to the angle subtended at the eye by the object at infinity, when seen directly.

As the object is very far off, the angle subtended by it at the eye is practically equal to the angle α subtended by it at the objective. Thus

$$\angle A'OB' = \alpha$$

Also, let $\angle A''EB'' = \beta$

∴ Magnifying power,

$$m = \frac{\beta}{\alpha} \simeq \frac{\tan\beta}{\tan\alpha} \qquad [\because \alpha, \beta \text{ are small}]$$

$$= \frac{A'B'/B'E}{A'B'/OB'} = \frac{OB'}{B'E}.$$

According to the new Cartesian sign convention,

$OB' = + f_0$ = focal length of the objective

$B'E = - u_e$ = distance of $A'B'$ from the eyepiece, acting as an object for it

$$\therefore \quad m = -\frac{f_0}{u_e}$$

Again, for the eyepiece :

$$u = - u_e \text{ and } v = - D$$

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

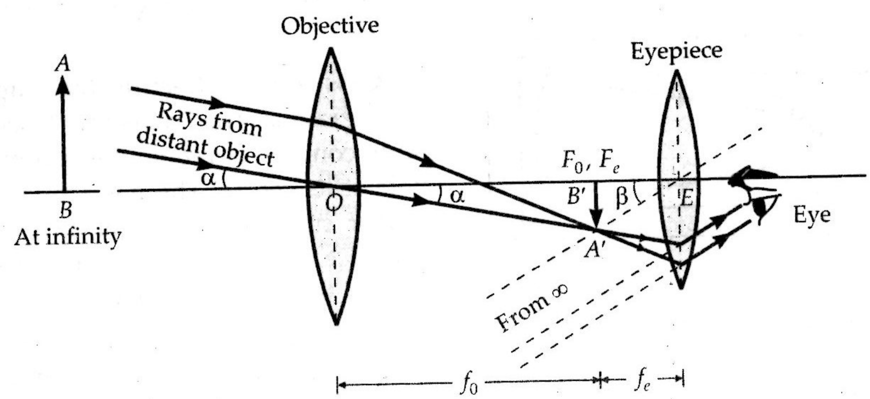
$\therefore \quad \frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{f_e}$

or $\quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} = \frac{1}{f_e}\left(1 + \frac{f_e}{D}\right)$

Hence $\quad m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

Clearly for large magnifying power, $f_0 >> f_e$. The negative sign for the magnifying power indicates that the final image formed is *real* and *inverted*.

(ii) When the final image is formed at infinity



As the object is very far off, the angle subtended by it at the eye is practically equal to the angle α subtended by it at the objective.

Thus

$\angle A'OB' = \alpha$

and let $\quad \angle A'EB' = \beta$

$\therefore$ Magnifying power,

$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} \quad [\because \alpha, \beta \text{ are small angles}]$$

$$= \frac{A'B'/B'E}{A'B'/OB'} = \frac{OB'}{B'E}$$

Applying new Cartesian sign convention,

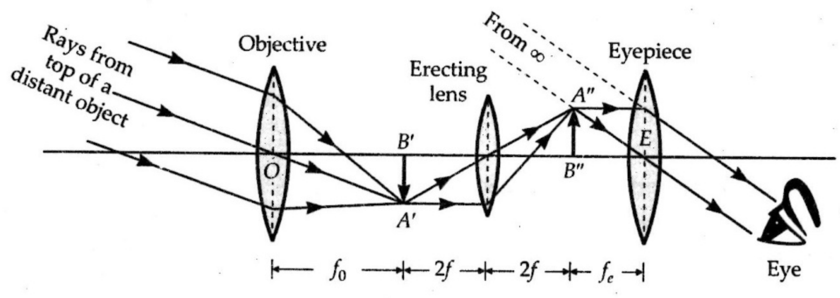
$OB' = +f_0 =$ Distance of $A'B$ from the objective along the incident light

$B'E = -f_e =$ Distance of $A'B'$ from the eyepiece *against* the incident light

$$\therefore \quad m = -\frac{f_0}{f_e}$$

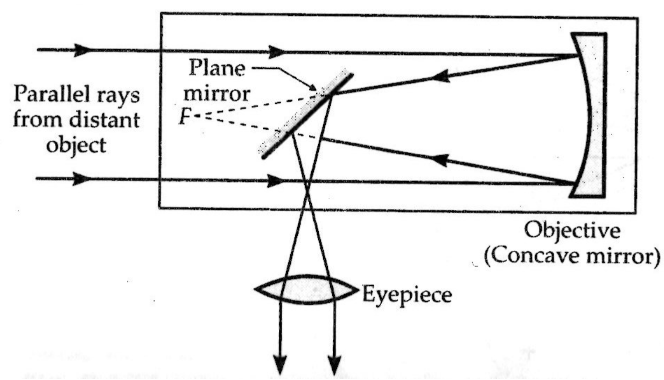
Clearly for large magnifying power, $f_0 >> f_e$. The negative sign for m indicates that the image is *real* and *inverted*.

(b) Terrestrial Telescope



2. Reflecting Telescopes

(a) Newtonian Telescope



(b) Cassegrain Telescope