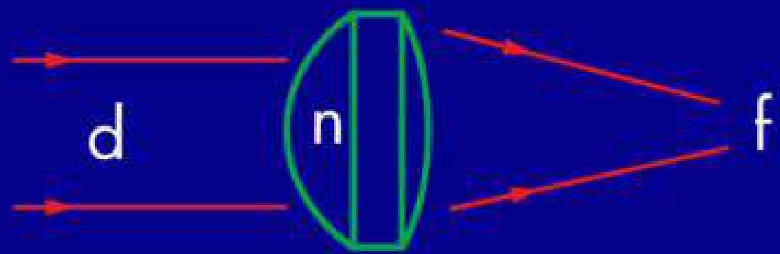
FOCUSING A LASER BEAM TO MINIMUM SPOT



ASSUMPTIONS

a. light is collimated

b. single lens: OFR BestForm type

1. Determine OPTIMUM FOCAL LENGTH, f_0

$$f_0 = C(d^4/\lambda)^{1/3} \qquad \lambda \text{ (mm)}$$

where C = 0.375 for n = 1.5

= 0.24   = 2.4

= 0.19   = 4.0

2. Determine BLUR CIRCLE Size

a. using OPTIMUM FOCAL LENGTH,

Blur Circle is either of the following:

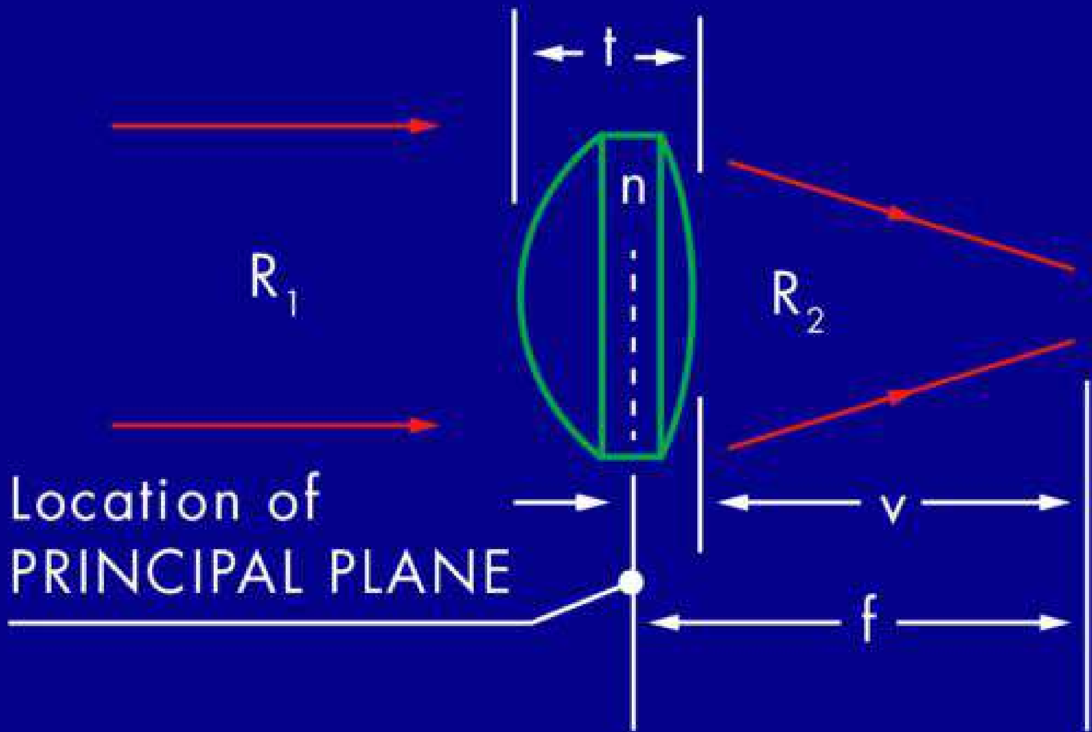
–or–

b. if not OPTIMUM FOCAL LENGTH,

Blur Circle is the LARGER of the following:

$$\frac{Kd_3}{f_2} \quad \text{or} \quad \frac{1.27\lambda f}{d} \qquad \lambda \text{ (mm)}$$

where K = 0.067 for n = 1.5
= 0.018 = 2.4
= 0.0087 = 4.0



1. $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{t(n-1)}{nR_1R_2}\right]$

