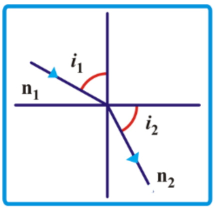
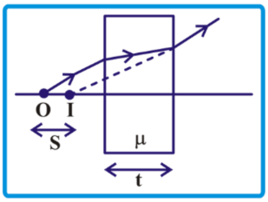
Geometrical Optics – III

Refraction

1. $n_1 \sin i_1 = n_2 \sin i_2$ Snell's Law.
2. $n = \frac{v}{c}$ refractive index.
3. $n = A + \frac{B}{\lambda^2}$ Cauchy's formulae



Plane Glass Slab



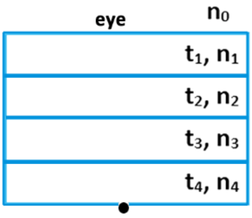
Emergent ray is parallel to incident ray.

$$\text{Shift}(s) = t\left(1 - \frac{1}{\mu}\right)$$

For almost normal incidence.

Multiple Slabs

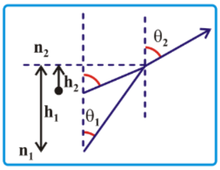
$$\frac{t}{n_0} = \frac{t_1}{n_1} + \frac{t_2}{n_2} + \frac{t_3}{n_3} + \frac{t_4}{n_4}$$



Refraction at Plane Surface

1. $\frac{h_1}{n_1} = \frac{h_2}{n_2}$

Apparent depth/height for almost normal incidence.

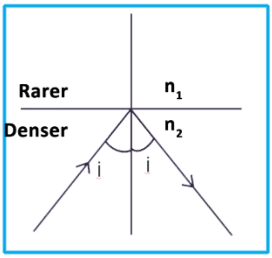


2. $h_1 \tan\theta_1 = h_2 \tan\theta_2$

TIR

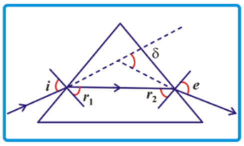
$\sin C = \frac{1}{n_{rel}}$

If i > C then TIR provided light is moving from Denser to rarer medium.



PRISM

$$\delta = i + e - A$$
$$A = r_1 + r_2$$



at minimum deviation

$$i = e$$
$$r_1 = r_2 = A/2$$

$$\delta_{min} = 2i - A$$

$$\mu = \frac{\sin\left(\frac{A + \delta_M}{2}\right)}{\sin\left(A/2\right)}$$

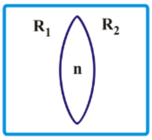
If A <<< then for small angle of incidence,

deviation $\delta = (n - 1)A$

Angle of dispersion $(\theta) = \delta_V - \delta_R$

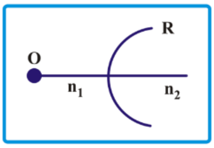
Lens Maker Formula

- $\frac{1}{f} = (n_{rel} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$



Refraction at Curved Surface

- $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$
- $m = \frac{\left(v/n_2\right)}{\left(\frac{u}{n_1}\right)}$



Thin Lens

- $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
- $m = \frac{v}{u} = \frac{h_I}{h_O}$
- $M_L = + m^2$
- $\frac{dv}{dt} = m^2 \frac{du}{dt}$ along the principal axis

where v, u are with respect to lens.

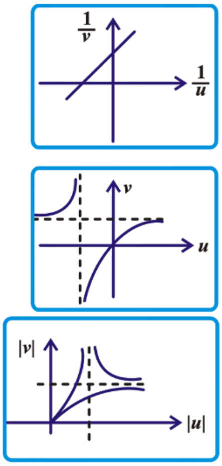
also dv/dt = v_i and du/dt = v_0 are

velocities with respect to lens.

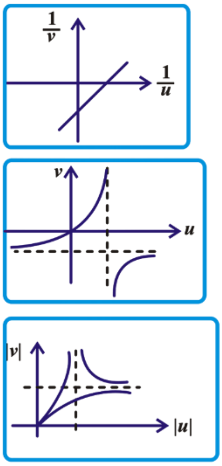
- **Power of a lens**

$$P = \frac{1}{f}$$

Convex Lens



Concave Lens



Combination of Lenses

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$\frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_L}$$

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

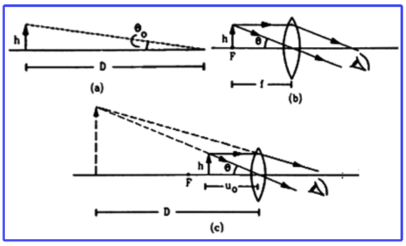
Two lenses separated by a distance d.

Position of equivalent lens in at $\frac{dF}{f_1}$ **from second lens.**

Optical Instruments

1. Simple Microscope

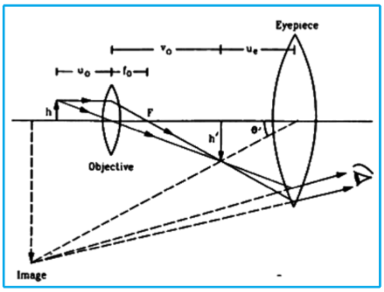
- $m = 1 + \frac{D}{f}$ Image at Near point
- $m = \frac{D}{f}$ Image at infinity (relaxed eye position)



Optical Instruments

2. Compound Microscope

- $m_0 = \frac{L}{f_0}$
- $m_e = 1 + \frac{D}{f_e}$ or $\frac{D}{f_e}$
- $m = m_0\, m_e$



Optical Instruments

3. Telescope

- $m = \frac{-f_0}{f_e}$
- $L = f_0 + f_e$
- $R = \frac{1}{\Delta\theta} = \frac{a}{1.22\,\lambda}$