

Original provided by Linda Lundström
Revised and translated by Per Jansson
Tel: 08-5537 8212
Mail: per.jansson@biox.kth.se

Optical Physics: Summary Session 3

Geometrical optics

Thin lenses:

The following equations hold for imaging using a thin lens:

- Lens maker's formula (thickness $\rightarrow 0$): $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} = (n_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
 f is the focal length, s_o and s_i are the distances object - surface (positive if object in OS) and surface - image (positive if image in IS) and R is the radius of curvature of the surface (positive if center of curvature in IS)
- Thin lens surrounded by air: $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} = (n_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
 f = focal length
- Newton's formula: $x_o x_i = f^2$
 x_o and x_i are the distances from front focal plane to object and back focal plane to image
- Imaging using mirror: $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} = -\frac{2}{R}$
- Transverse magnification: $M_T = \frac{y_i}{y_o} = -\frac{s_i}{s_o}$
 y_o and y_i are the image and objective heights, respectively (positive if above optical axis)
- Longitudinal magnification: $M_L = \frac{dx_i}{dx_o} = -\frac{f^2}{x_o^2} = -M_T^2$

Stops and pupils:

An optical systems light gathering capability and imaging constraints are usually described by the following parameters:

- **Aperture stop, AS:** The lens or aperture that limits the bundle of rays emanating from an object on axis and at a given distance from the system. The ray from an object point that passes through the center of AS is called **chief ray**. The ray from an object point that passes through the edge of AS is called a **marginal ray**.
- **Field stop, FS:** The lens or aperture that, together with AS, limits the bundle of rays from an object above/below the axis at a given distance from the system. FS limits the size of objects that can be imaged through the system.
- **Entrance pupil, IP:** The image of AS seen from the object space. IP limits the light cone entering the system.
- **Exit pupil, UP:** The image of AS seen from the image space. UP limits the light cone exiting the system.

For object points above/under the optical axis, the AS in combination with FS can block more light than for objects on axis. This gives a reduced intensity for off axis image points. This phenomenon is called **Vignetting**.