

Reflections on Light⁵

Students will explore the general behavior of light when it is reflected and the behavior of light when it is reflected in specific angles.

Suggested Grade Range: 7-12

Approximate Time: 1 hour

State of California Content Standards:

Mathematics Content Standards Grade 5: Measurement and Geometry

2.1 Measure, identify, and draw angles, perpendicular and parallel lines, rectangles, and triangles by using appropriate tools (e.g., straightedge, ruler, compass, protractor, drawing software).

Science Content Standards Grade 7: Physical Science

6. Physical principles underlie biological structures and functions. As a basis for understanding this concept:

c. Students know light travels in straight lines if the medium it travels through does not change.

f. Students know light can be reflected, refracted, transmitted, and absorbed by matter.

g. Students know the angle of reflection of a light beam is equal to the angle of incidence.

Relevant National Standards:

Mathematics Common Core State Standard: High School Geometry G-CO

12. Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

Next Generation Science Standards:

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

⁵ An early version of this lesson was adapted and field-tested by Karen Hardy, a participant in the California State University, Long Beach Foundational Level Mathematics/General Science Credential Program.

Lesson Content Objectives:

- Understand and use the vocabulary for the lesson: *angle of incidence*, *angle of reflection*, *normal line*, and *Law of Reflection*.
- Use a flashlight, mirror, and construction paper to explore angles of incidence and reflection.
- Generalize the results of the exploration to verify the Law of Reflection.
- Construct and describe a diagram of the light's path

Materials Needed:

- One flashlight per group of three
- Several small mirrors per group
- Colored construction paper
- One compass and straightedge per student
- One laser pointer per group (optional as an extension)

Summary of Lesson Sequence

- Lead students through their note taking by providing the vocabulary for the lesson: *angle of incidence*, *angle of reflection*, *normal line*, and *Law of Reflection*.
- Model for students the flashlight, mirror and construction paper set up.
- Guide students through their exploration reflecting light off a mirror onto a piece of construction paper.
- Check for students' understanding by asking the key questions provided while students are working.
- Close the lesson by allowing students to verbally describe what they discovered the to be Law of Reflection.

Classroom Set Up

This activity works well for students in groups of three or four.

Lesson Description

Introduction

Explain to students that they will be exploring how light is reflected off a mirror to predict the Law of Reflection. Show students the general set up using a flashlight, mirror, and construction paper. Do not turn on the flashlight when modeling the set up so that students may explore the path of the light in their own groups. With a mirror resting flat on a table, hold a flashlight at an angle pointing down toward the mirror. Explain that the light will reflect upward off the mirror and they will need to use a piece of construction paper to catch the light above the mirror.

Input and Model

Provide students with the vocabulary they will need for this activity so they may take notes:

Angle of incidence: *The angle formed by a ray of light that travels toward a surface and a line perpendicular to the surface. (Demonstrate the angle using a flashlight and an object, such as a string, that forms a line perpendicular to the mirror.)*

Angle of reflection: *The angle formed by a ray of light that travels away from the surface and a line perpendicular to the surface. (Do not demonstrate this angle because it will be the task of the students' to determine it.)*

Normal line: *The imaginary line perpendicular to the surface of reflection. (Demonstrate the normal line using an object, such as a string, perpendicular to the mirror's surface.)*

****Law of Reflection:*** (Explain that students will determine the Law of Reflection based on their exploration.)

Guide Students Through Their Practice

Provide each group of three or four students with a flashlight, mirrors and construction paper. Allow students to begin their exploration and remind them that their goal is to predict the Law of Reflection. Advise students that their task is to reflect light from a mirror onto the construction paper. Students should not lift the mirror from the table and

should not aim the light onto any surface other than the mirror and the construction paper. Move around the room to ensure students are following these directions. They will be shining the light onto the mirror from several different angles.

Check for Understanding

Check for students' understanding while they are exploring by utilizing the following questions/prompts:

Did you instinctively know where to hold the paper in order to catch the light?

What is the relationship between how you hold the flashlight and where the light goes?

What role does the mirror play?

Use your finger to outline the angle of incidence.

Use your finger to outline the angle of reflection.

