Name: _____ Hr: _____

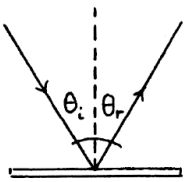
Unit 10 – Reflection

Grading: Show all work, keeping it neat and organized. Show equations used and include all units.

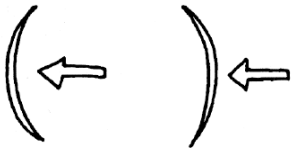
REFLECTION

Vocabulary **Reflection:** The bouncing of light.

The angle a beam of light makes when it strikes a surface is described with respect to the **normal**, an imaginary line drawn perpendicular to the surface. When light shines onto a mirror, the angle at which the light enters the mirror (angle of incidence) is exactly equal to the angle at which the light leaves the mirror (angle of reflection). This is called the **law of reflection** and is easily observed in a plane (flat) mirror.



Due to the curvature of a spherical or parabolic mirror, light reflected from its surface behaves somewhat differently than it does when reflected from a plane mirror. There are two types of spherical mirrors: **concave** (or converging) and **convex** (or diverging).



Concave **Convex**

The following terminology is used when describing how light is reflected from concave and convex mirrors.

Vocabulary **Object distance:** The distance from the mirror to the object. This value is always a positive number.

Vocabulary **Image distance:** The distance from the mirror to the image. An image can be **real** (able to be projected on a screen), or **virtual** (not able to be projected on a screen).

Vocabulary **Focal point:** The point where parallel rays meet (or appear to meet) after reflecting from a mirror. The distance from this focal point to the mirror is called the focal length. The **focal length** of a concave mirror always has a positive value while the focal length of a convex mirror always has a negative value.

Vocabulary **Mirror Equation:** $\frac{1}{\text{focal length}} = \frac{1}{\text{object distance}} + \frac{1}{\text{image distance}}$

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

Note: Many situations involving mirrors can also be solved using ray diagrams.

CONCAVE (CONVERGING) MIRRORS

If an object is located more than one focal length from a concave mirror as shown in figure A, the image it forms is real, inverted, and in front of the mirror. You can actually project this image onto a piece of paper. Both d_o and d_i have positive values.
If the object is at the focal point as in figure B, no image is formed because the reflected rays are parallel.

If an object is located less than one focal length from a concave mirror as in figure C, the image it forms is virtual, upright, enlarged, and behind the mirror. In other words, you must look into the mirror to see the image. Here, d_o has a positive value and d_i has a negative value.

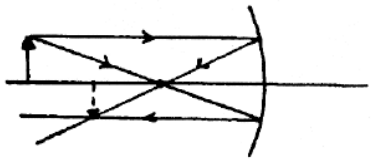


Figure A

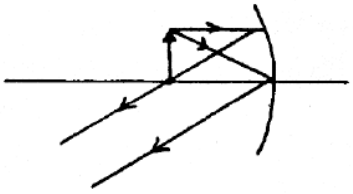


Figure B

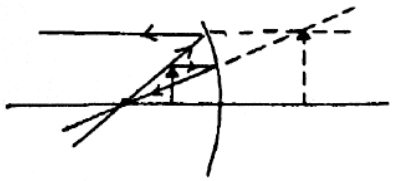
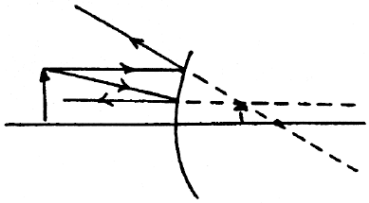


Figure C

CONVEX (DIVERGING) MIRRORS



The image formed by a convex mirror is always virtual, upright, smaller, and behind the mirror. The image can be seen only by looking into the mirror. Here d_o has a positive value while d_i has a negative value.

Solved Examples

Example 1: Sitting in her parlor one night, Gerty sees the reflection of her cat, Whiskers, in the living room window. If the image of Whiskers makes an angle of 40° with the normal, at what angle does Gerty see him reflected?

Solution: Because the angle of incidence equals the angle of reflection, Gerty must see her cat reflected at an angle of 40°.

Example 2: Wendy, a fortune teller, is polishing her crystal ball. It is so shiny that she can see her reflection when she gazes into it from a distance of 15 cm. a) What is the focal length of Wendy's crystal ball if she can see her reflection 4.0 cm behind the surface of the crystal ball? b) Is this image real or virtual?

a) Given: $d_o = 15$ cm

$d_i = -4.0$ cm

Unknown: $f = ?$

Original Equation: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Solve: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{15\text{ cm}} + \frac{1}{-4.0\text{ cm}}$

Getting a common denominator of 60 cm gives $\frac{1}{f} = \frac{4}{60\text{ cm}} - \frac{15}{60\text{ cm}} = \frac{-11}{60\text{ cm}}$

To find f, take the reciprocal of this sum. $f = \frac{-60\text{ cm}}{11} = -5.5$ cm.

The minus sign before the answer means that this is the focal length of a convex mirror.

b) The image seen *behind* a curved surface is always a **virtual image**.

Example 3: With his face 6.0 cm from his empty water bowl, Spot sees his reflection 12 cm behind the bowl and jumps back. a) What is the focal length of the bowl? b) What was surprising about Spots's reflection that may have caused him to jump?

a) Given: $d_o = 6$ cm

$d_i = -12.0$ cm

Unknown: $f = ?$

Original Equation: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Solve: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{6\text{ cm}} + \frac{1}{-12\text{ cm}}$

Getting a common denominator of 12 cm gives $\frac{1}{f} = \frac{2}{12\text{ cm}} - \frac{1}{12\text{ cm}} = \frac{1}{12\text{ cm}}$

To find f, take the reciprocal of this sum. f = 12 cm.

