Module 4:
Lens Maker's Equation

Course 1 of *Optical Engineering*: First Order Optical System Design

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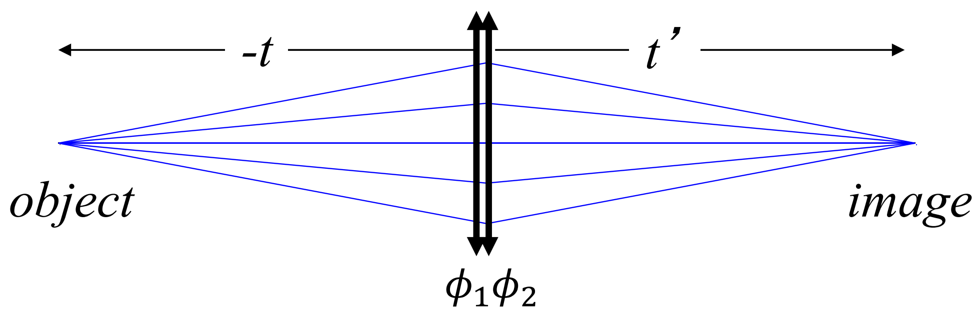
Two thin lenses in contact: First 2 lens formula

What is the equivalent focal length F of two thin lenses in contact?



Remember that the optical path length is

$$S \equiv \int_A^B n(\vec{r})\mathrm{d}s$$

So optical path lengths of contacted lenses just add

$$S_{tot} = S_1 + S_2$$
$$= -\frac{r^2}{2f_1} - \frac{r^2}{2f_2}$$
$$= -\frac{r^2}{2}\left(\frac{1}{f_1} + \frac{1}{f_2}\right)$$

Thus

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

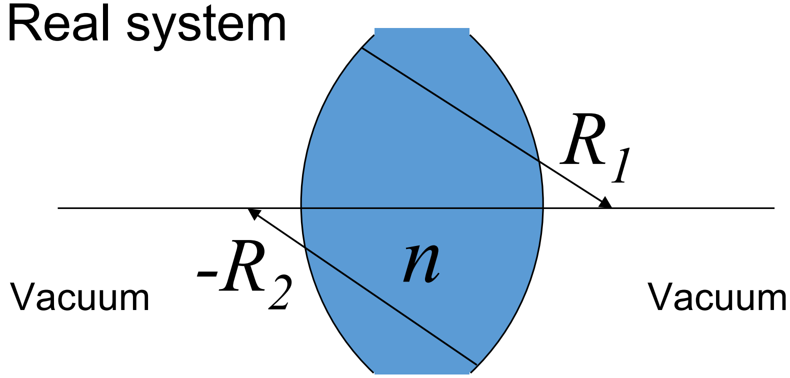
or

$$\boxed{\Phi = \phi_1 + \phi_2}$$

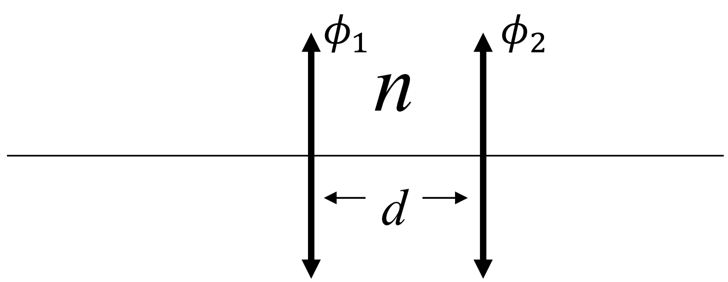
Powers add

Lens maker's equation: How to design singlet lenses

Real system



Equivalent thin lens system



Two thin surfaces separated by d

$$\Phi = \phi_1 + \phi_2 - \frac{d}{n}\phi_1\phi_2$$

We don't yet have the tools to derive this, so just accept it for now

$$= \frac{1}{R_1}(n-1) + \frac{1}{R_2}(1-n) + \frac{d}{n}\frac{1}{R_1 R_2}(n-1)^2$$

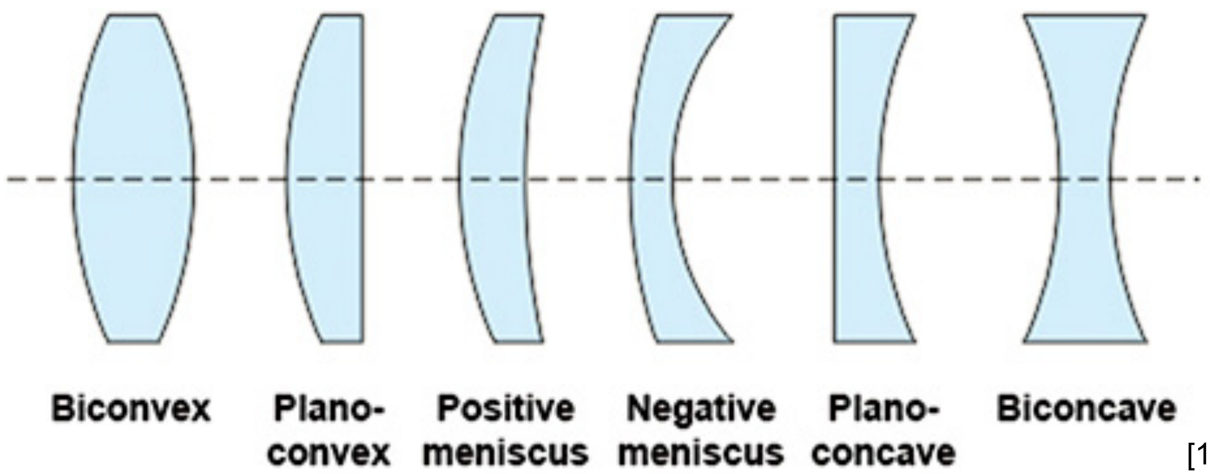
$$\boxed{= c_1(n-1) + c_2(1-n) + \frac{d}{n}c_1 c_2 (n-1)^2}$$

If d is << both R_1 and R_2

$$\Phi \approx (c_1 - c_2)(n-1)$$

Field guide to singlet lenses

Singlets are sufficiently common that it's worth giving all the possible combinations of surfaces and powers names



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