

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

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

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

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

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 .

$$B = 0 \quad \left[\begin{array}{l} \text{image formation} \\ \text{condition} \end{array} \right]$$

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

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

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

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

$$M = \text{Magnification} = \frac{y_2}{y_1}$$

(3)

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

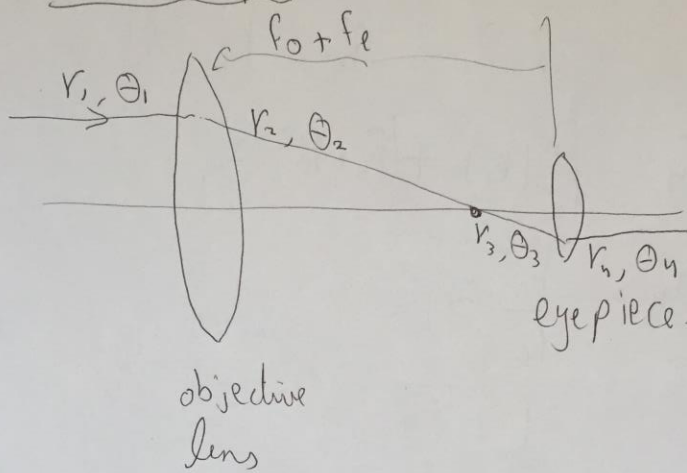
$$= 1 + d_i \left(-\frac{1}{d_o} \cdot \frac{1}{d_i} \right)$$

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

if d_i & d_o are +
this is inverted.

Telescope

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1) refraction at Objective:

$$\begin{bmatrix} r_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f_0} & 1 \end{bmatrix} \begin{bmatrix} r_1 \\ \theta_1 \end{bmatrix}$$

2) propagation through $f_0 + f_e$

$$\begin{bmatrix} r_3 \\ \theta_3 \end{bmatrix} = \begin{bmatrix} 1 & f_e + f_0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} r_2 \\ \theta_2 \end{bmatrix}$$

3) refraction at eyepiece

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

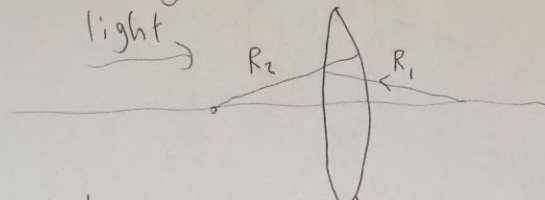
$$\begin{bmatrix} r_y \\ \theta_y \end{bmatrix} = \begin{bmatrix} -\frac{f_e}{f_o} & f_o + f_e \\ 0 & -\frac{f_o}{f_e} \end{bmatrix} \begin{bmatrix} r_i \\ \theta_i \end{bmatrix} \quad (5)$$

$$r_y = -\frac{f_e}{f_o} (r_i) + (f_o + f_e) \theta_i$$

$$\theta_y = \left(-\frac{f_o}{f_e} \right) \theta_i$$

↓
angular magnification.

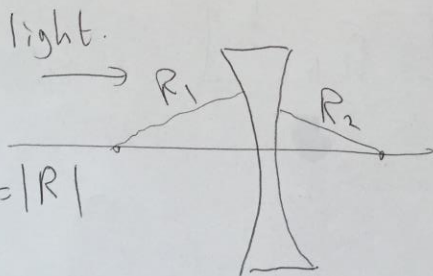
Focal length $f = (n-1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$ (6)



Let $|R_1| = |R_2| = |R|$ $R_1(+)$
 $R_2(-)$

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

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



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

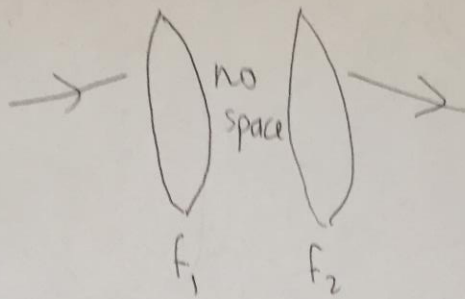
$R_1(-)$
 $R_2(+)$

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

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

Example:

(7)



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

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