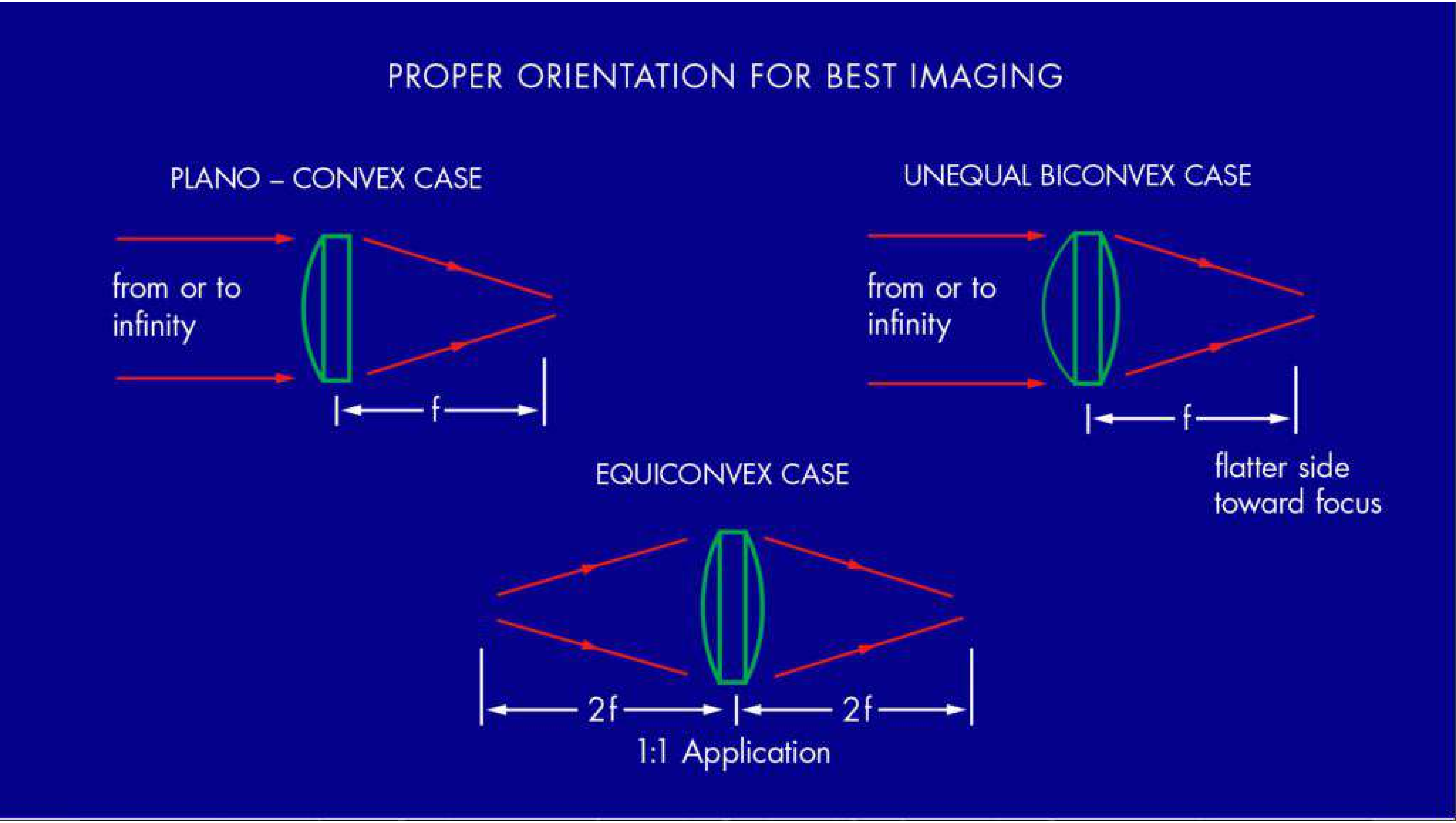
or if t << Diameter (1:6 or more)

