INTERNATIONAL SPY MUSEUM

LESSON PLAN
DEVELOPED SEPTEMBER 2023

REFLECTIVE RECON

GRADES | 4th - 8th
TIME | 60 minutes
SCIENCE BRANCH | Physics, Geometry

KEY CONCEPTS
Law of Reflection, Using a Protractor to Measure Angles

Lesson Overview

In this lesson, students will explore the law of reflection to calculate the angles required for situating a series of mirrors so that a light shone at one point will hit the target at a different location.

Learning Goals / Objectives

Students Will Be Able To:

- Explain and demonstrate an understanding of the law of reflection.
- Use a series of mirrors to guide a light beam to a specific location.
- Use a protractor to measure and draw angles.

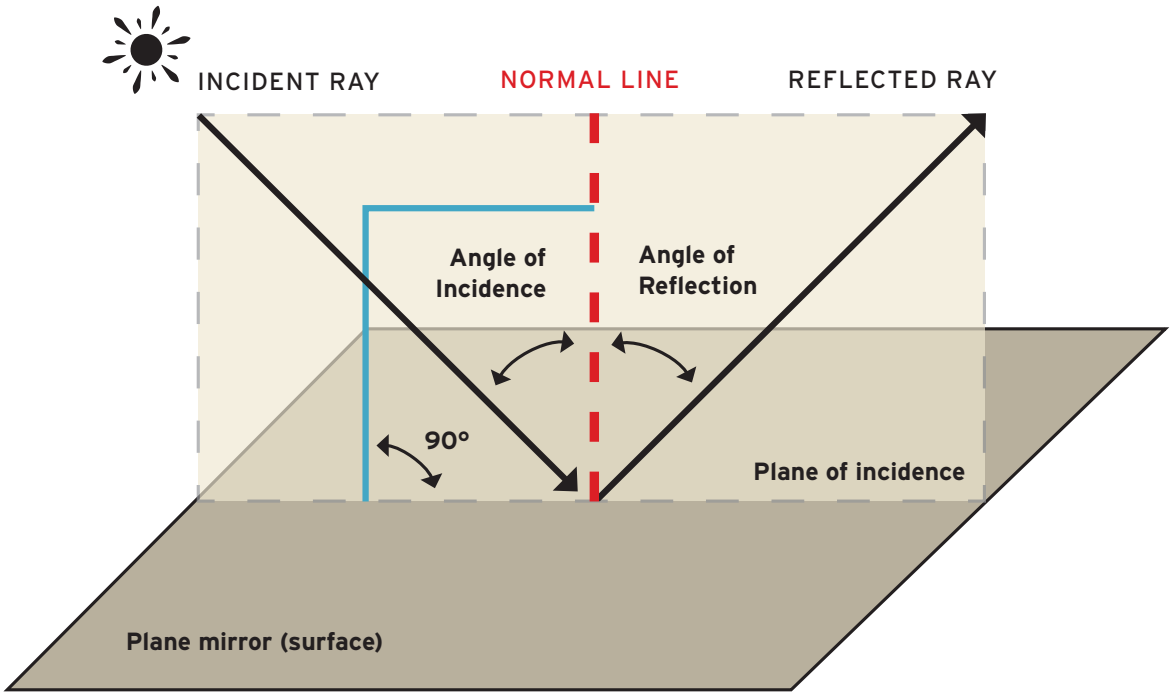
NGSS Performance Expectations

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. **Engaging in Argument from Evidence** Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**PS4.B: Electromagnetic Radiation** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object/s material and the frequency (color) of the light. **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. **ETS1.C: Optimizing the Design Solution** The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the rest results leads to greater refinement and ultimately to an optimal solution.	**Patterns** Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Background Information for Teachers

Light typically travels through space in straight lines. When a ray of light bounces off a smooth, flat, shiny surface such as a mirror or piece of metal, the angle at which it is reflected (known as the **angle of reflection**) is equal to the angle at which the light hit the surface (known as the **angle of incidence**). This is known as the **law of reflection**.

To measure the angle of incidence (or angle of reflection), you'll need to envision a line extending from the smooth, flat, shiny surface at a 90° angle. This is called the normal line. Using a protractor, measure the angle between the line of incidence and the normal line. Then, measure the angle between the line of reflection and the normal line. If measured correctly, these two angles will be the same.



