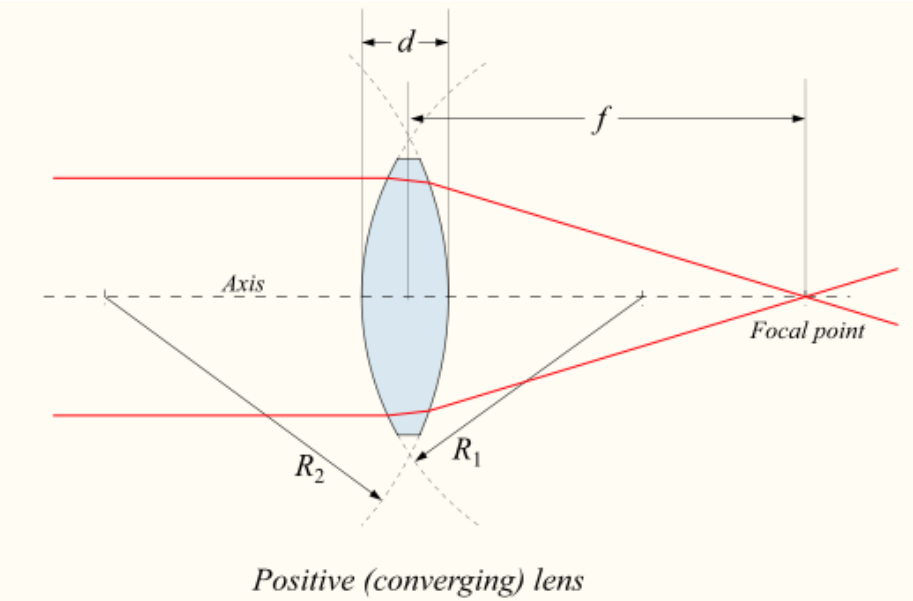
Thin Lens



Positive (converging) lens

Lens maker's formula

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

"Thin" lens➔ d is negligible

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

Paraxial approximation

$$\sin(\theta) \approx \tan(\theta) \approx \theta$$

$$\cos(\theta) \approx 1$$

See Hecht Ch. 5 and review the following Equations. Refer to lecture given on 9/14 for derivation of the following equations

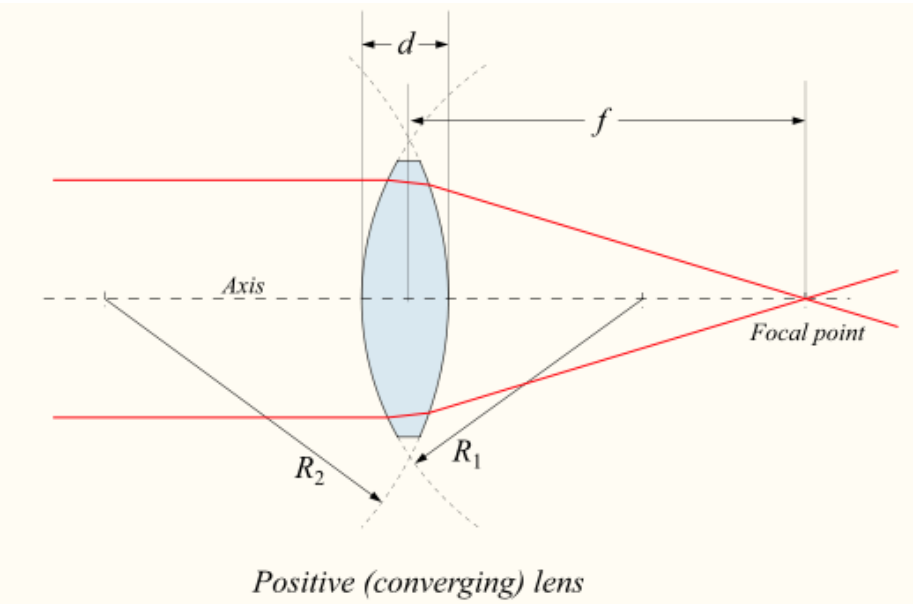
$$\frac{1}{f} = \frac{1}{s_0} + \frac{1}{s_i}$$

