Microscope.

It is an optical instrument used to see very small objects. Its magnifying power is given by

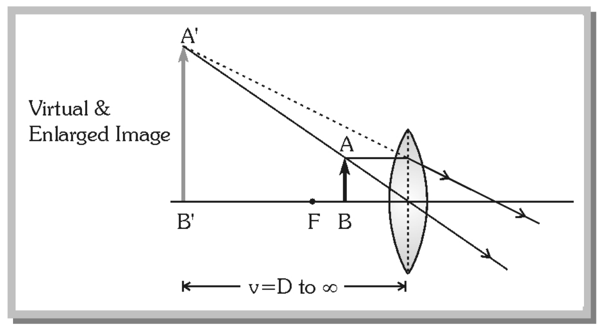
$$m = \frac{\text{Visual angle with instrument } (\beta)}{\text{Visual angle when object is placed at least distance of distinct vision } (\alpha)}$$

(1) Simple microscope

(i) It is a single convex lens of lesser focal length.

(ii) Also called magnifying glass or reading lens.

(iii) Magnification's, when final image is formed at D and ∞ (i.e. m_D and m_∞)



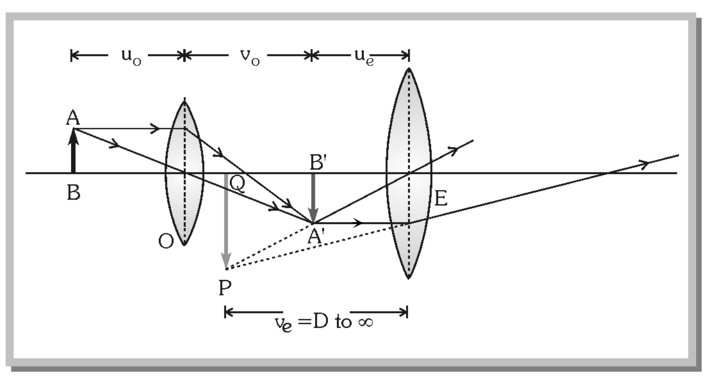
$$m_D = \left(1 + \frac{D}{f}\right)_{\max} \text{ and } \quad m_\infty = \left(\frac{D}{f}\right)_{\min}$$

Note: $m_{\max.} - m_{\min.} = 1$

If lens is kept at a distance a from the eye then $m_D = 1 + \frac{D-a}{f}$ and $m_\infty = \frac{D-a}{f}$

(2) Compound microscope

(i) Consist of two converging lenses called objective and eye lens.



(ii) $f_{\text{eye lens}} > f_{\text{objective}}$ and $(\text{diameter})_{\text{eye lens}} > (\text{diameter})_{\text{objective}}$

(iii) Final image is magnified, virtual and inverted.

(iv) $u_0 =$ Distance of object from objective (o), $v_0 =$ Distance of image $(A'B')$ formed by objective from objective, $u_e =$ Distance of $A'B'$ from eye lens, ve = Distance of final image from eye lens, f0 = Focal length of objective, fe = Focal length of eye lens.

Magnification: $$m_D = -\frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right) = -\frac{f_0}{(u_0-f_0)}\left(1+\frac{D}{f_e}\right) = -\frac{(v_0-f_0)}{f_0}\left(1+\frac{D}{f_e}\right)$$

$$m_\infty = -\frac{v_0}{u_0}.\frac{D}{F_e} = \frac{-f_0}{(u_0-f_0)}\left(\frac{D}{f_e}\right) = -\frac{(v_0-f_0)}{f_0}.\frac{D}{F_e}$$

Length of the tube (i.e. distance between two lenses)

When final image is formed at D; $$L_D = v_0 + u_e = \frac{u_0 f_0}{u_0 - f_0} + \frac{f_e D}{f_e + D}$$

When final images is formed at ∞ ; $$L_\infty = v_0 + f_e = \frac{u_0 f_0}{u_0 - f_0} + f_e$$

(Do not use sign convention while solving the problems)

Note: $$m_\infty = \frac{(L_\infty - f_0 - f_e)D}{f_0 f_e}$$

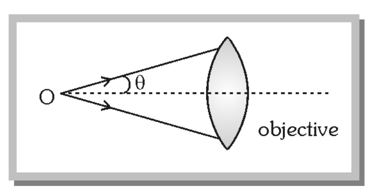
For maximum magnification both f_0 and f_e must be less.

$$m = m_{\text{objective}} \times m_{\text{eye lens}}$$

If objective and eye lens are interchanged, practically there is no change in magnification.

(3) Resolving limit and resolving power: In reference to a microscope, the minimum distance between two lines at which they are just distinct is called Resolving limit (RL) and its reciprocal is called Resolving power (RP)

$$R.L. = \frac{\lambda}{2\mu\sin\theta}$$ and $$R.P. = \frac{2\mu\sin\theta}{\lambda} \Rightarrow R.P. \propto \frac{1}{\lambda}$$



λ = Wavelength of light used to illuminate the object,

μ = Refractive index of the medium between object and objective,

θ = Half angle of the cone of light from the point object, $\mu\sin\theta$ = Numerical aperture.

Note: Electron microscope: electron beam $(\lambda \approx 1\mathring{A})$ is used in it so it's R.P. is approx. 5000 times more than that of ordinary microscope $(\lambda \approx 5000\ \mathring{A})$