Use your finger to outline the normal line.

Use the vocabulary you learned today to describe how the light is reflected.

Independent Practice

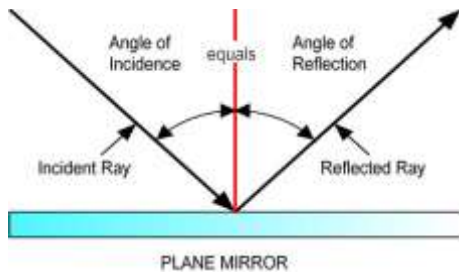
Using their understanding of the Law of Reflection, students should work independently to construct and label a diagram of the light's path using a compass and straightedge.

Diagrams should include a depiction of the following: flashlight, mirror, construction paper, angle of incidence, normal line, angle of reflection, and an indication of the congruent angles.

Closure

To close the lesson, allow students to describe verbally what they predict the Law of Reflection to be. Encourage students to use the vocabulary presented in the lesson. Once a few students have had an opportunity to state the Law of Reflection in their own words, allow them to update their notes:

Law of Reflection: *the angle of incidence measured from the normal line is equal to the angle of reflection measured from the normal line.*



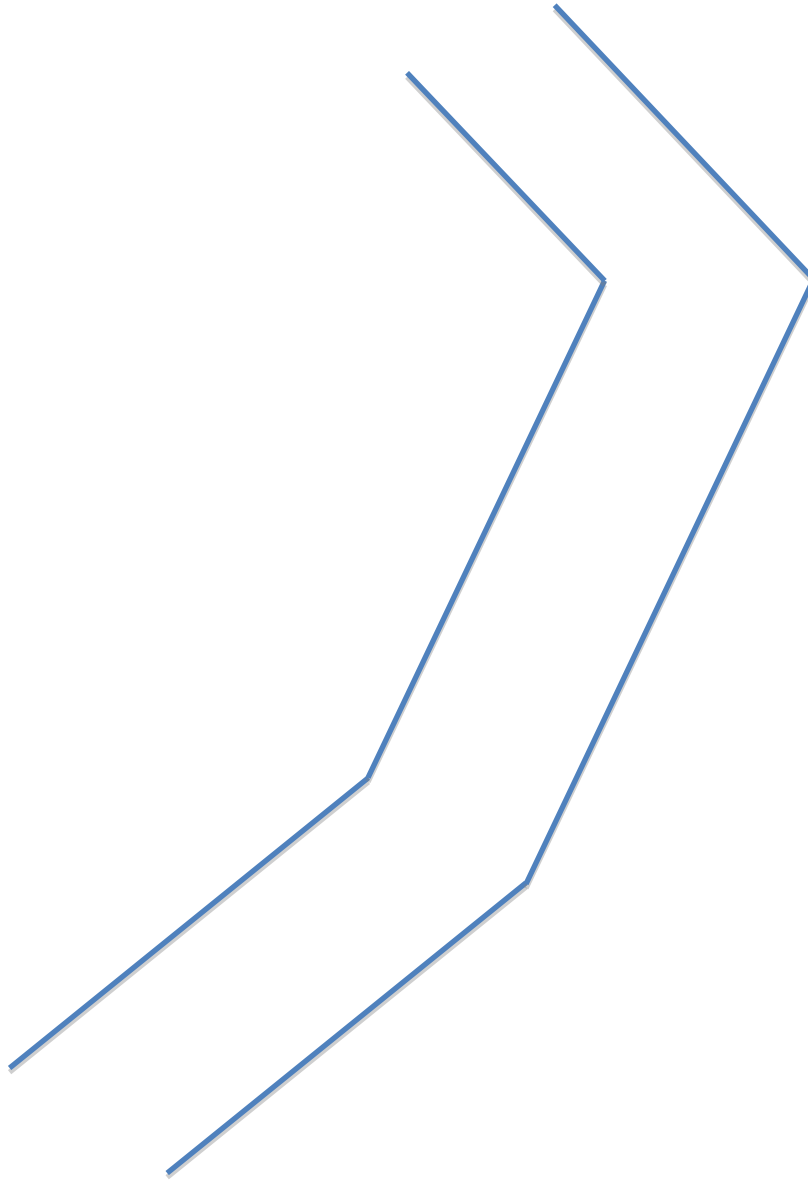
Give students directions to write a description of their diagram using the Law of Reflection.

