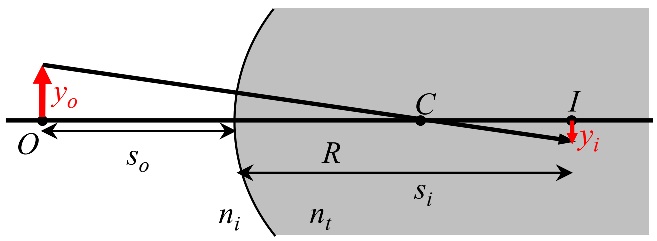
Spherical surface:

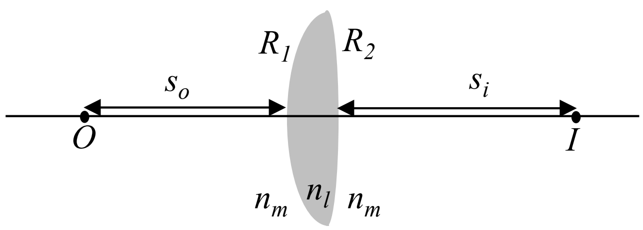


$$\frac{n_i}{s_o} + \frac{n_t}{s_i} = \frac{n_t - n_i}{R}$$

$$M_T \equiv \frac{y_i}{y_o} = -\frac{n_i s_i}{n_t s_o}$$

$$M_L \equiv \frac{ds_i}{ds_o} = -\frac{n_i s_i^2}{n_t s_o^2}$$

Thin Lens and spherical mirrors (symmetric medium):



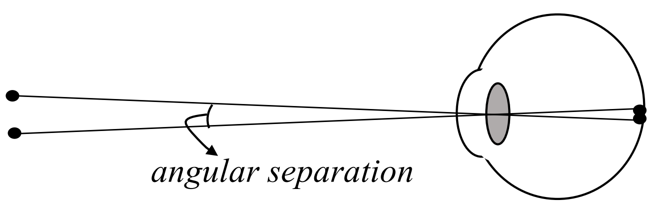
$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$M_T \equiv \frac{y_i}{y_o} = -\frac{s_i}{s_o}$$

$$M_L \equiv \frac{ds_i}{ds_o} = -\frac{s_i^2}{s_o^2}$$

Lensmakers' formula:

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{(n_l - n_m)}{n_m}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



Angular Resolution of the Eye: *the smallest angular separation of two points that can be resolved by the eye.*

Magnifying Power:

$$MP \equiv \frac{\alpha_{with\_aid}}{\alpha_{unaided}}$$

(α is the angle subtended at the eye)

Magnifying Glass:

$$MP_{s_i=\infty} = \frac{D}{f}$$

$$MP_{s_i=D} = \frac{D}{f} + 1$$

(D=25 cm is the near point of the human eye)

Microscope:

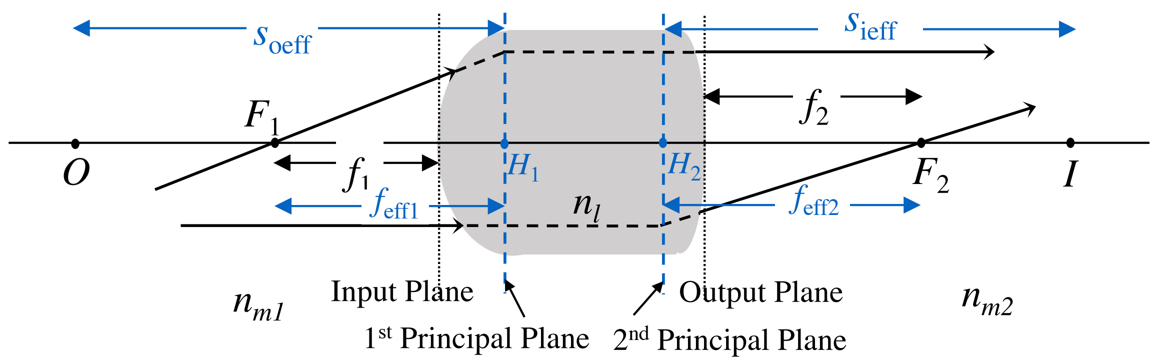
$$MP_{s_i=\infty} = -\left(\frac{L}{f_{obj}}\right)\left(\frac{D}{f_e}\right)$$

