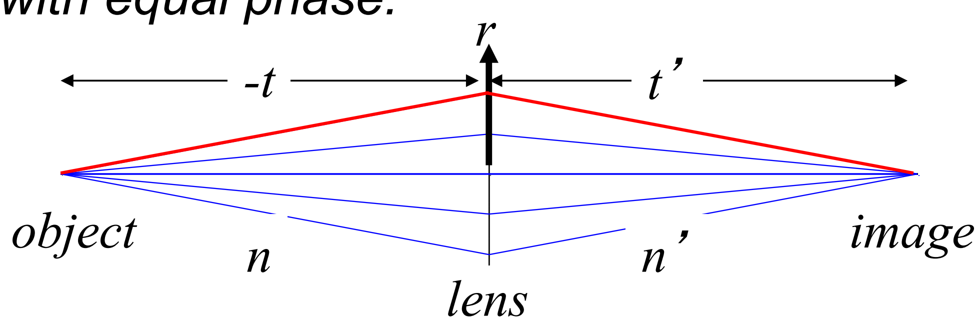
Module 4:
Optical Path Length of a Paraxial Lens

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

with **Dr. Robert R. McLeod and Dr. Amy C. Sullivan**

What is a lens? Paraxial thin lens via Fermat

Define a lens as a thin phase function that connects all the rays from object to image *with equal phase.*



OPL on axis = OPL off axis

$$-nt+n't'=n\sqrt{t^2+r^2}+n'\sqrt{t'^2+r^2}+S_{lens}(r)$$ Fermat's principle

$$\approx -nt-\frac{r^2}{2}\frac{n}{t}+n't'+\frac{r^2}{2}\frac{n'}{t'}+S_{lens}(r)$$ Binomial approx.

Solve for OPL of lens

$$\boxed{S_{lens}(r)=-\frac{r^2}{2}\left(-\frac{n}{t}+\frac{n'}{t'}\right)=-\frac{r^2}{2f}}$$

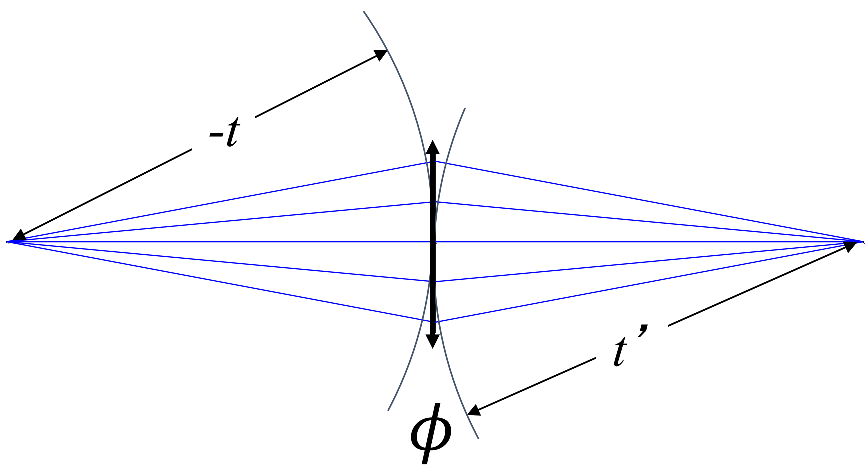
…using the Gaussian thin lens equation

$$\frac{1}{f}\equiv\phi=-\frac{n}{t}+\frac{n'}{t'}$$

Variables

f	Focal length of lens	[m]
$\phi=1/f$	Power of lens	[diopters]

What is a lens? Transforms wavefront curvature



The power of a lens is the algebraic increment in curvature added to the incident wavefront.

$$\frac{1}{t'} = \frac{1}{t} + \phi$$ In air