$$x_0 x_i = f^2$$

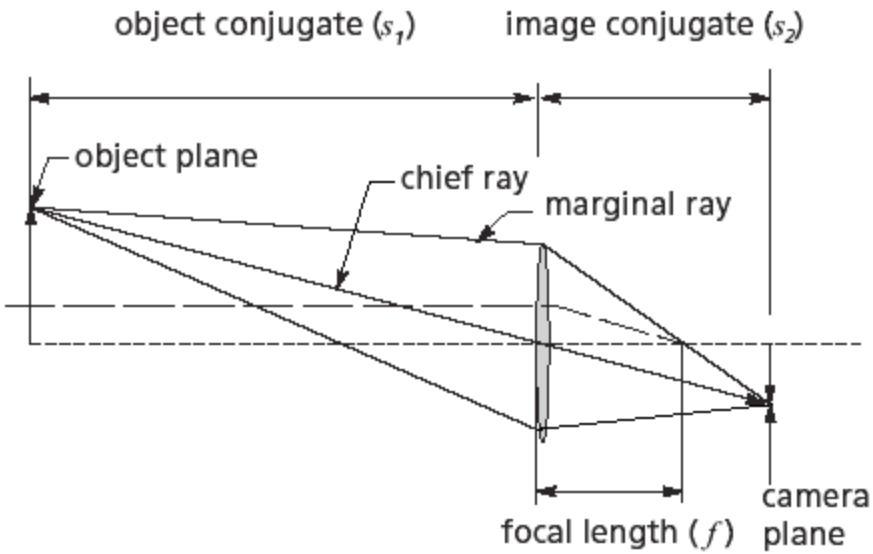
$$M_T \equiv \frac{y_i}{y_0} = -\frac{s_i}{s_o}$$

