PHYS 1120 Discussion 9. Ray Optics

Summary

Mirrors

When ray tracing to characterize an image produced by a curved mirror, three rays are useful:

A **central** ray travels to the mirror from the direction of its center of curvature and reflects back along the same path.

A **paraxial** ray travels to the mirror parallel to its principal axis and reflects along a line through the mirror's focal point.

A **focal** ray travels to the mirror along a line from its focal point and reflects along a line parallel to the principal axis of the mirror.

Lenses

There are also three useful rays for finding the image produced by a lens.

A **principal** ray passes straight through the center of the lens without deflection.

A **paraxial** ray travels to the lens parallel to its principal axis and deflects to follow a line to a focal point. In a converging lens, the focal point is on the other side of the lens from the object; in a diverging lens, the focal point is on the same side of the lens as the object.

A **focal** ray travels to the lens along a line from a focal point of the lens and deflects to follow a line parallel to the principal axis of the lens. In a converging lens, the focal point is on the same side of the lens as the object; in a diverging lens, the focal point is on the other side of the lens from the object.

Very distant objects

For both lenses and mirrors, the image of an object located infinitely far away can be located without tracing the paraxial ray. The image will be on the focal plane.

Thin lens equation

Despite its name, the equation applies to both lenses and mirrors. Where f is the distance from the lens or mirror to its focal point, d_o is the distance from the lens or mirror to the object, and d_i is the distance from the lens or mirror to the image, the following relationship applies.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

For a converging lens or mirror, the focal length f is positive. For a diverging lens or mirror, f is negative. The **magnification**, which is the size of the image relative to the size of the object, is $M = -d_i/d_o$.

Problems

Set up ray-tracing diagrams to scale for the given lens and mirror configurations. Locate and characterize the images by ray tracing, and use the thin lens equation to find the image distances d_i and magnifications M.

Converging mirrors

For these, assume the focal length is 30 cm.

d_o, cm	$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$	d_i, cm	M
45			
60			
90			
10			
20			

What does the sign of the image distance tell you about the image?

What does the sign of the magnification tell you about the image?

Diverging mirrors

For these, assume the focal length is –30 cm.

d_o, cm	$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$	d_i, cm	M
15			
30			
60			

Converging and diverging lenses

Assume focal lengths of ±30 cm, and use the same object distances as with the mirrors. The equations are identical, so you don't need to repeat them. Do the ray tracing exercises, and answer the same questions.