

ENEE 408E Optical System Design

Design Projects #1, 9/16/03

Due 9/25/03

- (1) A thick lens with $n = 1.55$ has $R_1 = 100$ mm, $R_2 = -140$ mm with $d = 30$ mm. Calculate the position of the principal planes and the paraxial focal length of the lens.
- (2) For the lens in question (1) write a computer program using Matlab, Mathcad, or whatever, to carry out exact ray tracing through the lens in a 2-D model. Make the lens aperture (the full diameter over which rays can enter) 20mm. Show a family of rays entering the lens traveling parallel to the axis and leaving through a blurred focus. Confirm that the focal length for rays near the axis agrees with the paraxial focal length calculated in question (1)

- (3) An optical system has

$$\begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} 3 & -4 \\ -0.5 & 1 \end{pmatrix}$$

Calculate:

- (i) the focal length
- (ii) the position of the principal planes
- (iii) the output ray parameters if $r_1 = 0.002$ m, $r'_1 = 2^\circ$.
- (iv) the input ray parameters if $r_2 = 0.003$ m, $r'_2 = 3^\circ$.
- (4) A ray with parameters r_1, r'_1 strikes a plane mirror. Determine a ray transfer matrix for the plane mirror that gives the ray parameters after reflection. Use your matrix to find the reflected ray parameters when $r_1=0.002$ m, $r'_1 = 3^\circ$
- (5) for question (3) part (iii) calculate the parameters of the ray when it returns to the input plane if a plane mirror is placed perpendicular to the axis and a distance of 10mm after the original output plane. Draw a diagram to illustrate your answer
- (6) A spherical surface of radius of curvature 200mm has air to the left and glass ($n=1.5$) to the right. A ray of light enters traveling from left to right. Where does it cross the axis? A ray of light traveling parallel to the axis enters traveling from right to left. Where does it cross the axis?
- (7) Where are the principal planes in question (6)?
- (8) A point source of light is placed 200mm from a concave mirror of radius of curvature 100mm. Calculate the blurring (spherical aberration) of the image at the paraxial image plane. The blurring is the diameter of the illuminated region at the paraxial image plane. Do an exact calculation using the precise geometry and Snell's law. Do not use the small angle approximation for the calculation of the blurring. The open aperture of the concave mirror is 75mm. This is the diameter of the mirror perpendicular to its axis.