Measuring Paraxial Properties of Lenses I

Background: Read Wyant's Paraxial Properties sections 1.1.3 and 1.2.3, Section 1.1 of the OPTI 515 notes, and Nofziger's Nodal Slide Notes on course website.

Introduction: The laboratory explores different methods of measuring the first order properties of lenses and optical systems. Three methods for measuring the radius of curvature of an optical surface will be examined. In addition, the cardinal points of a multi-element lens will be measured with a nodal slide.

1. **Geneva Gauge –** Make sure the Geneva gauge is calibrated by pressing it against a flat surface and verifying a zero reading. Next, measure an optical surface with a Geneva gauge. Recall that the gauge assumes the "Crown" material with a refractive index 1.53. Based on this assumption, what is the radius of curvature of the surface? How do the measurements change if the gauge is not perpendicular to the surface?

2. **Spherometer –** A spherometer makes a similar measurement as the Geneva gauge. However, it has two added features that improve its performance. First, whereas the Geneva gauge has two peripheral pins and a central pin that measures surface sag, the spherometer has three peripheral pins (or in our case a complete circular ring) that ensure that the measurement pin is perpendicular to a spherical surface. Second, the spherometer measures surface sag directly and makes no assumption the material's refractive index. Measure the *same* optical surface as part 1 with the spherometer. What is the sag of the surface? What is the radius of curvature of the surface based on the spherical sag formula? What is the radius of curvature of the surface based on the parabolic approximation to a sphere? How do these radii compare to each other? How do these values compare to the radius predicted with the Geneva gauge? If the Geneva gauge and the Spherometer give different results for the radius, predict what the index of refraction of the material is.

$$\text{Sphere Sag} = R - \sqrt{R^2 - r^2} \qquad\qquad \text{Parabolic Sag} = \frac{r^2}{2R}$$

3. **Thin Lenses –** Measure the front and back radii of a 1D (diopter) trial lens. Using the Lensmaker's Formula estimate the refractive index n_o of the trial lens material. Measure the radii of trial lenses with powers 2.5D, 5D, 7.5D and 10D. Use these radii, the Lensmaker's formula and n_o to estimate the powers of the trial lenses. Plot the predicted power versus the labeled power. Where does the thin lens assumption break down?

4. **Nodal Slide –** The nodal slide is a useful tool for determining the cardinal points of an optical system. The nodal slide takes advantage of two properties of the nodal points. First, for systems in air, the nodal points coincide with the principal points. Second, if the optical system is rotated about the rear nodal point, the focus spot appears stationary. Mount the copy lens on the nodal slide. Set up a collimated light source. Find the position of the rear focal point by determining where the collimated beam comes to focus. Rotate the nodal slide.

Did the focal spot move? Adjust the axial position of the lens and repeat the rotation. Did the focal spot move more or less? Iteratively adjust the lens position and rotation until the focus is stationary. The rear nodal point is now over the center of rotation of the nodal slide. Reverse the orientation of the copy lens and repeat the process to find the front nodal point. Clearly label the positions of the cardinal points. What is the effective focal length of the system?