$$M_L \equiv \frac{dx_i}{dx_0} = -\frac{f^2}{x_0^2}$$

Thin Lens



Positive (converging) lens



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

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

$$\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2}$$

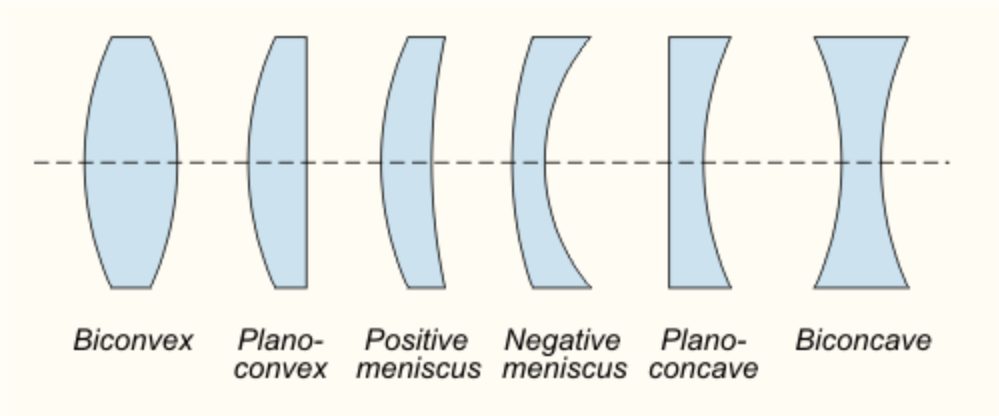
$$M_T = \frac{S_2}{S_1}$$

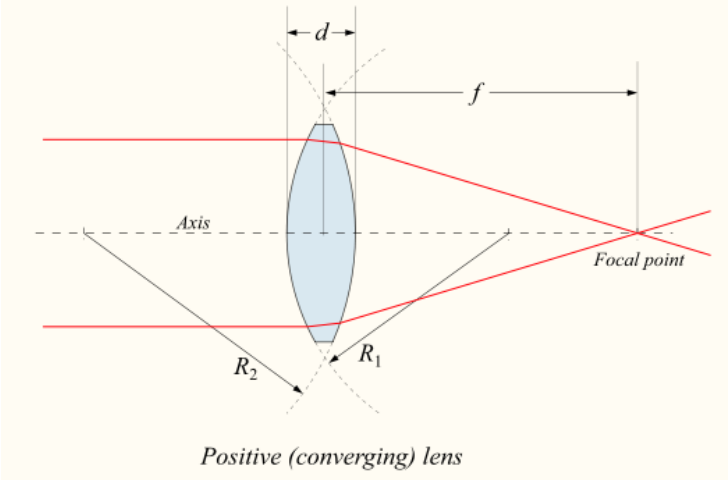
Simulation

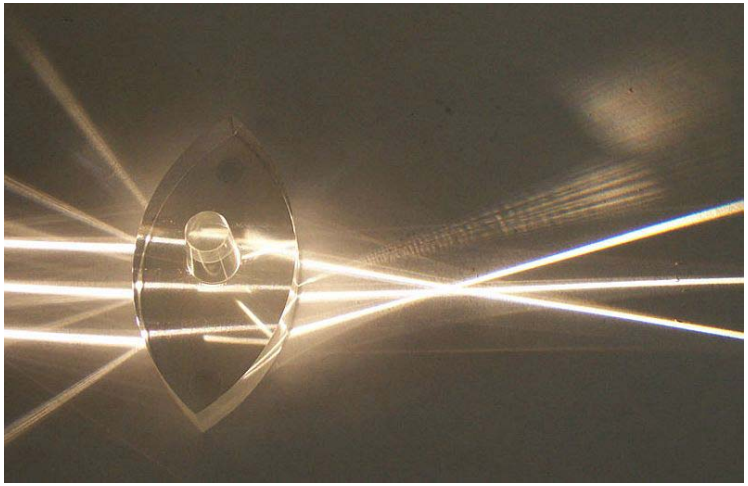
Thin Lens: link

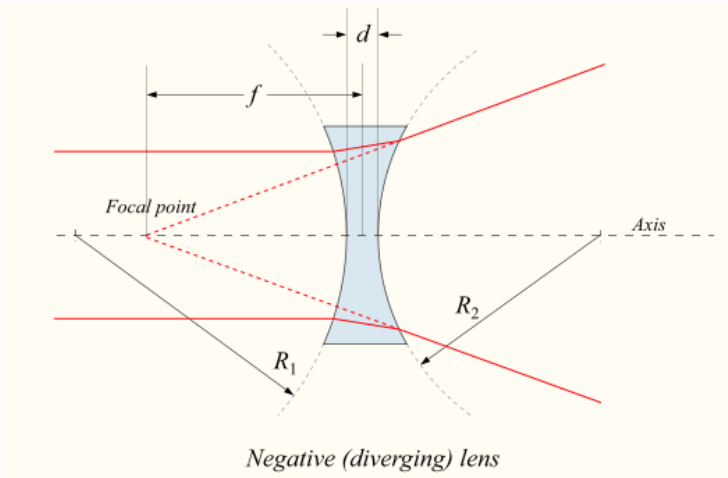
Thin lens combination:

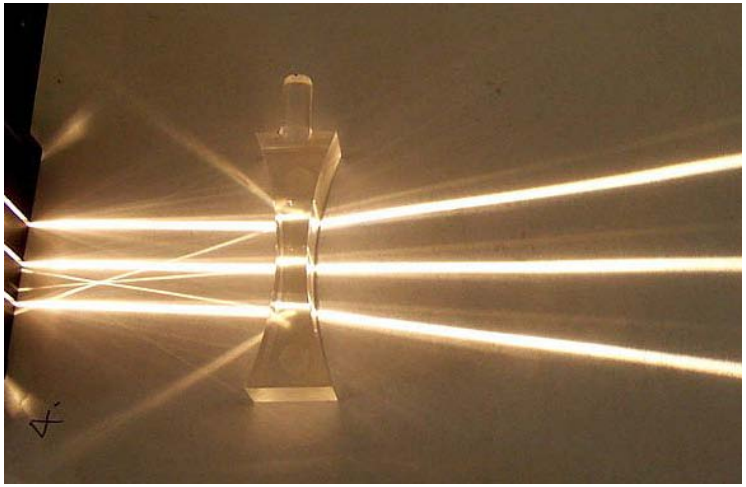
http://silver.neep.wisc.edu/~shock/tools/ray.html


Biconvex
Plano-convex
Positive meniscus
Negative meniscus
Plano-concave
Biconcave