1a. $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

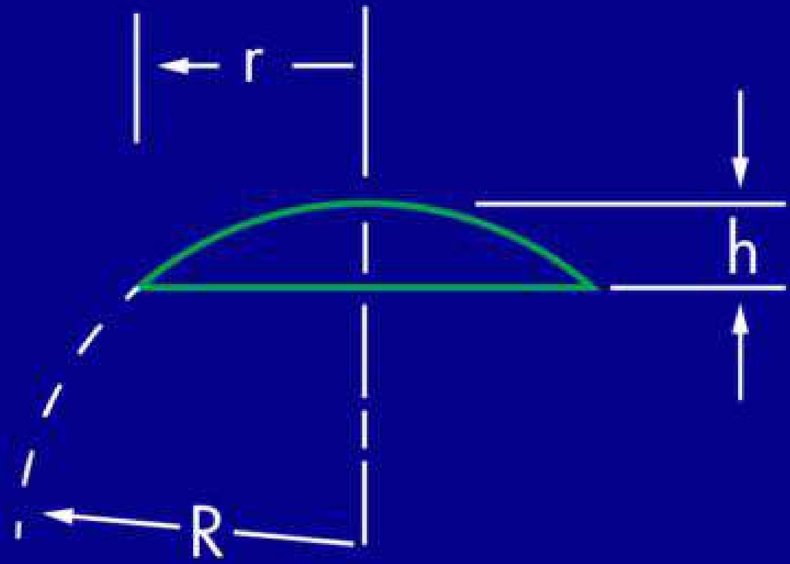
2. $v = f\left[1 - \frac{t(n-1)}{nR_1}\right]$

3. $p = -\frac{ft(n-1)}{nR_1}$

4. $f = \frac{vn+t}{n}$


PROPER ORIENTATION FOR BEST IMAGING
PLANO – CONVEX CASE
from or to infinity
f
UNEQUAL BICONVEX CASE
from or to infinity
f
flatter side toward focus
EQUICONVEX CASE
2f
2f
1:1 Application