$$MP_{s_i=D} = -\left(\frac{L}{f_{obj}}\right)\left(\frac{D}{f_e} + 1\right)$$

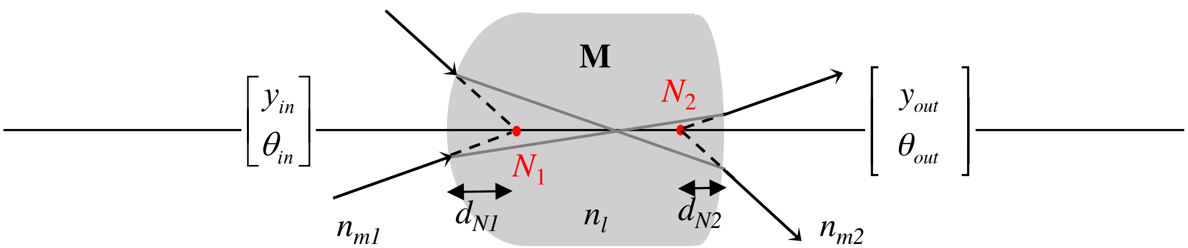
(L=16 cm is the tube length of the microscope)

Refractive Astronomical Telescope:

$$MP_{s_i=\infty} \equiv -\frac{f_o}{f_e}$$



$$\boxed{\frac{n_{m1}}{s_{oeff}} + \frac{n_{m2}}{s_{ieff}} = \frac{n_{m1}}{f_{eff1}} = \frac{n_{m2}}{f_{eff2}}}$$



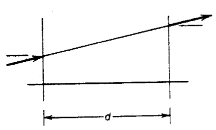
$$f_{eff1} = -\frac{n_{m1}/n_{m2}}{C}$$
$$f_{eff2} = -\frac{1}{C}$$

$$d_{H1} = \frac{D - n_{m1}/n_{m2}}{C}$$
$$d_{H2} = \frac{A-1}{C}$$

$$d_{N1} = \frac{D-1}{C}$$
$$d_{N2} = \frac{A}{C} - \frac{n_{m1}/n_{m2}}{C}$$

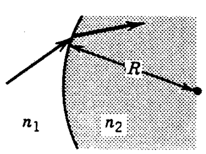
Matrices of Simple Optical Components

Propagation in homogeneous medium of thickness *d:*



$$\mathbf{M} = \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}$$

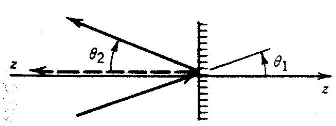
Refraction at spherical boundary:



$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ \frac{(n_1 - n_2)}{n_2 R} & \frac{n_1}{n_2} \end{bmatrix}$$

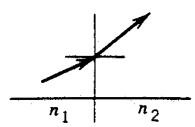
Convex R>0; Concave R<0

Reflection from a planar mirror:



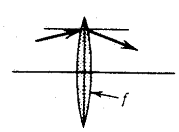
$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Refraction at planar boundary normal to the optical axis:



$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ 0 & \frac{n_1}{n_2} \end{bmatrix}$$

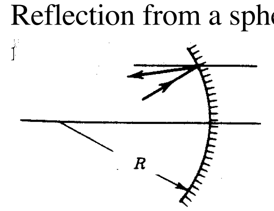
Transmission through a thin lens:



$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{bmatrix}$$

Convex *f*>0; Concave *f*<0

Reflection from a spherical



$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ -\frac{2}{R} & 1 \end{bmatrix}$$

Concave R>0; Convex R<0