Suggestions for Differentiation and Extension

- To extend this activity to outside of the classroom, allow students to find examples of the Law of Reflection outside of class and return with a diagram of what they found. They might find evidence of the law of reflection with light or sound but they might also find that objects follow the law of reflection as well. A ball reflecting off a surface (basketball, billiards, miniature golf, etc.) will also follow the law of reflection.
- To extend the activity in class, have students construct an arrangement of mirrors that would reflect light from a fixed point A to another fixed target point B. As an added challenge, place obstacles between the points to create a maze for students to work with by adjusting mirror positions and angles. If available, laser pointers should be used for this extension. Students could first predict the path of the laser then set up the maze to see if their prediction was accurate using a figure such as the ones below.

Extension Activities:

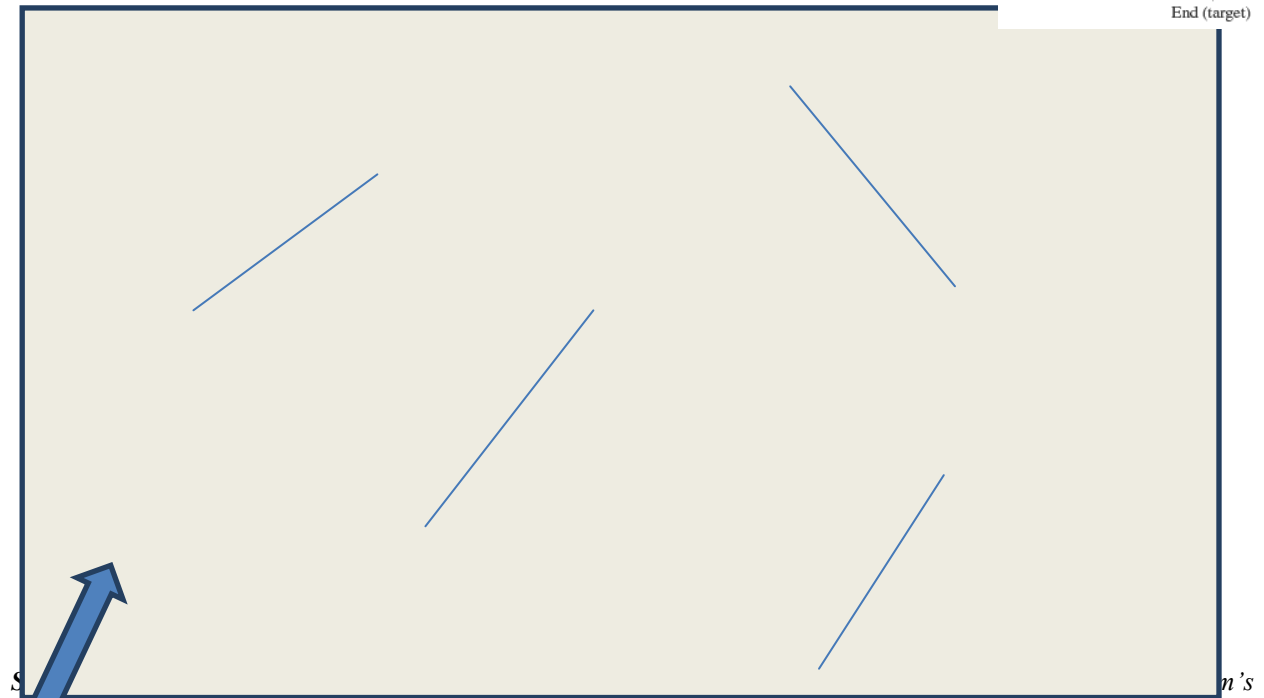
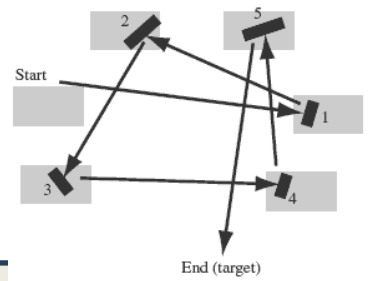
Challenge students to make the light move down the prescribed pathway. They use mirrors and a laser beam or flashlight.