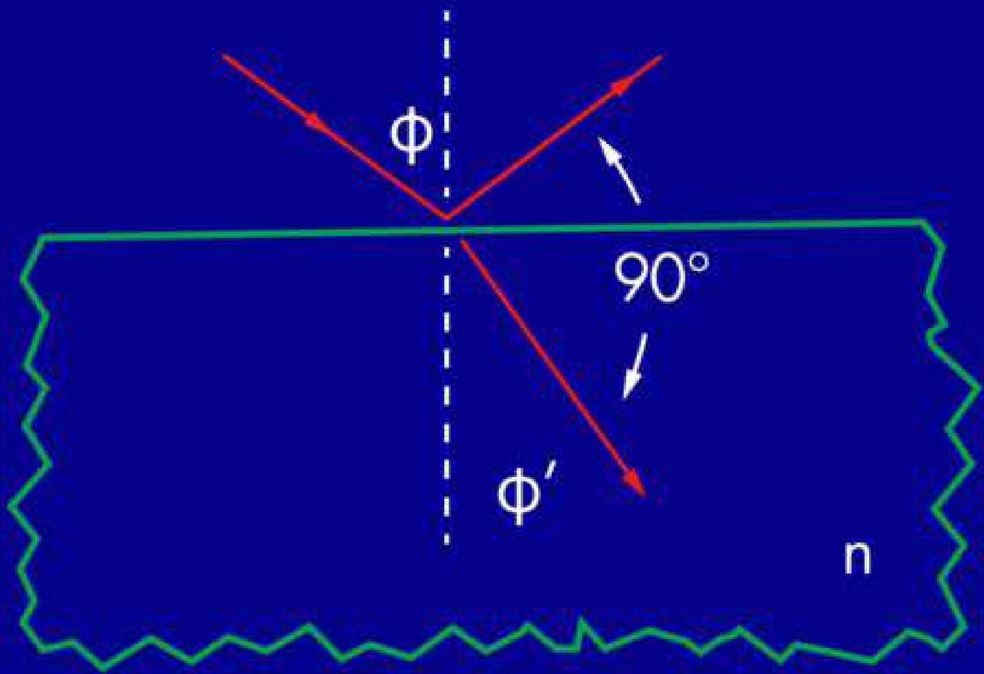
SAGITTAL HEIGHT OF SPHERICAL SURFACE



$$h = R - (R^2 - r^2)^{1/2}$$

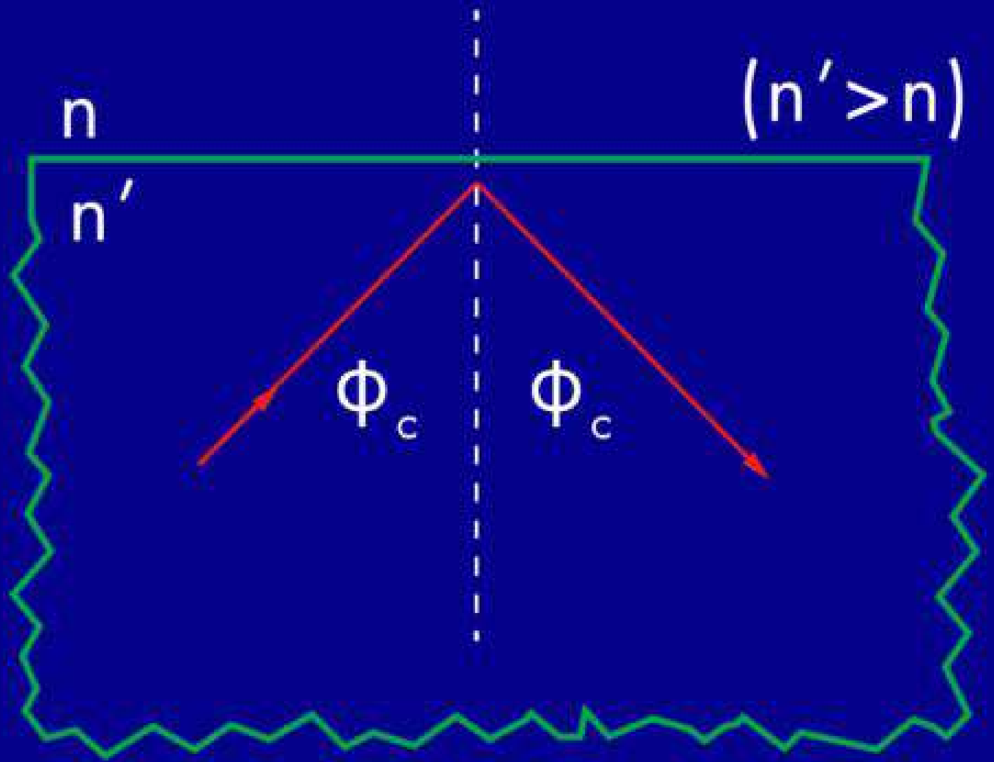
$$= R\left[1 - \cos\left(\sin^{-1}\frac{r}{R}\right)\right]$$

BREWSTER'S ANGLE



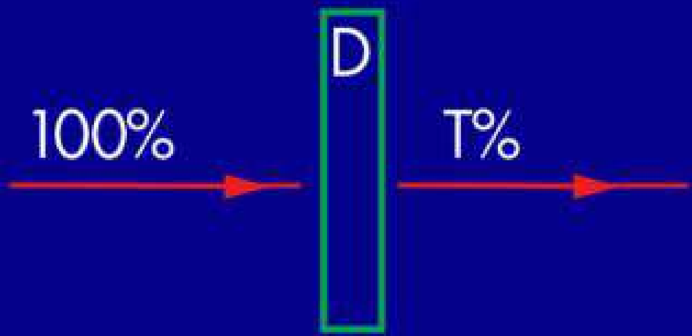
$$\phi = \tan^{-1} n$$

CRITICAL ANGLE FOR TOTAL INTERNAL REFLECTION



$$\sin \phi_c = \frac{n}{n'}$$

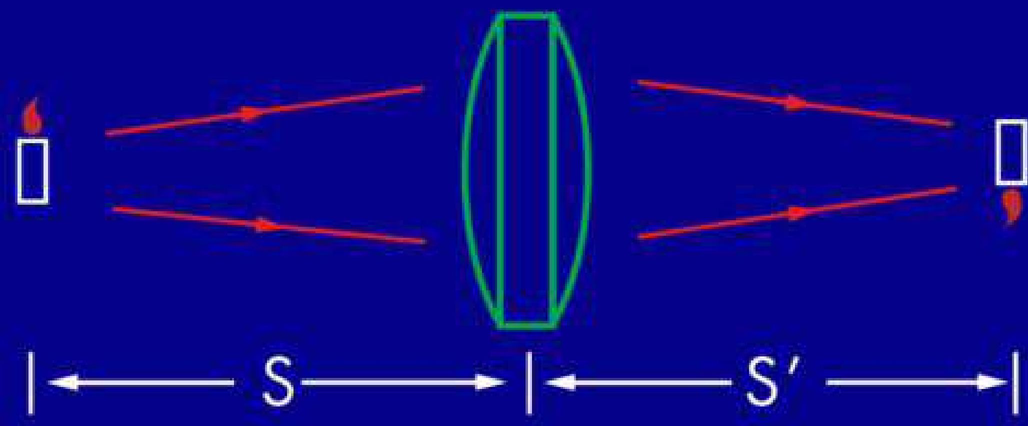
NEUTRAL FILTERS: DENSITY VS TRANSMITTANCE



