Reflection and Image Formation by Plane and Cylindrical Mirrors

Purpose: To investigate how the apparent location of an image reflected from a plane mirror relates to the location of the object, by using Ray Tracing to locate the object and image, and to measure the object distance and the image distance. To use Ray Tracing to measure the focal lengths of cylindrical (convex and concave) mirrors.

Apparatus: Optics Bench, Light Source, Ray Table and Base, Component Holder (2), Slit Plate, Ray Optics Mirror, Parallel Ray Lens.

Introduction: Looking into a mirror and seeing a nearly exact image of yourself hardly seems like the result of simple physical principles. But it is. The nature of the image you see in a mirror is understandable in terms of the principles you have already learned: the Law of Reflection and the straight-line propagation of light.

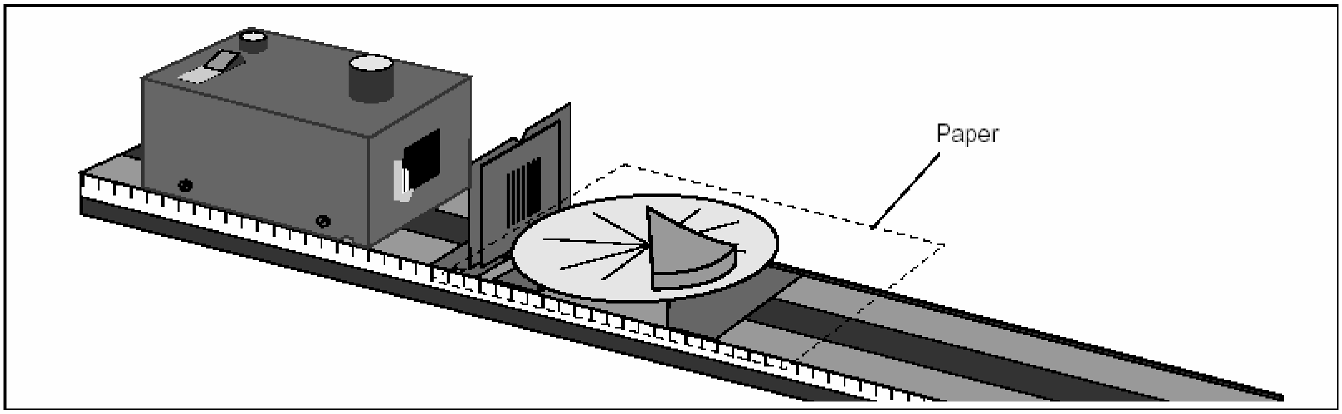


Figure 1 Experimental set-up for image formation by a plane mirror.

Procedure: Image Formed by a Plane Mirror

1. Set up the equipment as shown in Figure 1. Adjust the Slit Plate and Light Source positions for sharp, easily visible rays. As shown, place a blank, white sheet of paper on top of the Ray Table, and place the Ray Optics Mirror on top of the paper. Position the mirror so that all of the light rays are reflected from its flat surface. Draw a line on the paper to mark the position of the flat surface of the mirror.
2. Look into the mirror along the line of the reflected rays so that you can see the image of the Slit Plate and, through the slits, the filament of the Light Source. (Rotate the mirror as needed to do this.) Do the rays seem to follow a straight line into the mirror? With a pencil, mark two points along one edge of each of the incident and reflected rays. Label the points (r_1, r_2, etc.), so you know which points belong to which ray.
3. Remove the paper and reconstruct the rays, using a pencil and straightedge, as shown on the next page in Figure 2. If you need to, tape on additional pieces of paper so that the reconstructed rays can be traced all the way to the point where they converge at the object (the filament) and to the point where they converge at the image of the filament. Draw dotted lines to extend the incident and reflected rays back to the object and its image. On your drawing, label the position of the filament and the apparent position of its reflected image. Extend the plane of the mirror as necessary.
4. What is the perpendicular distance from the filament to the plane of the mirror (distance d_2, as shown in Figure 2)? What is the perpendicular distance from the image of the filament to the plane of the mirror (distance d_1, as shown in Figure 2)?