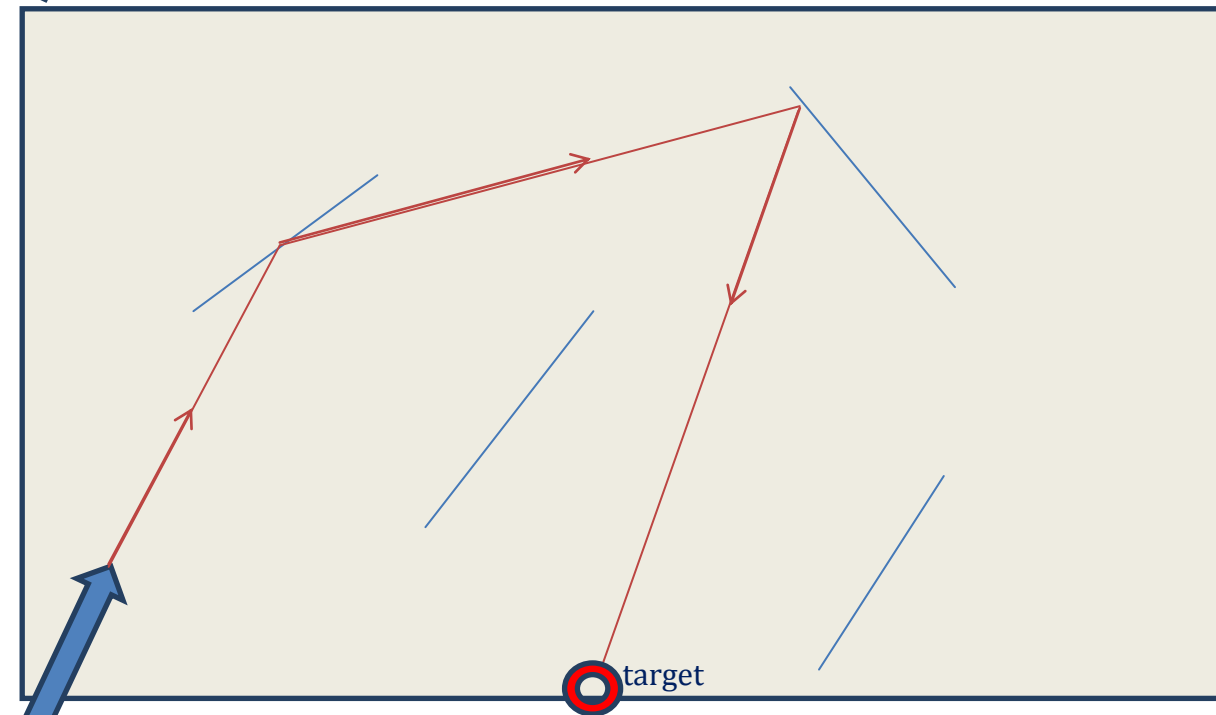
Extension Activities:

Once students understand the law of reflection they can use their new knowledge to **predict the path of light**. In this extension activity the teacher sets up a series of mirrors and the starting point for a light beam (laser pointers work best for this). The students' task is to determine where the light beams will be after being turned on. It is worth noting that not all mirrors will be used (they might be, but don't have to be).

Sample arrangement of mirrors and incoming light beam.



Students should be encouraged to test their prediction to see if they were correct.

