Optics I:
Spherical Mirrors and Index of Refraction
Spring 2008

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

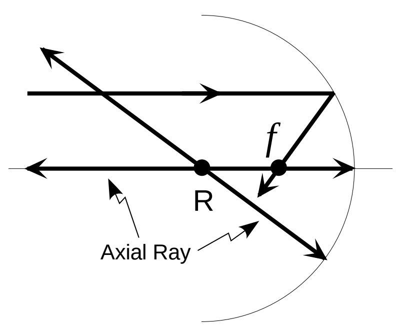

Figure 1

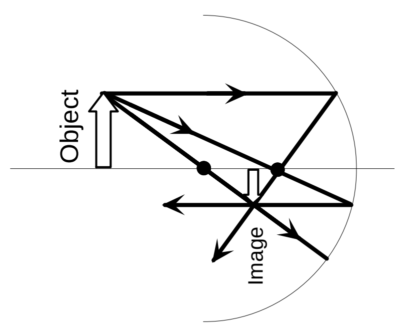

Figure 2

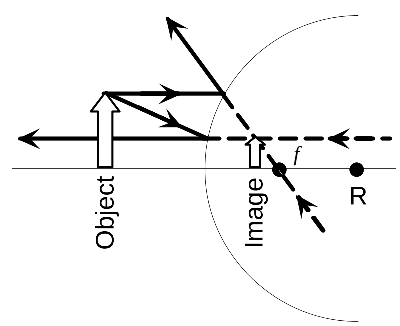

Figure 3

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):*

   a. Create a new picture using the same mirror, using *lightly drawn* rays to find the focal point.

   b. 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, ƒ, 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.*

   a. Place the triangle of glass on the page, and trace around its edges.

   b. Trace a ray entering the triangle (about 30° 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.

   c. Find the index of refraction for the glass triangle by applying Snell's law to θ_1 and θ_2, then applying again to θ_3 and θ_4 (use $n_{air} = 1.00$). Compare your measured value to the accepted value for glass: $n_{glass} = 1.50$.

7. ***Critical Angle****:*

   a. Draw a *new* picture and aim a ray so it leaves the opposite side of the glass triangle at about 90° (*figure 5*). Measure and record the angle **in** the glass: this is the *critical angle*, θ_c, beyond which all the light will be reflected internally.

   b. Calculate the expected value for θ_c for a ray traveling *from* glass *to* air. Compare this value to the one you just measured.

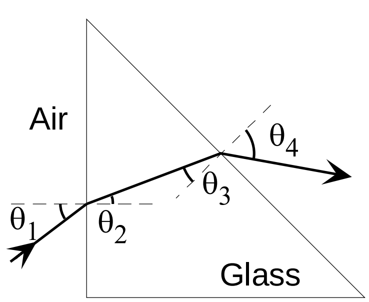

Figure 4

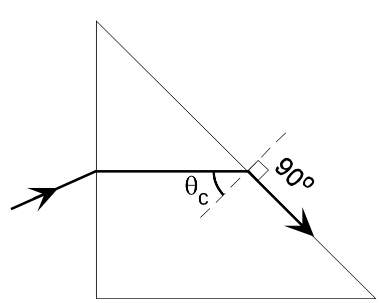

Figure 5