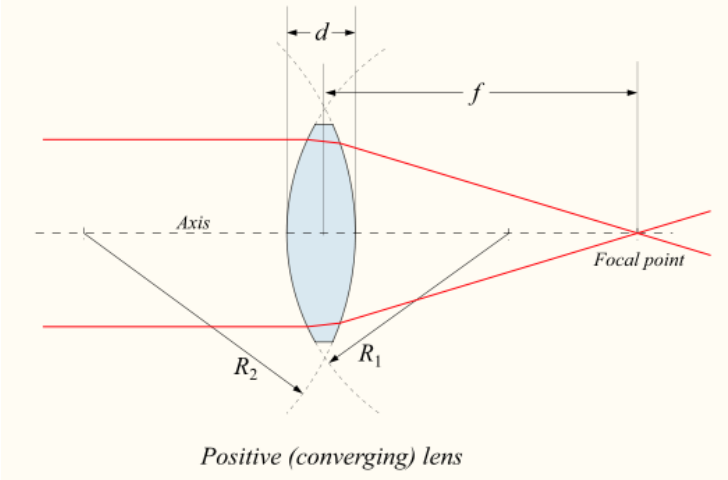

d
f
Axis
Focal point
R_2
R_1
Positive (converging) lens

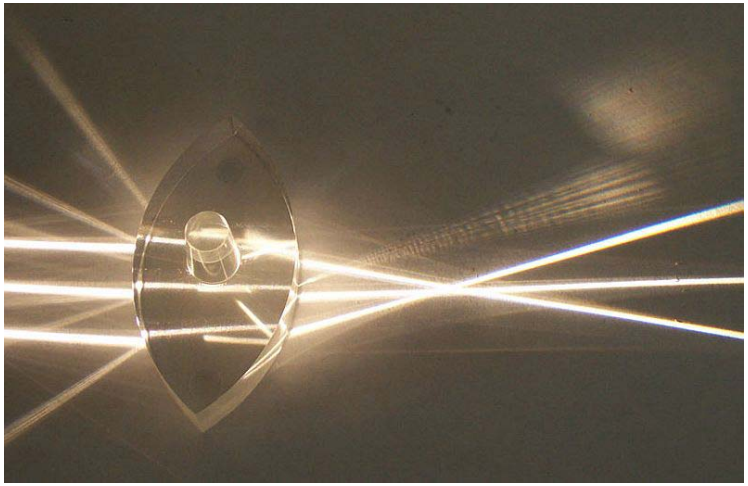


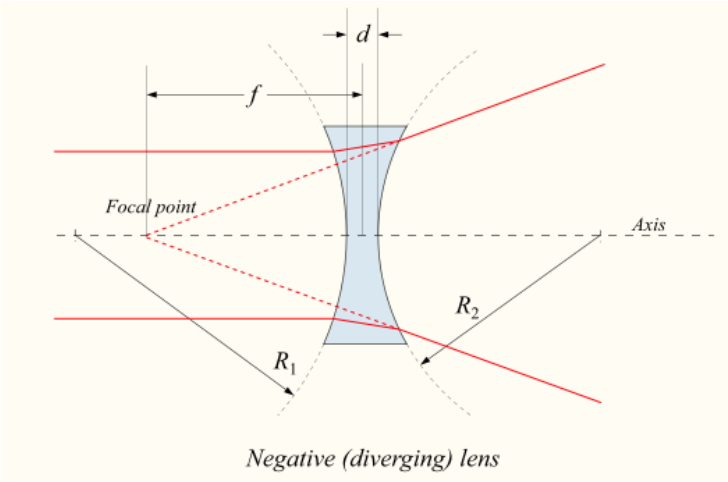

d
f
Focal point
Axis
R_2
R_1
Negative (diverging) lens

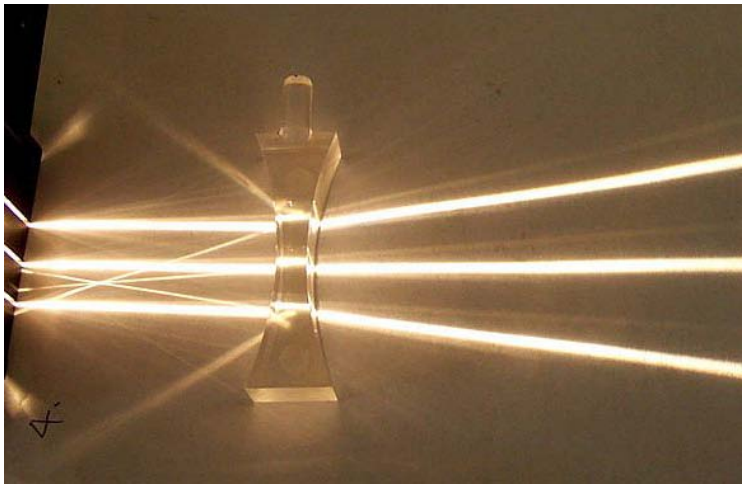