$$D = \log_{10}\left(\frac{1}{T}\right)$$

$$T = (\log^{-1} D)^{-1} = (10^{D})^{-1}$$

OBJECT – IMAGE RELATIONSHIP



$$\frac{1}{f} = \frac{1}{S} + \frac{1}{S'}$$

$$\text{Magnification} = \frac{S'}{S}$$

PLANE OF INCIDENCE is the Plane containing the Rays of Light

TRANSMITTANCE OF PLANE – PARALLEL PLATE, INDEX = n

$$T = \frac{2n}{n^2+1}$$ assuming zero absorption

$$T = \frac{e^{-at}(1-R)^2}{1-R^2e^{-2at}}$$ includes both absorptive and reflective losses

t = Thickness
a = Absorption Coefficient

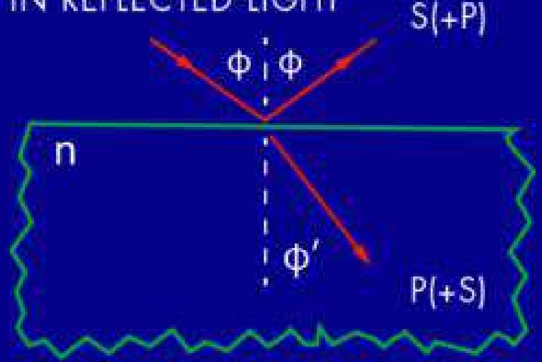
COMPONENTS OF POLARIZATION IN REFLECTED LIGHT

P-POLARIZATION...Plane of Polarization PARALLEL to Plane of Incidence

S-POLARIZATION...Plane of Polarization PERPENDICULAR to Plane of Incidence

For example, at 45°, transmittance or a zero-absorption thin plate is:

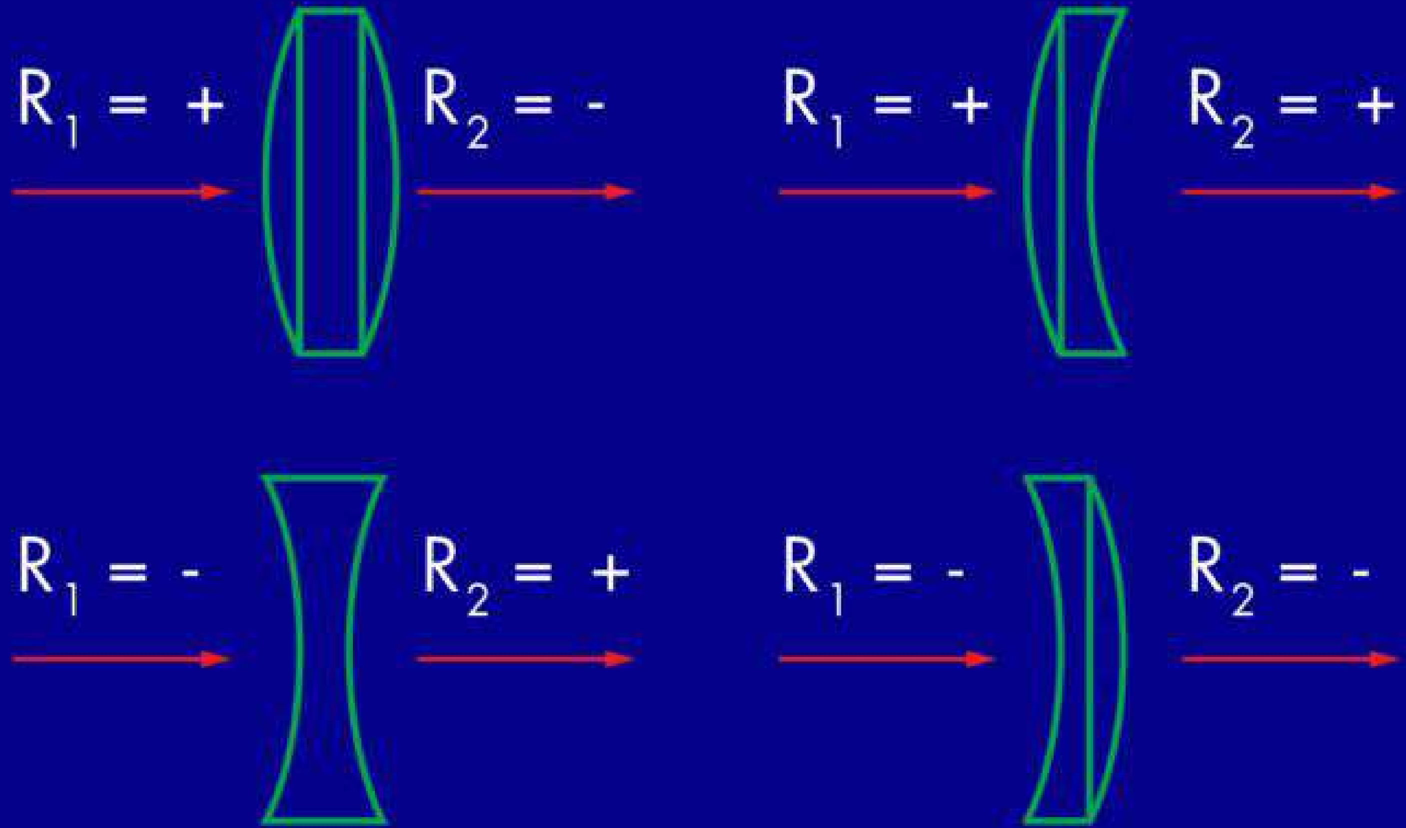
n =	1.517	1.7	4.0
=	0.825	0.757	0.348



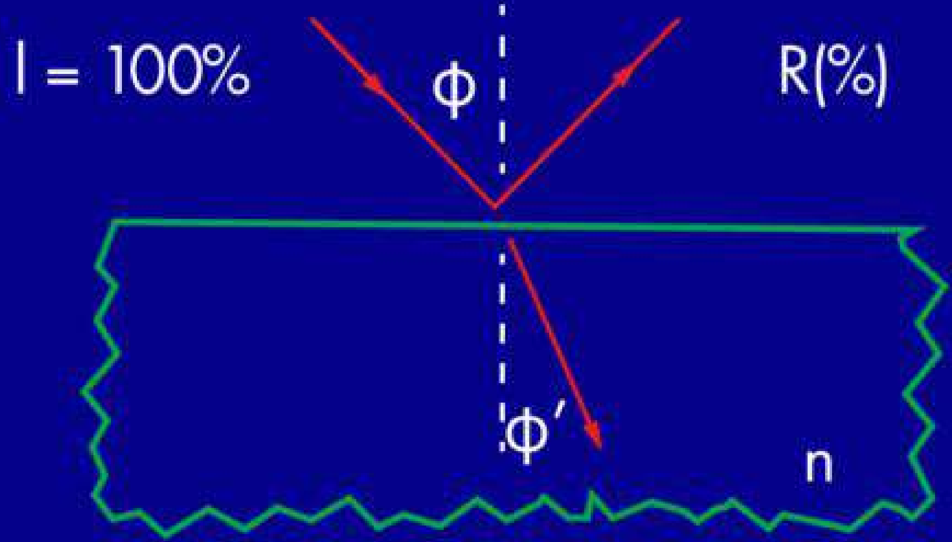
$$R_s = \frac{\sin^2(\phi-\phi')}{\sin^2(\phi+\phi')} \qquad R_p = \frac{\tan^2(\phi-\phi')}{\tan^2(\phi+\phi')}$$

