Ozobot Bit Classroom Application:

Demonstration of Reflection from Plane and Parabolic Mirrors

Created by

Richard Born

Associate Professor Emeritus

Northern Illinois University

richb@rborn.org

Topics

Physics, Law of Reflection, Plane Mirror, Concave Parabolic Mirror, Angle of Incidence, Angle of Reflection, Focus, Normal, Virtual Image, Real Image, Protractor, Measurements, Spotlight, Solar Oven

Ages

Grades 7 – 12

Duration

20-25 minutes

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rborn@niu.edu

Introduction

The concept of a ***light ray*** is quite useful as rays indicate the direction in which energy flows in a beam of light. Consider reflection of light as an example. *When an incident ray of light strikes a mirror surface, the reflected ray lies in the same plane as that of the incident ray, and the angle of reflection equals the angle of incidence*. This is a statement of the ***law of reflection***. Angles of incidence and reflection are measured from normals to the surface, *i.e.*, from lines perpendicular to the surface. The law of reflection holds for curved surfaces as well as plane surfaces, as in ordinary mirrors in bedrooms and bathrooms. For the case of curved-surface mirrors, the normals are drawn perpendicular to planes that are tangent to the curved surface at the point where the incident ray hits.

The law of reflection is frequently encountered in introductory physical science and physics courses. In these courses it is common to study reflection from both plane mirrors and concave parabolic mirrors. This Ozobot Bit classroom application provides a quick ***demonstration*** of the law of reflection as it applies to these two types of mirrors. Via simulation, Ozobot Bit acts as if he were a ray of light, but traveling very slow so that the students can easily visualize the process of reflection.

The OzoMaps and Blockly Programs for this Classroom Application

There are two OzoMaps for this lesson—one for reflection from a plane mirror and one for reflection from a concave parabolic mirror. Each of these OzoMaps requires a *different* OzoBlockly program. Make sure that the program *ReflectionPlane.ozocode* is used with the plane mirror OzoMap and the program *ReflectionParabolic.ozocode* is used with the concave parabolic mirror OzoMap. For reference purposes while discussing this classroom application, Figures 1(a) and 1(b) contain small versions of the OzoMaps. Full page versions for both maps that can be printed and used with Ozobot Bit appear on the final two pages of this document.

Figure 1(a) shows the OzoMap for reflection from a plane mirror. The mirror is shown as a gray horizontal line running the entire length of the map. A *light source* in front of the mirror is shown in the lower right corner. Three pairs of *incident/reflected rays* are shown as heavy green, red, and blue lines for Oz0bot Bit to follow. The light-colored dashed lines behind the mirror (top half of the OzoMap) show how the reflected rays appear to be emanating from a ***virtual image*** of the light source in the upper right of the OzoMap. The light-gray dashed *normals* to the surface show that the angle of incidence, *i*, equals the angle of reflection, *r*.