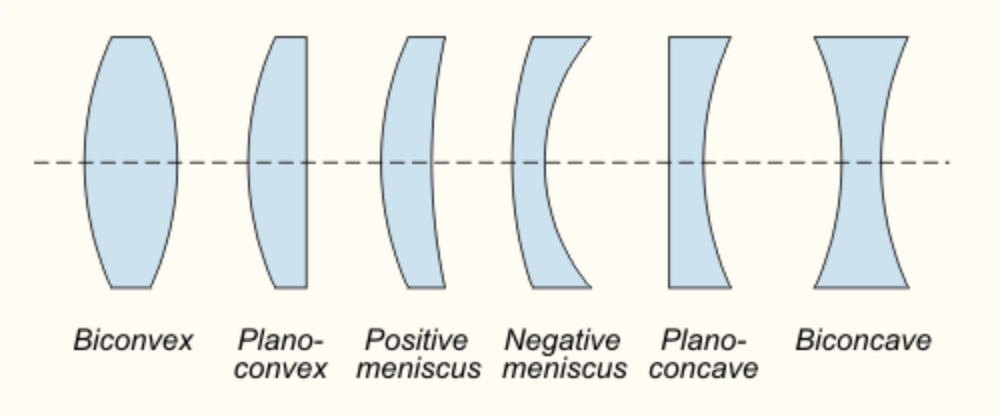
Converging and Diverging Lenses: Ray Diagrams





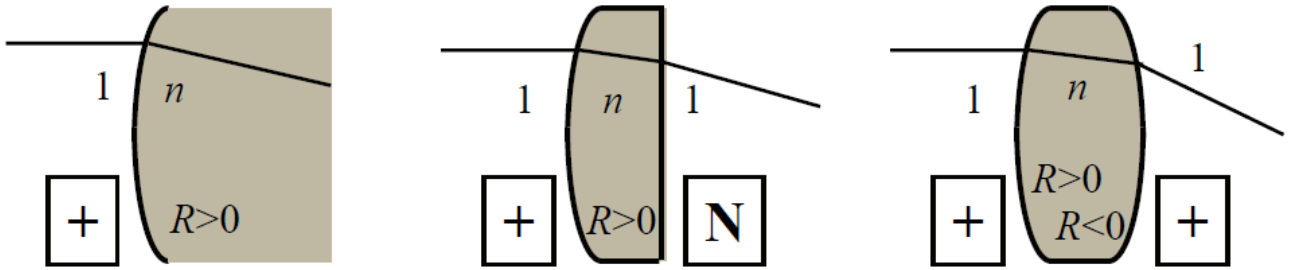






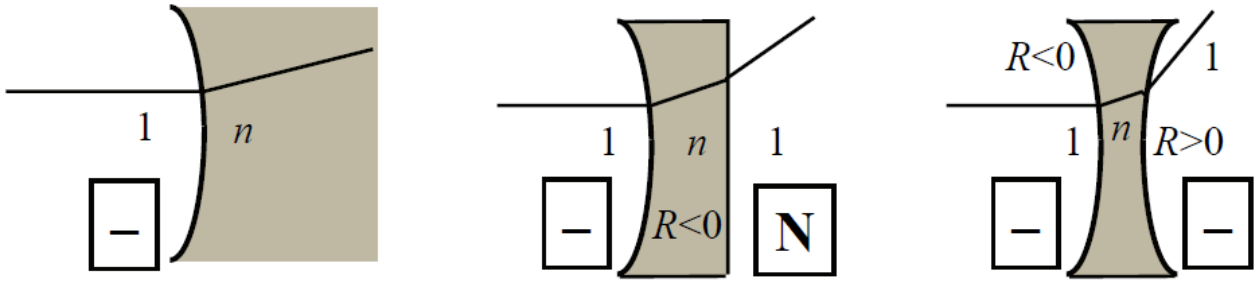
$$\frac{1}{f} \approx (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right].$$