RULES ON SIGNS

Light always travels from Left to Right



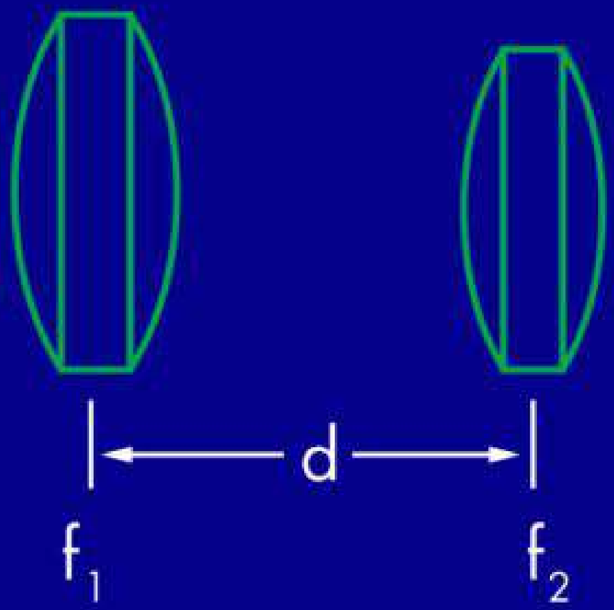
TOTAL REFLECTANCE



$$R = \frac{1}{2}\left[\frac{\sin^2(\phi - \phi')}{\sin^2(\phi + \phi')} + \frac{\tan^2(\phi - \phi')}{\tan^2(\phi + \phi')}\right]$$

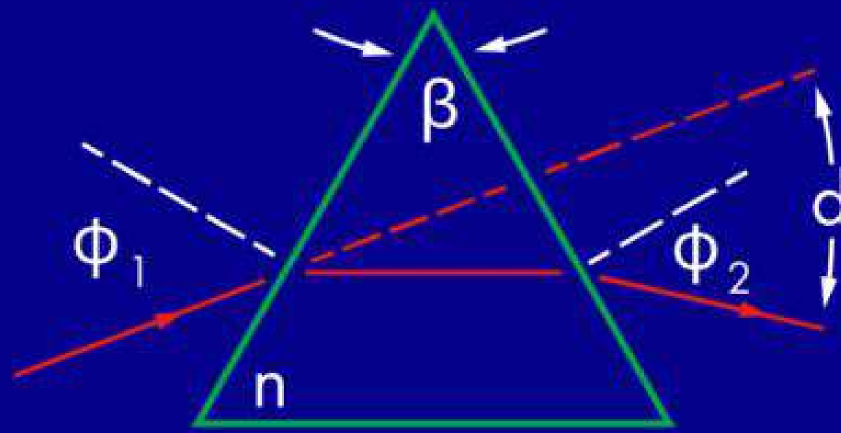
$$= \left(\frac{n-1}{n+1}\right)^2 \text{ when } \phi = 0°$$