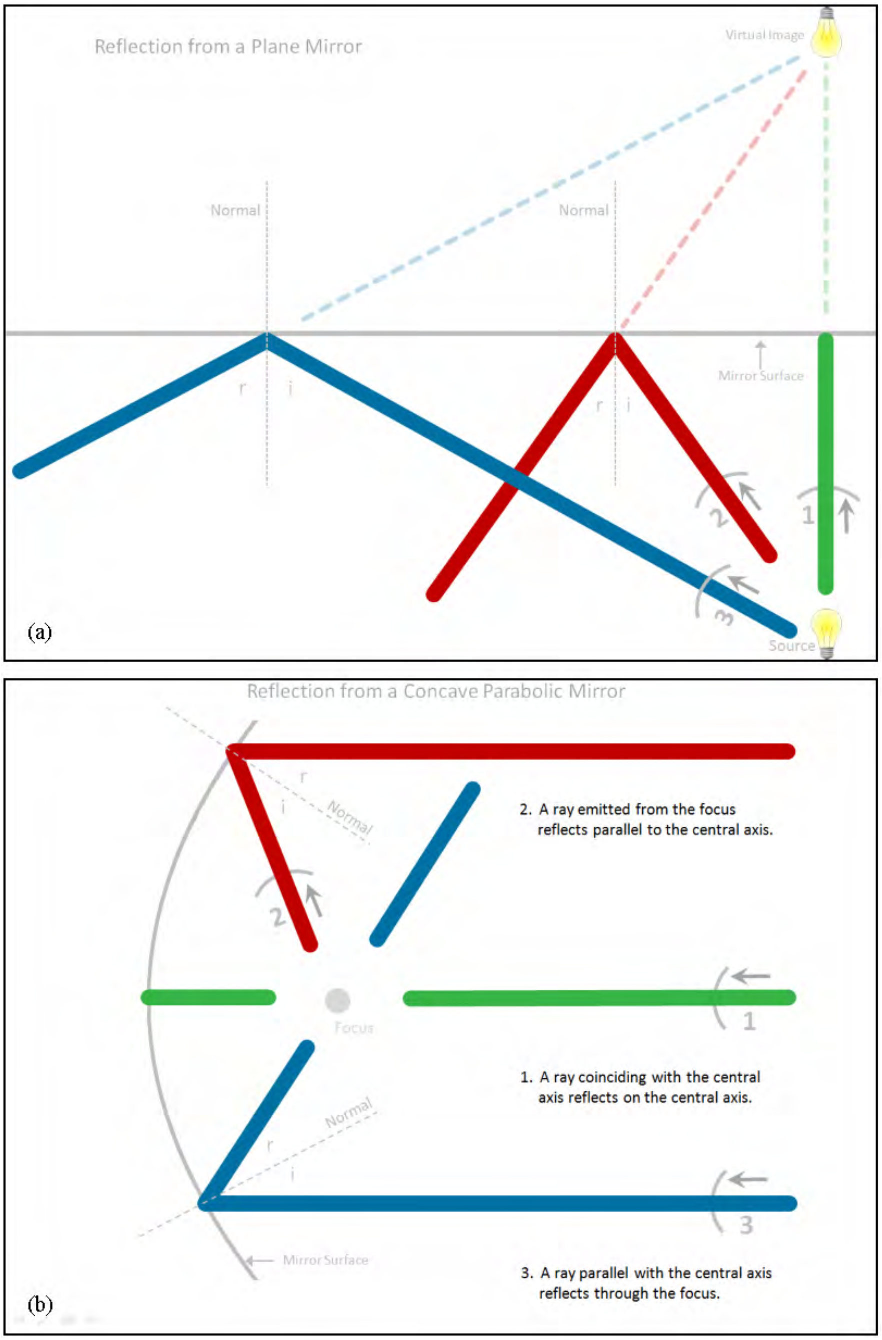


Figure 1 (a) and (b)

Figure 1(b) shows the OzoMap for reflection from a concave parabolic mirror. The curved concave parabolic reflector is shown in light gray on the far left of the diagram. Three pairs of incident/reflected rays are shown as heavy green, red, and blue lines for Oz0bot Bit to follow. These three pairs show that:

1. *An incident ray coinciding with the **central axis** reflects on the central axis. (green)*
2. *An incident ray emitted from the **focus** reflects parallel to the central axis. (red)*
3. *An incident ray coming in parallel to the central axis reflects through the focus. (blue)*

Normals to the mirror's surface show that the angle of incidence, *i*, equals the angle of reflection, *r*, obeying the law of reflection.

Running the Ozobot Bit Programs

1. There are two OzoBlockly programs accompanying this classroom application. Load the OzoBlockly program *ReflectionPlane.ozocode* when using the “Reflection from a Plane Mirror” OzoMap. Load the program *ReflectionParabolic.ozocode* when using the “Reflection from a Concave Parabolic Mirror” OzoMap.
2. Make sure that Ozobot Bit is calibrated on paper before running the program.
3. Make sure that Ozobot Bit has clean wheels and plenty of battery charge.
4. Place Ozobot Bit at the location labeled with the number 1, facing the direction shown by the gray arrow and with his leading edge on the curved gray line.
5. Start Ozobot Bit by double-pressing the start button. He will display a green LED and follow the green pair of incident/reflected rays.
6. Ozobot Bit will stop at the end of the green reflected ray and display a white light for seven seconds. This should give you time to lift and move Ozobot Bit to location 2. He will display a red LED and follow the red pair of incident/reflected rays
7. Ozobot Bit will stop at the end of the red reflected ray and display a white light, again giving you seven seconds to lift and move Ozobot Bit to location 3. He will display a blue LED and follow the blue pair of incident/reflected rays.
8. Ozobot Bit will stop at the end of the blue reflected ray, display a white LED momentarily and then turn off automatically.

