

Imaging and Aberration Theory – Seminar 1

Exercise 1-1: Lagrange Invariant for Illumination Systems

An object with a diameter of 2.5 mm should be illuminated with a numerical aperture of $NA = 0.3$. If the aplanatic, corrected illumination system can accept a numerical aperture of $NA = 0.9$ of the light source, what is the minimum size of the radiating area of the lamp?

Exercise 1-2: Nonlinearity at a Single Plano-Convex Lens

Assume a parallel ray that is focused down by a plano-convex lens with a spherical rear surface (radius = R). The incidence angle at the rear surface is i . If the lens is turned around, the incidence angles at the front and the rear surface are approximately $i/2$ respectively. Compare the degree of nonlinearity due to exact law of refraction for these two configurations of the lens in the third-order-approximation. How can the well-known rule be understood to orientate the lens in the proper way for focussing?

Exercise 1-3: Paraxial Imaging at a Surface

Consider the refraction of a ray at the interface between two media n and n' in paraxial approximation (small incidence angles, close to the optical axis, negligible surface sag).

- a) Derive the *paraxial raytrace equation* for refraction at a spherical surface

$$n'u' = nu - yF, \quad (1)$$

where $F = (n' - n)/R$ is the power of the surface and the ray is parametrized by its height y and its angle u to the optical axis before and after the surface.

- b) Show that object and image locations s and s' are related by

$$\frac{n'}{s'} - \frac{n}{s} = F = \frac{n' - n}{R} \quad (2)$$

- c) Calculate the back- and the front-focal length f' and f of the system.

[Hint: Use the following sketch and apply the standard sign convention.]

