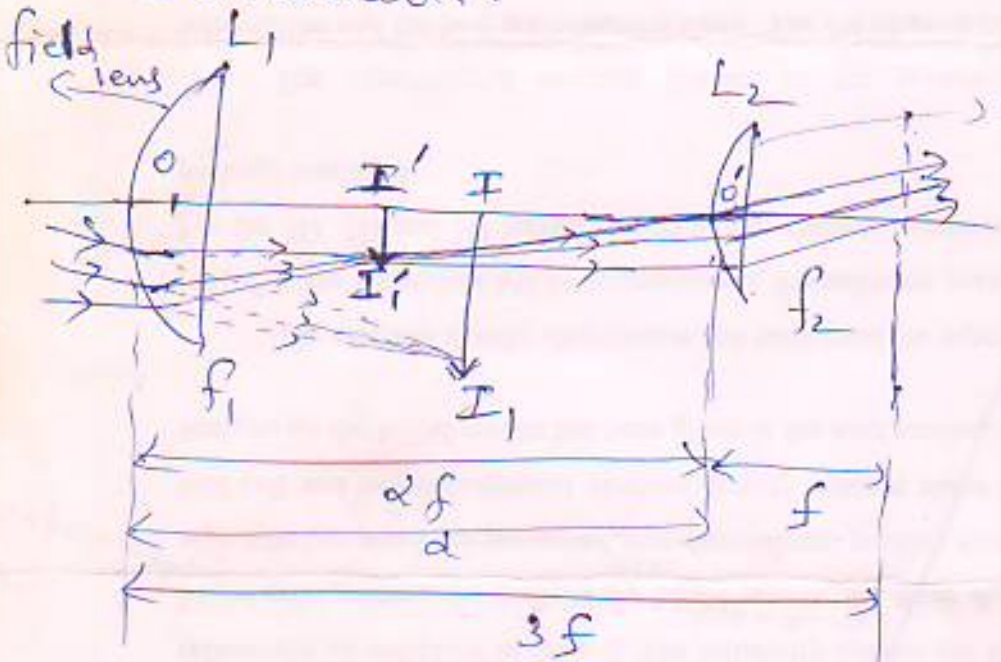
Huygens eyepiece

This is an achromatic eyepiece, in which chromatic aberrations are reduced to a minimum.

The Spherical aberrations are also eliminated.



This eye piece consists of two lenses with focal lengths in the ratio 3:1

The distance between the lenses is the difference in their focal lengths, That is $d = 3f - f = 2f$

The focal lengths are such that the deviation produced by one lens cancels the deviation produced by the other lens.

The field lens has a focal length f_1
The eye lens " " " " f_2.
They are placed at a distance d apart.
∴ The focal length of the combined lens is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Differentiating,

$$-\frac{dF}{F^2} = -\frac{df_1}{f_1^2} - \frac{df_2}{f_2^2} + d\left(\frac{df_1}{f_1^2 f_2} + \frac{df_2}{f_1 f_2^2}\right)$$

The dispersive power is given by

$$\omega = \frac{-dF}{F} = -\frac{df_1}{f_1} = -\frac{df_2}{f_2}$$

$$+\frac{dF}{F} = +\frac{df_1}{f_1} + \frac{df_2}{f_2} - d\left(\frac{df_1}{f_1 f_1 f_2} + \frac{df_2}{f_1 f_2 f_2}\right)$$

$$\frac{\omega}{F} = \frac{\omega}{f_1} + \frac{\omega}{f_2} - d\left(\frac{\omega}{f_1 f_2} + \frac{\omega}{f_1 f_2}\right)$$

$$\frac{\omega}{F} = \frac{\omega f_2 + \omega f_1 - 2\omega d}{f_1 f_2}$$

For achromatism $\frac{\omega}{F} = 0$

$$\frac{\omega f_2 + \omega f_1 - 2\omega d}{f_1 f_2} = 0$$

$$\omega f_2 + \omega f_1 - 2\omega d = 0$$

$$2\omega d = \omega f_1 + \omega f_2$$

$$\boxed{d = \frac{f_1 + f_2}{2}}$$

Also for equal deviation of a ray by the two lenses, the distance between the two lenses should be equal to $f_1 - f_2$.

∴ The focal lengths of the two lenses should be $3f$ and f

$$d = \frac{3f + f}{2} = 2f$$

Also, $3f - f = 2f$

$I I_1$ is the image of the distant object formed if the field lens is absent.

When the field lens is placed, the rays are refracted, and the image is formed at $I' I_1'$.

This image lies at the focus of eye lens so that the final image is seen at infinity (parallel out coming rays).

The focal length of the combination is

$$\frac{1}{F} = \frac{1}{f} + \frac{1}{3f} - \frac{2f}{f \cdot 3f}$$

$$\frac{1}{F} = \frac{1}{f} + \frac{1}{3f} - \frac{2}{3f}$$

$$= \frac{3+1-2}{3f} = \frac{2}{3f}$$

$$\boxed{F = \frac{3}{2} f}$$

Huygens eye piece is called negative eyepiece, because, the real inverted image lies behind the field lens & this image acts as a virtual object for the eye lens.