

## Optics I: Spherical Mirrors and Index of Refraction Spring 2009

### Introduction

This lab consists of a series of self-contained experiments to be performed independently. Your instructor will show you the method of ray tracing for each object. *In order to pass this lab you **must** use a very sharp pencil.* Where appropriate, label the object and the image, and indicate their direction (before and after they reflect or refract). Use a solid line for real rays, and a dashed line for virtual rays.

When performing ray tracing for curved mirrors, there are usually three rays that can be drawn:

1. The incident ray is parallel to the axis, and reflects through the focal point,  $f$ .
2. The incident ray goes through  $f$ , and reflects parallel to the axis.
3. The incident ray goes through  $R$ , and reflects back upon itself.

To keep our ray diagrams from being cluttered, only *two* of the above rays need be drawn. Depending upon the type of mirror and location of the object, you may use different pairs of rays.

### Experiment

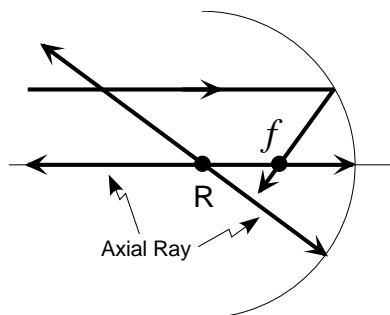


Figure 1

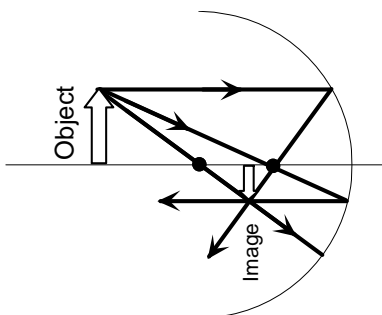


Figure 2

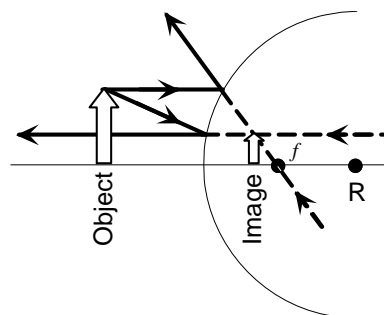


Figure 3

#### 1. *Concave Mirror I* (Is the focal length half the radius?):

- a. Place your mirror near the center of a sheet of graph paper. Orient the mirror perpendicular to a line on the page (the *axis*). Trace an *axial ray* (one which reflects back on itself) along this axis.
- b. Draw two incident rays parallel to the axis. The **focal point** is located where the reflected rays cross the axis (see *figure 1*). Keep the incident rays close to the axis to reduce *spherical aberration*.
- c. Measure the **focal length** (distance between the focal point and the mirror).
- d. Find the radius of curvature of the mirror (using two axial rays), then measure the radius. Is the radius twice the focal length?

2. **Concave Mirror II** (*Real image of an object*):

- Create a new picture using the same mirror, using *lightly drawn* rays to find the focal point.
- Draw a 2 cm long arrow, starting on the axis and 3 focal lengths from the mirror to represent an object. Find the *image* of this *object* using two rays that originate at the arrowhead. The image is located where the reflected rays intersect (*figure 2*). Is the image real or virtual? Be sure to label *o* and *i*.

3. **Concave Mirror III** (*“The makeup mirror” – Virtual image of an object*):

- Create a new picture, and repeat (2), but place your object **0.5** focal lengths from the mirror. Is the image real or virtual? *Keep your mirror near the center of the page!*

Thought question: *If the object is placed on the focal point,  $f$ , where will the image be located?*

4. **Convex Mirror I** (*Focal point = half the radius?*):

- You will repeat (1), except that you are working on the outer curved surface (convex). Extend the reflected rays on the *other side* (the inner curved surface) of the mirror to find the focal point and radius of curvature.

5. **Convex Mirror II** (*“The security mirror” – Virtual image of an object*):

- Same as (2) except the image is virtual (*figure 3* – be sure to place your mirror near the center of your page!).

6. **Index of Refraction** ( *$n$  for glass from Snell's law*):

*Important Note: All angles are measured **from** a normal to the surface **to** the ray. Ignore rays that go over the top of the glass.*

- Place the triangle of glass on the page, and trace around its edges.
- Trace a ray entering the triangle (about  $30^\circ$  or so from the normal), and extend its path **seen in the glass** to determine the refracted angle (*figure 4*). Also draw the ray that exits on the other side of the glass triangle.
- Find the index of refraction for the glass triangle by applying Snell's law to  $\theta_1$  and  $\theta_2$ , then applying again to  $\theta_3$  and  $\theta_4$  (use  $n_{\text{air}} = 1.00$ ). Compare your measured value to the accepted value for glass:  $n_{\text{glass}} = 1.50$ .

7. **Critical Angle:**

- Draw a *new* picture and aim a ray so it leaves the opposite side of the glass triangle at about  $90^\circ$  (*figure 5*). Measure and record the angle **in** the glass: this is the *critical angle*,  $\theta_c$ , beyond which all the light will be reflected internally.
- Calculate the expected value for  $\theta_c$  for a ray traveling *from* glass *to* air. Compare this value to the one you just measured.

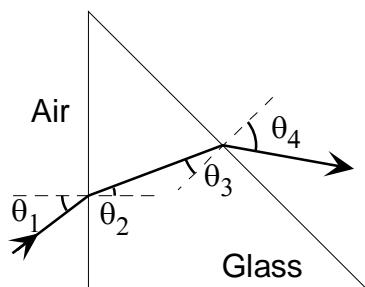


Figure 4

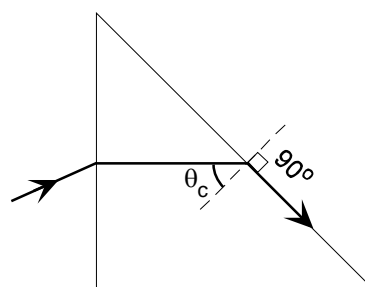


Figure 5