Positive power : exiting rays converge



Simple spherical refractor (positive) | Plano-convex lens | Bi-convex lens

Negative power : exiting rays diverge



Simple spherical refractor (negative) | Plano-concave lens | Bi-concave lens

Summary : Real and Virtual Images

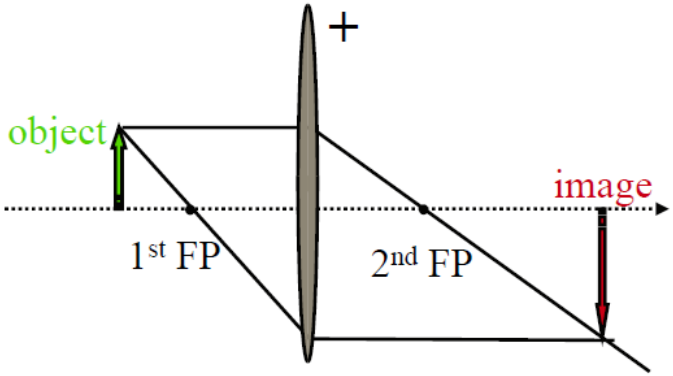


image: real & inverted; $M_T<0$

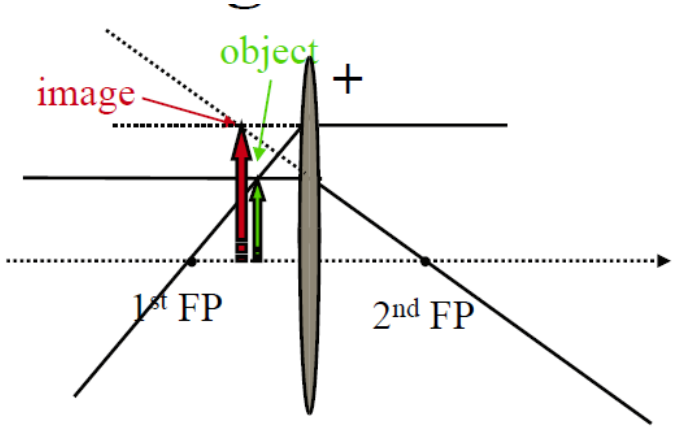


image: virtual & erect; $M_T>1$

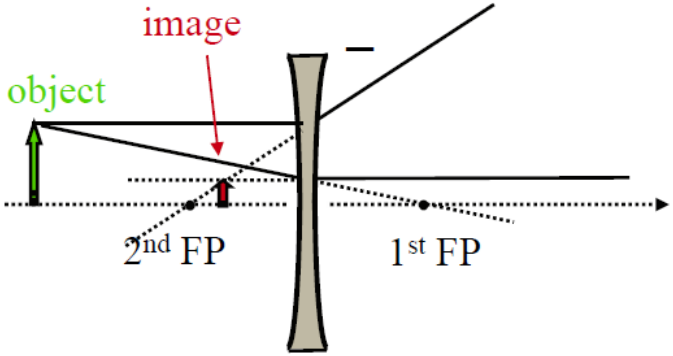


image: virtual & erect; $0<M_T<1$

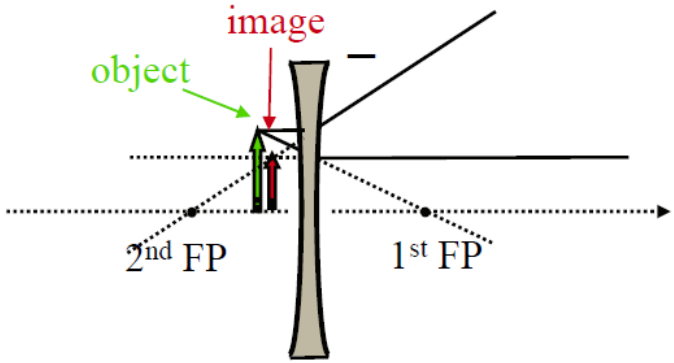


image: virtual & erect; $0<M_T<1$

Vendors for Optics, Optical Design Software

Optical design

–Code V

–**Oslo ➔ OSLO EDU**
http://www.lambdares.com/education/oslo_edu/

–Zemax

Optics & opto-mechanics

