Experiment  Image Formation with Cylindrical Lenses

EQUIPMENT NEEDED:
- Optics Bench
- Ray Table and Base
- Slit Plate
- Parallel Ray Lens
- Light Source
- Component Holder (2)
- Cylindrical Lens
- Slit Mask

Introduction
You have investigated image formation through reflection. The principles at work in image formation through refraction are analogous. Similar ray tracing techniques can be used to determine the form and location of the image. The important differences are (1) the Law of Refraction replaces the Law of Reflection in determining the change in direction of the incident rays; and (2) the bending of the rays takes place at two surfaces, since the light passes into and then out of the lens.

In this experiment, you will use the Ray Table to study the properties of image formation with cylindrical lenses. The properties you will observe have important analogs in image formation with spherical lenses.

Procedure
Set up the equipment as shown in Figure 13.1. Position the Cylindrical Lens on the Ray Table so the rays are all incident on the flat surface of the lens.

Focal Point
Adjust the position of the Parallel Ray Lens to obtain parallel rays on the Ray Table. Adjust the Cylindrical Lens so its flat surface is perpendicular to the incident rays and so the central ray passes through the lens undeflected.

1) Measure F.L.₁ and F.L.₂ (see Figure 13.1).
F.L.₁ = ________________________.
F.L.₂ = ________________________.

Remove the Parallel Ray Lens and Component Holder. Remove the Slit Mask from its Component Holder. Set the Holder aside and replace the Slit Mask on the front of the Light Source. Move the Ray Table and Base close enough to the Light Source so the filament of the Light Source is a distance f₁ from the curved side of the Cylindrical Lens.

2) Describe the refracted rays.

3) Turn the Cylindrical Lens around and place it on the Ray Table so that its straight side is a distance f₂ from the filaments (you may need to move the Ray Table and Base closer to the Light Source).
Describe the refracted rays.
③ Why is one focal length shorter than the other? (Hint: consider the refraction of the light rays at both surfaces of the lens.)

**Image Location**

Remove the Slit Mask from the front of the Light Source. Move the Ray Table and Base so it is as far from the Light Source as possible. Set the Cylindrical Lens on the Ray Table with the straight side toward the Light Source.

① Where is the image formed?

② What happens to the location of the image as you move the Light Source closer?

③ Is an image still formed when the Light Source is closer than the focal length of the lens? If so, what kind?

**Magnification and Inversion**

In the plane of the Ray Table, the filament of the Light Source acts as a point source. To observe magnification and inversion, an extended source is needed. As shown below, two positions of the Light Source filament can be used to define an imaginary arrow, of height \( h_o \).

Position the filament of the Light Source first at the tail of the imaginary arrow, then at the tip. At each position, locate the image of the filament. The height of the image arrow, \( h_i \), divided by the height of the object arrow, \( h_o \), is the magnification of the image.

Measure the magnification for several different distances between the Light Source and the lens.

① Qualitatively, how does the degree of magnification depend on the distance between the object and the lens?

② Is the image inverted? Is it inverted for all object locations?

**Cylindrical Aberration**

Cylindrical aberration is the distortion of the image caused by imperfect focusing of the refracted rays. Place a blank sheet of paper over the Ray Table. Arrange the equipment as in Figure 13.1 so all the light rays are refracted by the Cylindrical Lens. Use the Slit Mask to block all but two rays. Do this for several pairs of rays.

① Are all the rays focused at precisely the same point?

② How would you alter the shape of the lens to reduce the amount of cylindrical aberration?