5. What is the relationship between object distance (d_2) and image distance (d_1) for reflection in a plane mirror?

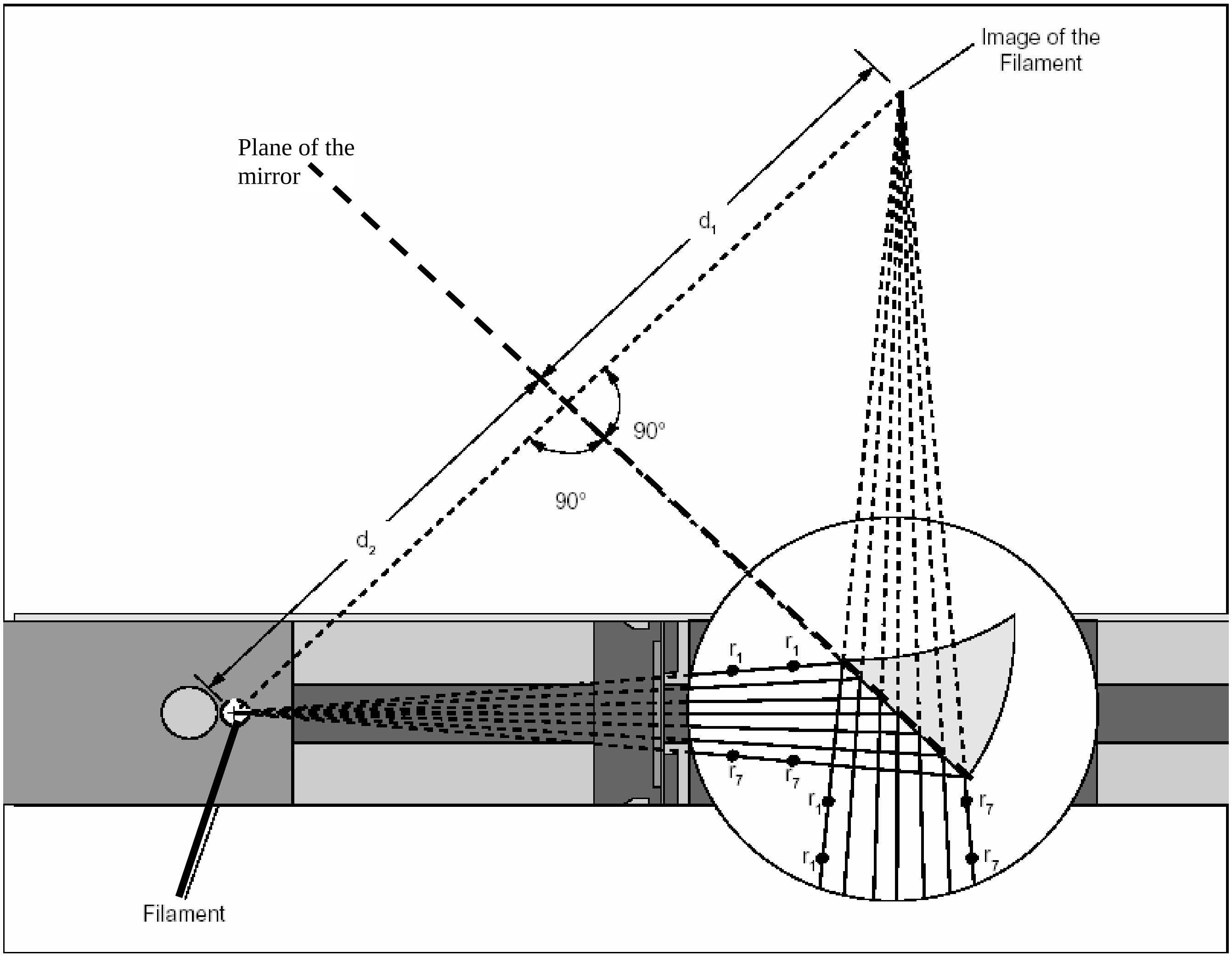


Figure 2 Geometry of ray tracing for plane mirror experiment.

The Focal Length of Cylindrical Mirrors

Introduction: Ray tracing techniques can be used to locate the image formed by reflection from any mirror of known shape. For a given object, light rays diverging from it are reflected from the mirror according to the Law of Reflection. If the reflected rays intersect at a point, a real image is formed at that point. If the reflected rays do not intersect, but would if they were extended back *behind* the mirror, a **virtual** image is formed at the point where the extended rays cross. Does a plane mirror form a real or virtual image? In this experiment, you will use the Ray Table to study the properties of image formation from cylindrical surfaces. The properties you will observe have important analogs in image formation by spherical mirrors.