–Newport / New Focus

–Opto-Sigma

–Thorlabs

–Edmund Optics

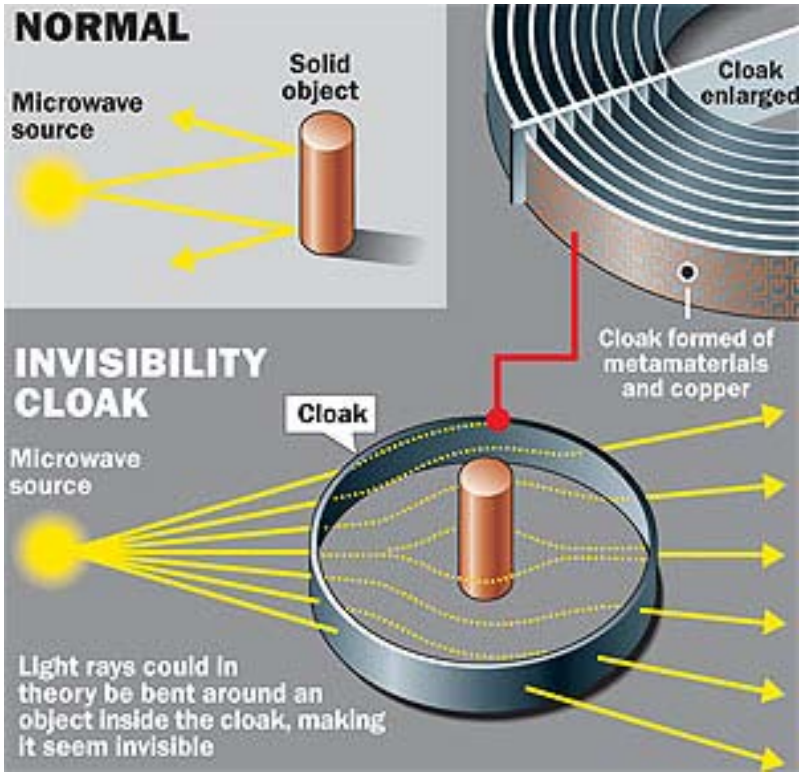
Transfer Matrix Method (not covered yet)

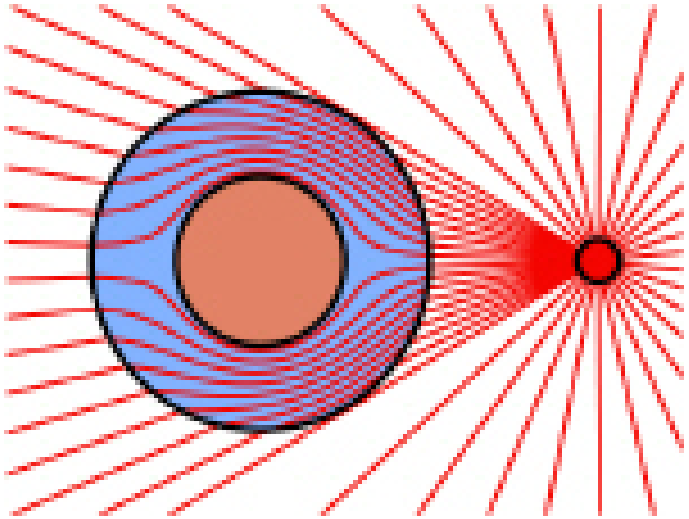
The ray transfer matrix method (ABCD matrix) is a commonly used method to deal with complicate multiple optical elements , see, for example:

http://en.wikipedia.org/wiki/Ray_transfer_matrix_analysis

We may cover this method if time permitted.

Invisible Cloaks?





Negative Refraction Resources

- http://en.wikipedia.org/wiki/Negative_refraction
- http://en.wikipedia.org/wiki/Metamaterial
- "Reversing Light: Negative Refraction", John Pendry and David Smith, Physics Today (Dec 2003).
- John Pendry's presentation slides
  - http://www.cleoconference.org/materials/07pendry.pdf