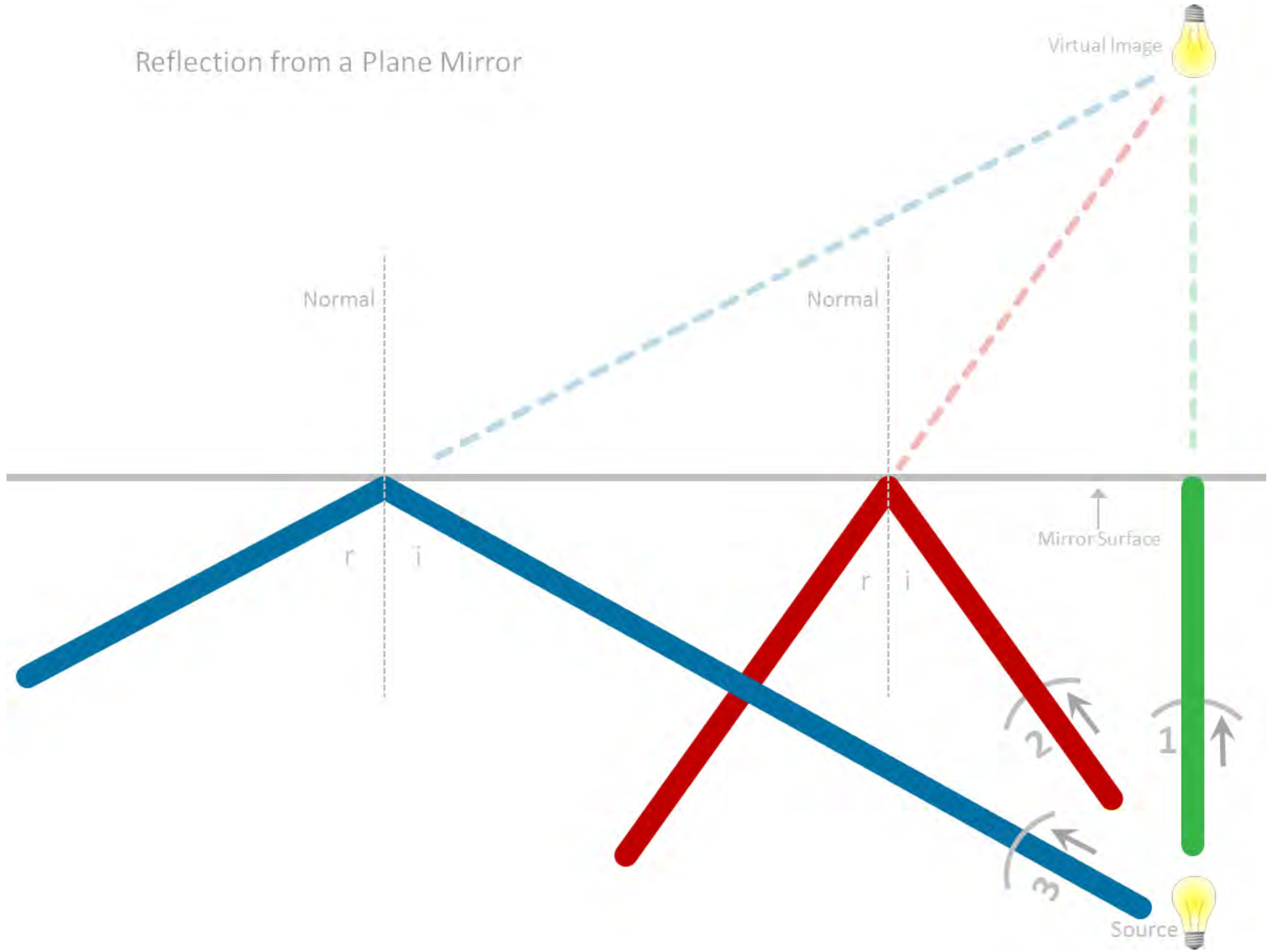
Discussion Questions/Activities

1. How does the distance from the light source to the plane mirror compare to the distance from the virtual image to the plane mirror?
2. If you have protractors available, have the students measure the angles of incidence and reflection for the red and blue rays for the plane mirror. Are *i* and *r* equal? What is the value of the angle of incidence and angle of reflection for the green ray?
3. Why is the reflection of the light bulb in the plane mirror referred to as a *virtual image*?
4. How could a spotlight be constructed by the use of a concave parabolic mirror?
5. How could a solar oven be constructed by the use of a concave parabolic mirror?
6. If you have protractors available, have the students measure the angles of incidence and reflection for the red and blue rays for the concave parabolic mirror. Are *i* and *r* equal? What is the value of the angle of incidence and angle of reflection for the green ray?

Answers to Discussion Questions/Activities

1. The distances are the same, as can be proven by considering congruent triangles.
2. RED $i=r\approx36°$; BLUE $i=r\approx61°$; GREEN $i=r=0°$
3. Light ***appears*** to be coming from behind the mirror, but it ***not actually*** doing so. The image is, therefore, referred to as a *virtual* image, not a *real* image.
4. Place the light bulb at the focus of the concave parabolic mirror. Paint the portion of the light bulb facing away from the concave parabolic mirror with an opaque reflective coating to keep light from emanating in all directions from the light bulb.
5. Allow parallel rays of light from the sun to hit the concave parabolic mirror. They will all meet near the focus. ***Caution: The focal point can be hot enough to start a fire.***
6. RED $i=r\approx35°$; BLUE $i=r\approx29°$; GREEN $i=r=0°$

Reflection from a Plane Mirror



Reflection from a Concave Parabolic Mirror