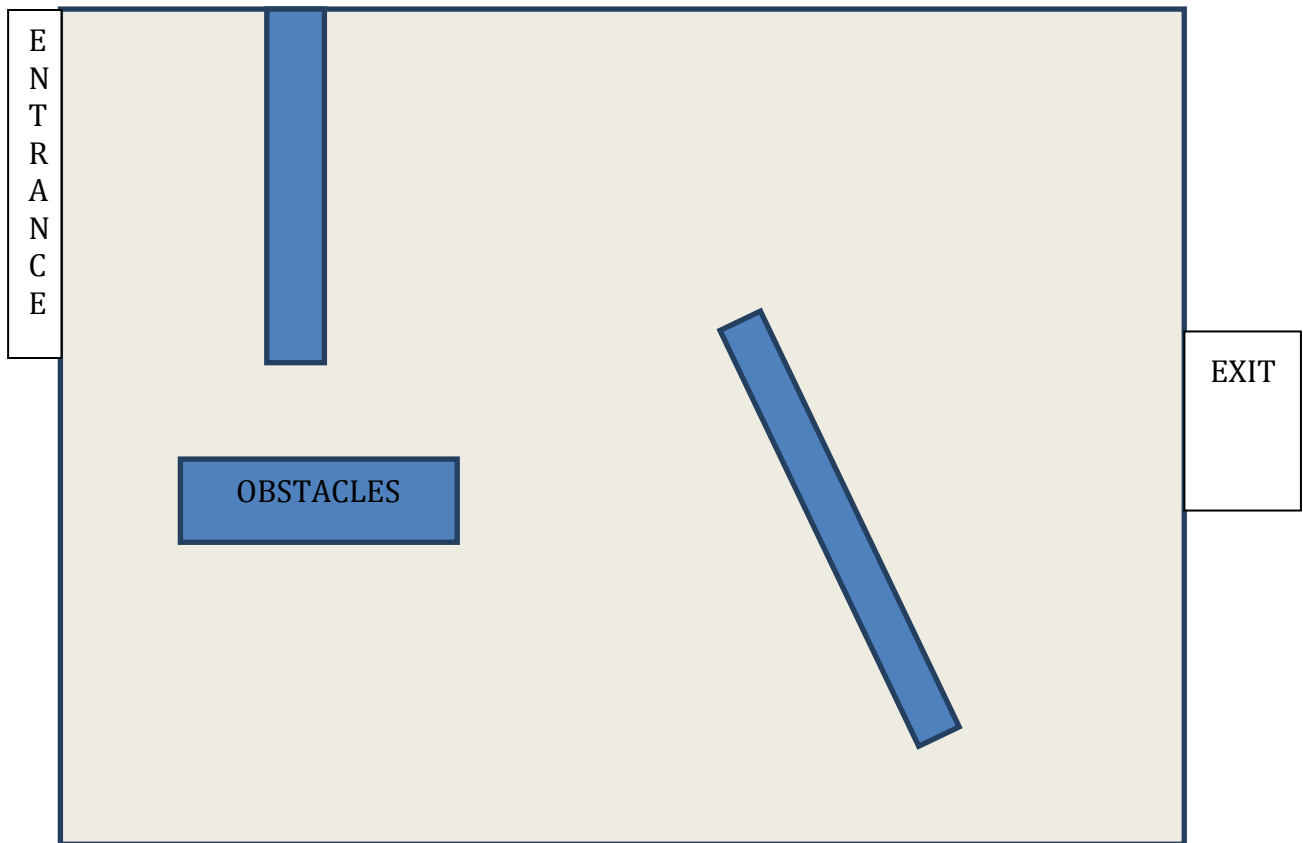


Extension Activities:

Once students understand the law of reflection they can use their new knowledge to determine the placement of mirrors so that a light beam can travel around obstacles in order to go from the entrance to the exit point in a “maze”. You can either draw a series of obstacles on a piece of chart paper or you can place actual obstacles on the tabletop for students to avoid. Indicate an entrance and exit point and have students predict where they should place mirrors so that the light beam successfully travels from the entrance to the exit. Placing or drawing obstacles on chart paper provides a writing surface for students to draw the light path, measure angles, etc. Once students have placed all their mirrors they are allowed to test their predictions to see how they did.

Materials needed: small plane mirrors, small binder clips (attached to the bottom side edge of the mirror to hold the mirror erect), laser beam (one per class is sufficient), protractors, rulers (helps for drawing straight lines), colored markers

Sample maze



Once students have successfully arranged mirrors so the light beam goes from entrance to exit you can challenge them to do complete the task using a specific number of mirrors.