

## **Lesson 4: Navigational Aids Used by Great Lakes Ships?**

By: Craig Croone, Northfield Middle School

Target: Grades 6-10

**Time:** 2 days. One day for limitations and one day for hazards. This lesson will focus on hazards with the intention of studying the fresnel lens and lighthouse system on Lake Superior.

### **What are/were some of the navigational aids used on the Great Lakes?**

1. Historically
  - a. Lighthouse
    - Fresnel Lens

An extra day may be used to discuss modern navigation and GPS.

### **Lesson Overview**

The goal of this lesson is to get students thinking about how products get from where they are produced to where they are used. In this lesson the student will demonstrate through discussion and demonstration a knowledge of how lighthouses worked to keep shipping safe on the Great Lakes and in particular to experiment and see how the Fresnel Lens works.

### **Background**

In 1822, a French Physicist, named Augustine Fresnel, invented a lens that would make his name commonplace along the seacoasts of Europe and North America, and along the coasts of the Great Lakes. His lens looked like a giant glass beehive with a light at the center. The lens has concentric rings of glass prisms above and below to bend the light into a narrow beam. At the center, the lens is shaped like a magnifying glass (convex), so the concentrated beam is even more powerful. The center lens bends the light into a round beam and turning the lens creates a flashing effect. His tests showed that an open flame lost nearly 97% of its light, and a flame with reflectors behind it still lost 83% of its light, his (fresnel) lens was able to capture all but 17% of its light. Because of its amazing efficiency, a fresnel lens could easily throw its light 20 or more miles to the horizon.

Seven types of the lens were developed. They were called orders. The first three largest orders were for seacoast lights, while orders four through six were smaller and for harbor or bay lights. There was also a 3 to 5 order lens, which was used mostly in the Great Lakes.

In Europe, the new lenses were quickly adopted. The head of the U.S. Lighthouse Board, Stephen Pleasonton, resisted the fresnel lens. It was not until the 1850's that most U.S. lights were converted.

### **Minnesota Science Standards Addressed:**

1. History and Nature of Science. B. Science inquiry, 3. The student will use appropriate technology and mathematics skills to access, gather, store, retrieve and organize data.
2. History and Nature of Science. D. Historic Perspectives, 2. The student will cite examples of how science and technology contribute to changes in agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing or communication.
3. Earth and Space Science. A. Earth Structure and Processes, The student will investigate the impact humans have on the environment.

**Objective:**

Students will identify the fresnel lens as the invention that caused the greatest transformation in lighthouse technology. They will understand that a fresnel lens consists of a concentric array of circular prisms surrounding a central convex lens called a bulls-eye, which concentrate light entering the lens onto a central path. If a light source is placed behind the bulls-eye, light-striking rows of prisms close to the bulls-eye will be refracted (bent) onto a path that is perpendicular to the lens surface. Light that strikes rows of prisms farther away from the bulls-eye will be reflected as well as refracted onto the same path.

**Pre-Assessment**

Have students through discussion or a brief written essay discuss why lighthouses were important to Great Lakes shipping and what was the most important part of the lighthouse.

**Materials:**

- A fresnel lens.
- A concave lens.
- A convex lens.
- A ruler.
- A white index card.
- A small bright light source. A simple work light with a 60-watt bulb will be sufficient.

**Procedure**

Compare the lens.

- The students will compare the lens. Have them look closely at the fresnel lens and record or tell what is different about the fresnel lens compared to the other lens. Ask the students, "Is the fresnel lens a magnifier?" Students may record their observations in a lab notebook. The lens is a magnifier. The fresnel lens will be thinner and flatter and have a bigger diameter. The greater the diameter, the more light gathering or in the case of a lighthouse the more projecting power you will have.

Find the focal length of the lens using the small white card and the light source.

- The focal length is the distance to the focal point where all the light is concentrated to one point. Measure the focal length of the fresnel lens and record it.

How useful is the fresnel lens?

- An ordinary concave or convex lens is thick and heavy. The fresnel lens is thin and therefore lighter in weight. It is superior where large lens are needed, like lighthouses.

The students will list 3 reasons why fresnel lens would have been used in a lighthouse on the Great Lakes.

### **Assessment**

Assess student understanding with a class discussion or written answers in a journal to the preceding lab questions.

### **Extensions**

The student may investigate where fresnel lens are used today?

- Overhead projectors, traffic lights are some examples.

The student may “visit” some lighthouse on line and gather information on the fresnel lens and report back to the class.

### **Resources**

O’shea, Dr. Donald C. (1990). Optics Discovery Kit The Optical Society of America Washington, D.C.

Weintraub, Aileen. (August 2003) Great Lighthouses of North America. PowerKids Press Beecher, IL

Weintraub, Aileen. (August 2003) Navesink Twin Lights: The First US Lighthouse to Use a Fresnel Lens. PowerKids Press Beecher, IL

### **Websites**

<http://thunderbay.noaa.gov/history/maritime.html>

[http://www.exploratorium.edu/snacks/giant\\_lens.html](http://www.exploratorium.edu/snacks/giant_lens.html)

[http://terrypepper.com/lights/lake\\_superior.htm](http://terrypepper.com/lights/lake_superior.htm)

<http://lighthousegetaway.com/lights/fresnel.html>

<http://www.buddyproject.org/thematic/lighthouse.asp>