TWO THIN LENSES



Resultant Focal Length $f_1 = \frac{f_1 f_2}{f_1 + f_2 - d}$

ANGULAR DISPLACEMENT THROUGH A PRISM

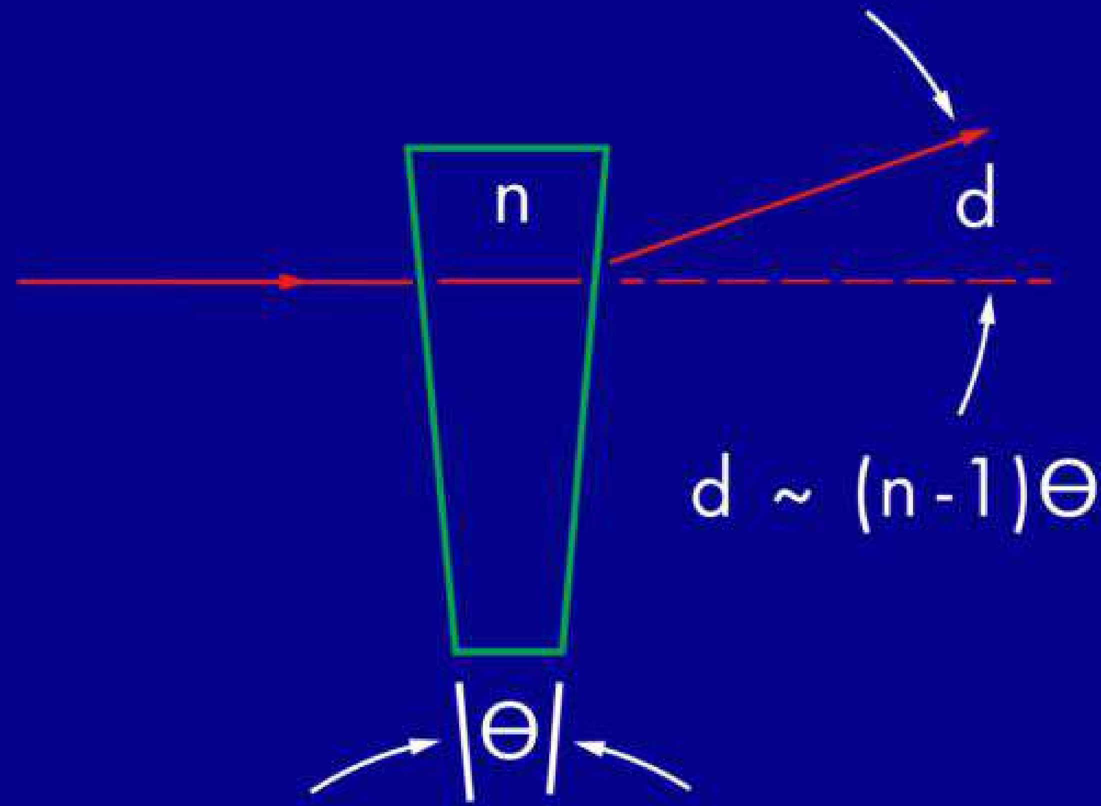


$$d = \phi_1 + \phi_2 - \beta$$

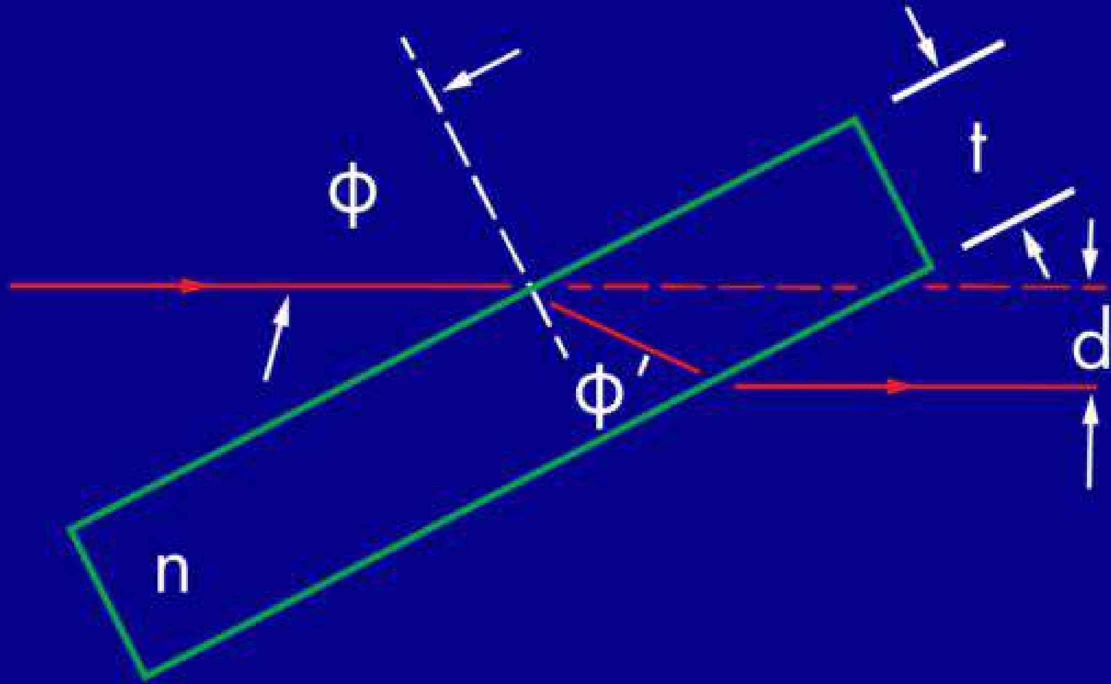
$$\phi_2 = \sin^{-1}[n \sin(\beta - \phi'_1)]$$

$$\text{where } \phi'_1 = \sin^{-1}[\tfrac{1}{n} \sin \phi'_1]$$

DEVIATION THROUGH SMALL WEDGE



DISPLACEMENT THROUGH PARALLEL PLATE



$$d = t \sin\phi \left(1 - \frac{\cos\phi}{n \cos\phi'}\right)$$

SNELL'S LAW