The positive answer means that the bowl was acting as a concave mirror.

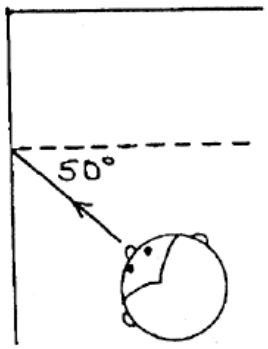
b) The surprising thing Spot noticed about his reflection was that it appeared larger than life!

Exercises – Draw a sketch for each exercise!

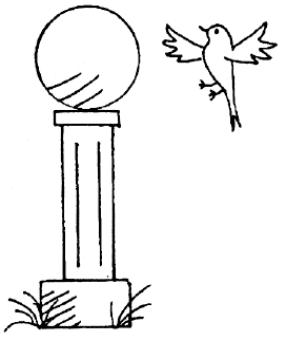
Exercise 1: a) If you are standing 1.5 meters away from a plane mirror, how far from you is your image? b) What is the focal length of a plane mirror?

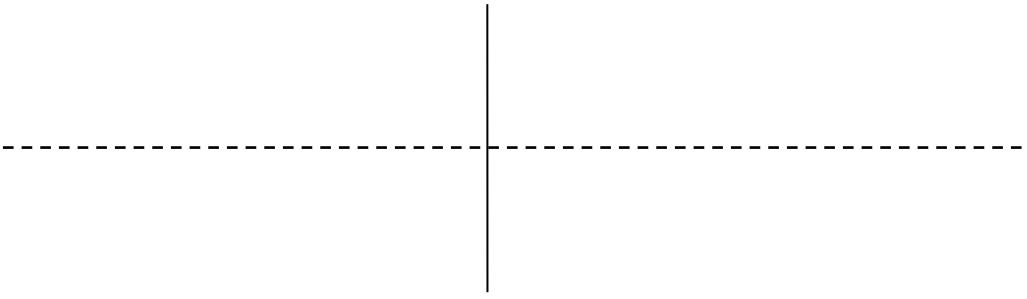
Exercise 2: Ivan is in a house of mirrors with one of his friends when he comes to two mirrors situated at an angle of 90°. Ivan stands so that light shining on his face is incident on one mirror at an angle of 50°, as shown. At what angle will this light reflect from the second mirror?

Draw the rays on the diagram, and explain your reasoning below.

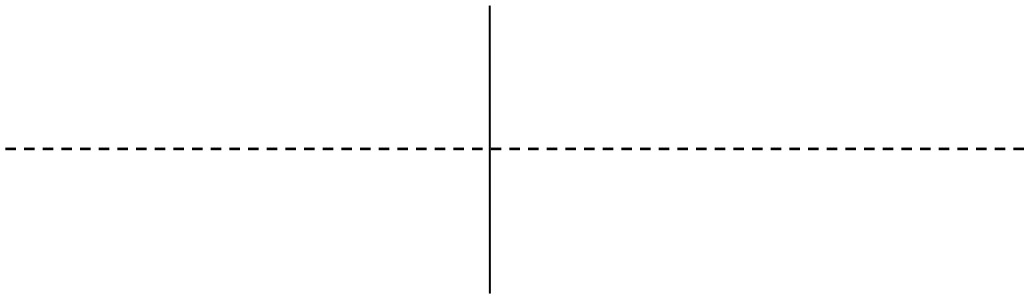


Exercise 3: A popular lawn ornament in the 1960s was a colored reflecting sphere that sat in the yard as a decoration. a) If a bird is 10.0 cm from a blue reflecting sphere and sees its image reflected 5.0 cm behind the surface of the sphere, what is the focal length of the spherical reflector? b) Sketch a ray diagram. c) Would the bird's image appear larger or smaller than the bird itself?

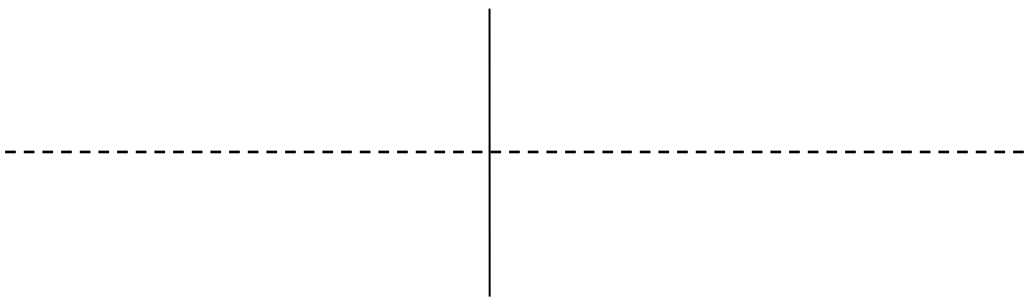




Exercise 4: Polly applies her mascara while looking in a concave mirror whose focal length is 18 cm. She looks into it from a distance of 12 cm. a) How far is Polly's image from the mirror? b) Sketch a ray diagram. c) Does it matter whether or not Polly's face is closer or farther than one focal length? Explain.



Exercise 5: A friend is wearing a pair of mirrored sunglasses whose convex surface has a focal length of 20.0 cm. a) If your face is 40.0 cm from the sunglasses, how far behind the sunglasses is your image? b) Sketch a ray diagram.



Exercise 6: a) Where must an object be placed with respect to a concave mirror with a focal length of 1 meter in order for its image to be focused on a screen 6 meters from the mirror? b) What type of image is formed? (Real or virtual? Upright or inverted?) c) Sketch a ray diagram.