Procedure:

6. Set up the equipment as shown in Figure 3. Carefully adjust the position of the Parallel Ray Lens to obtain **parallel** rays on the Ray Table. Position the Ray Optics Mirror on the Ray Table so that the rays are all reflected from the concave surface of the mirror. Carefully adjust the mirror on the Ray Table so that **the incident rays are parallel to the optical axis of the mirror**. See the inset in Figure 3. Measure F.L., the focal length of the concave cylindrical mirror. You may place a sheet of paper under the mirror, and mark the location of the mirror surface, the

optic axis and the point of convergence of the near axis rays. The focal length is the distance (along the optic axis) from the surface of the mirror to the point where the reflected rays converge.

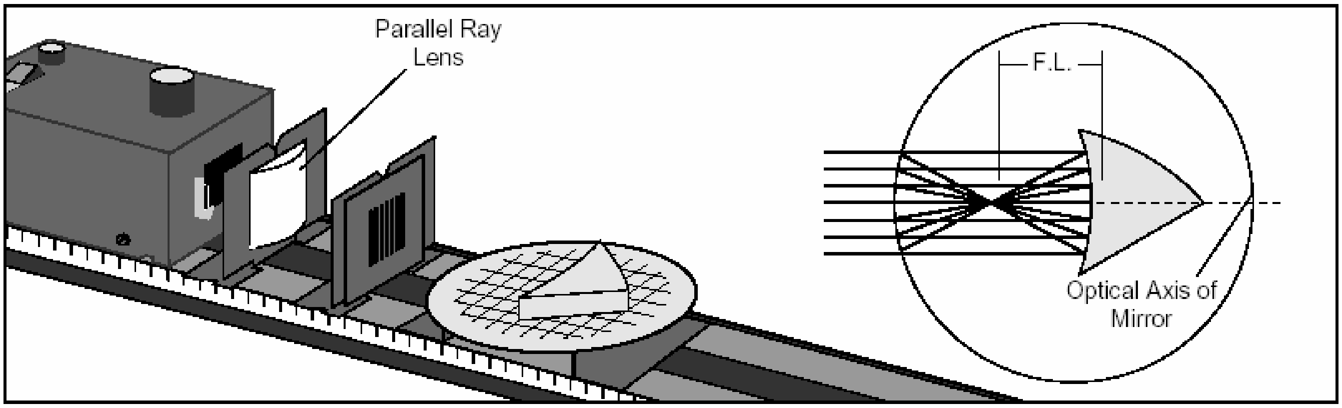
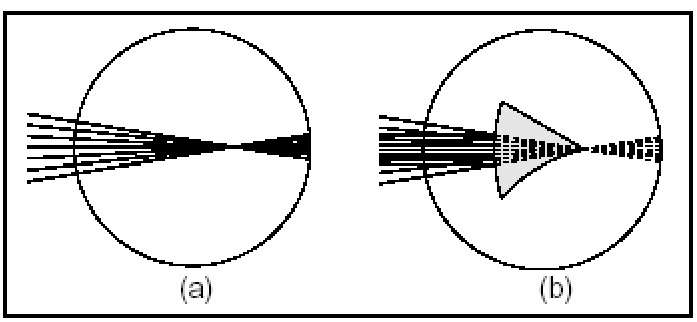


Figure 3 Experimental set-up for concave cylindrical mirror.

7. Next, you will measure the focal length of the convex side of the cylindrical mirror. This time, the reflected rays will not converge to a point, but will diverge from the mirror surface as though they originated at a source *behind* the mirror. Use a new sheet of paper and ray tracing techniques to measure the focal length of the convex cylindrical mirror. The focal length for this mirror is the distance (again along the optic axis) from the surface of the mirror to the point where the reflected rays that are extended *back into* the mirror converge. As before, be sure to align the Parallel Ray Lens, Slit Plate and Mirror so that the incident rays are parallel to the optic axis, and mark the convex surface of the Mirror and the optic axis on your sheet of paper.
8. Finally, you will observe what happens when a **virtual object** is positioned at the focal point of the convex mirror. With nothing on the Ray Table but a sheet of clean paper, adjust the Light Source and the Parallel Ray Lens so the rays cross at a point on the Ray Table, as shown in Figure 4(a). Since rays diverge from this point of intersection, it can be used as an **object**. Place the convex side of the Ray Optics Mirror so that its **focal point** is coincident with the point where the rays cross, as in Figure 4(b). Of course, with the mirror in this position, the rays are reflected and don't actually cross. The point where the rays did cross, though, acts as a **virtual object**.



9. Describe the resulting behavior and appearance of the reflected rays.

Figure 4 Rays converging at a point (a) will serve as a virtual object for the convex mirror (b).