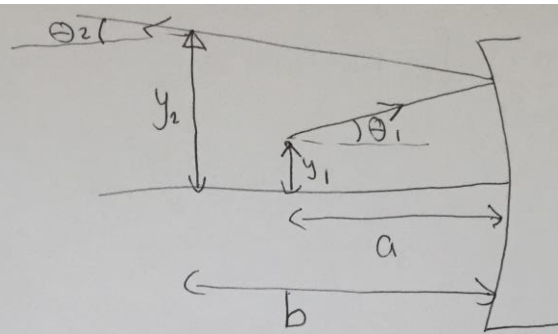


1

$$\begin{bmatrix} y_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1 & b \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \frac{2}{R} & 1 \end{bmatrix} \begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & b \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & a \\ \frac{2}{R} & \frac{2}{R}a+1 \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$$

$$= \begin{bmatrix} 1+\frac{2b}{R} & a+\frac{2}{R}ab+b \\ \frac{2}{R} & \frac{2}{R}a+1 \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$$

$$\begin{bmatrix} y_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1+\frac{b}{f} & a+b+\frac{ab}{f} \\ \frac{1}{f} & 1+\frac{a}{f} \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$$

In general

$$\begin{bmatrix} y_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix} = \begin{bmatrix} Ay_1 + B\theta_1 \\ Cy_1 + D\theta_1 \end{bmatrix}$$

To form an image at y_2, all rays should converge at y_2.

$\therefore$ y_2 is independent of θ_1

$B = 0$ [image formation condition]

if $a = d_o$; $b = d_i$

$\therefore$ $a + b + \frac{ab}{f} = 0 \Rightarrow d_o + d_i + \frac{d_o d_i}{f} = 0$

$$\frac{d_o d_i}{f} = -d_o - d_i$$

$$\boxed{\frac{1}{f} = -\frac{1}{d_i} - \frac{1}{d_o}}$$

M = Magnification $\equiv \dfrac{y_2}{y_1}$

for $B = 0 \Rightarrow A \equiv \dfrac{y_2}{y_1} = 1 + \dfrac{d_i}{f}$

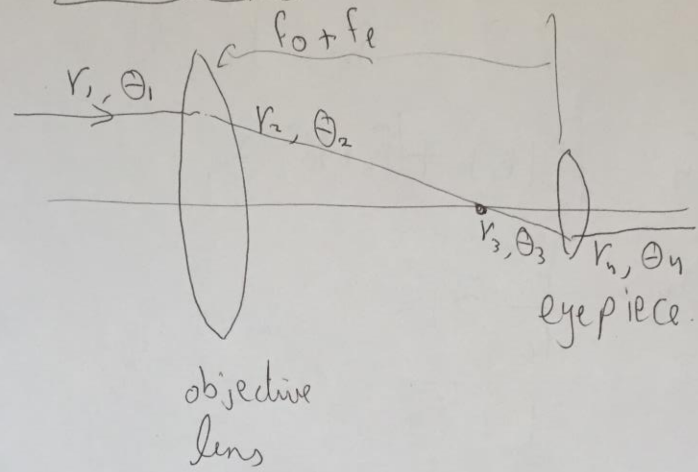
$= 1 + d_i\left(\dfrac{-1}{d_o} - \dfrac{1}{d_i}\right)$

$= 1 - \left(\dfrac{d_i}{d_o} + 1\right) = (-)\dfrac{d_i}{d_o}$

if d_i & d_o are $+$

this is inverted.

Telescope



1) refraction at Objective.

$$\begin{bmatrix} r_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_o} & 1 \end{bmatrix} \begin{bmatrix} r_1 \\ \theta_1 \end{bmatrix}$$

2) propagation through $f_o + f_e$

$$\begin{bmatrix} r_3 \\ \theta_3 \end{bmatrix} = \begin{bmatrix} 1 & f_e + f_o \\ 0 & 1 \end{bmatrix} \begin{bmatrix} r_2 \\ \theta_2 \end{bmatrix}$$

3) refraction at eyepiece

$$\begin{bmatrix} r_4 \\ \theta_4 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_e} & 1 \end{bmatrix} \begin{bmatrix} r_3 \\ \theta_3 \end{bmatrix}$$

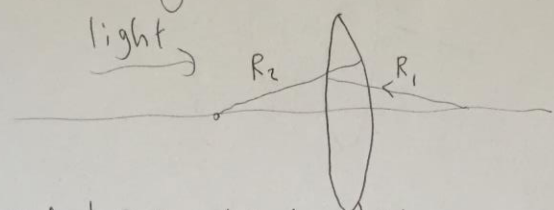
$$\begin{bmatrix} r_4 \\ \theta_4 \end{bmatrix} = \begin{bmatrix} -\frac{f_e}{f_o} & f_o + f_e \\ 0 & -\frac{f_o}{f_e} \end{bmatrix} \begin{bmatrix} r_1 \\ \theta_1 \end{bmatrix}$$

$$r_4 = -\frac{f_e}{f_o}(r_1) + (f_o + f_e)\,\theta_1$$

$$\boxed{\theta_4 = \left(-\frac{f_o}{f_e}\right)\theta_1}$$

angular magnification.

Focal length $f = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

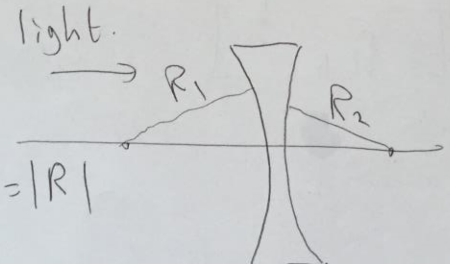


let $|R_1| = |R_2| = |R|$

$R_1 (+)$
$R_2 (-)$

$$f = (n-1)\left(\frac{1}{|R_1|} - - \frac{1}{|R_2|}\right)$$

$$f = (n-1)\left(\frac{2}{R}\right) = (+) \quad f > 0$$



$R_1 (-)$
$R_2 (+)$

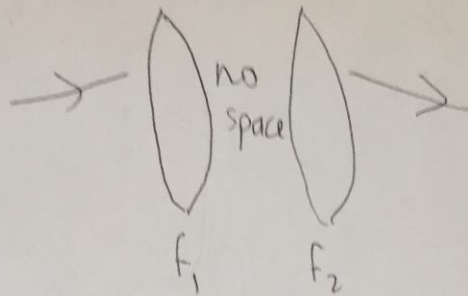
$|R_1| = |R_2| = |R|$

$$f = (n-1)\left(\frac{-1}{|R_1|} - \frac{1}{|R_2|}\right)$$

$$f = -(n-1)\left(\frac{1}{R}\right)$$

$f < 0$

Example:



$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_2} & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_1} & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_1} - \frac{1}{f_2} & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_{tot}} & 1 \end{bmatrix}$$