Materials

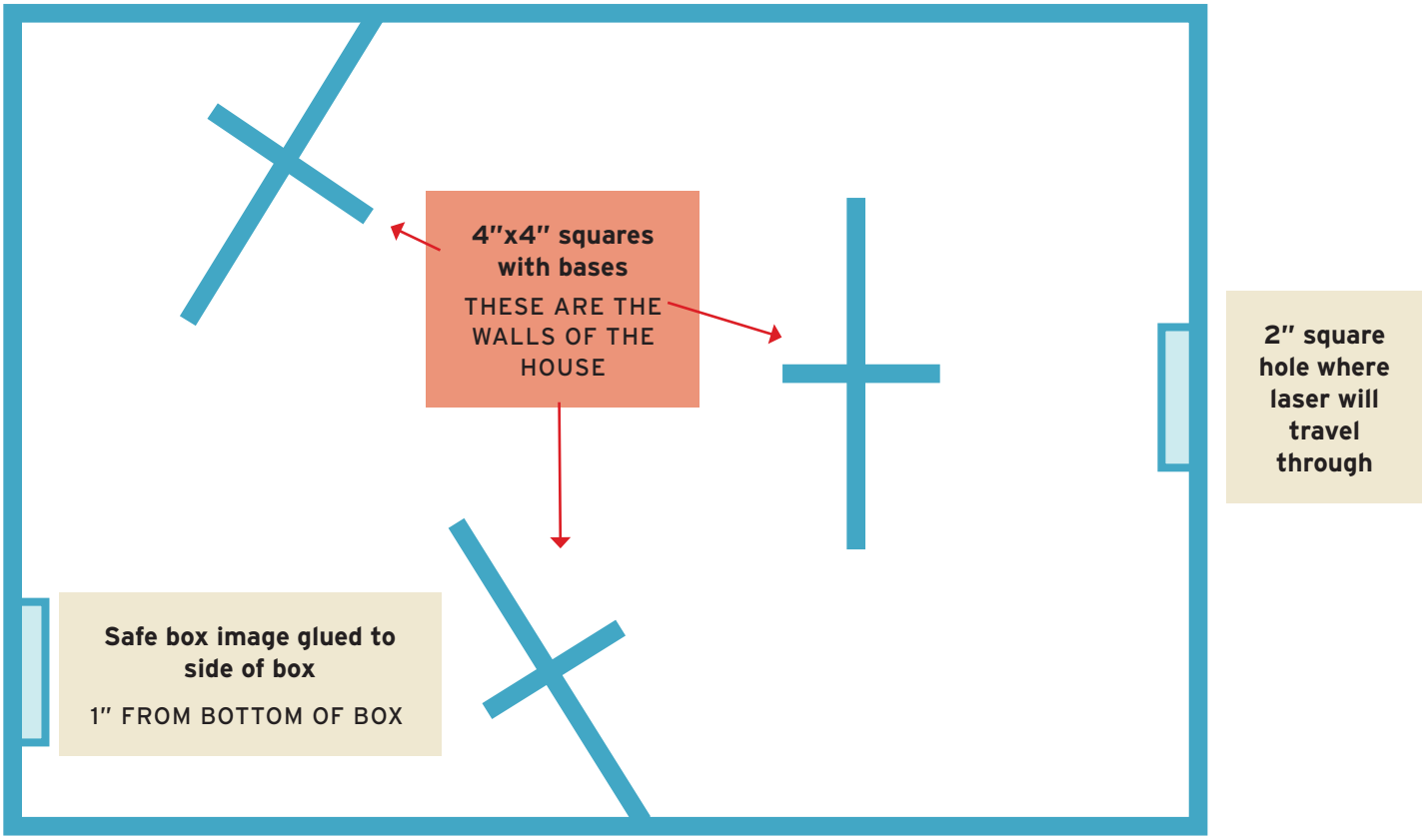
Each group (2-4 students per group) needs:

- O Glue
- O Protractor
- O Ruler
- O Scissors
- O Safe box image cutout (located in cardboard box stencil document)
- O A laser pointer (or flashlight which produces a strong, narrow beam of light)
- O Several 2" x 2" square adhesive mirror tiles (at least 3 per group)
- O Large cardboard box with flaps (with sides of box no more than 10" high)
- O Cardboard box stencils document
- O Optional: box cutter and hot glue gun (for teacher to use)

Preparation

Can be done by teacher ahead of time OR each group during class.

1. Cut the 4 top flaps off a cardboard box. Save the flaps.
2. Cut a 2" x 2" square cutout from one side of each box. The cutout should be 1" above the bottom of the box (use Cardboard Box Stencil as reference for size.)
3. Glue the safe box image (found in Cardboard Box Stencil document) to the inside wall of the box on the opposite side of the 2" x 2" hole. The safe box can be anywhere along that wall as long as it is 1" above the bottom edge.
4. From the saved cardboard flaps, cut the following (use Cardboard Box Stencil as reference if want)
   - O three 4"x 4" squares
   - O three (or more) 3" x 3" squares
   - O six (or more) 1" x 3" pieces
5. Make a 1/2" cut in the middle of one side of each 4" x 4" and 3" x 3" piece.
6. Make a 1/2" cut in the middle on the 3" side of each 1" x 3" piece.
7. Using one square piece and one 1" x 3" piece, hold them perpendicular to one another with the two cuts lined up. Push the two cardboard pieces together to form a base. Repeat this process until all the 4" x 4" and 3" x 3" squares are freestanding.
8. Peel the backing off a mirror. Attach the mirror to a 3" x 3" square. Repeat this step until each 3" x 3" cardboard square has a mirror attached.
9. Glue the three 4" x 4" cardboard squares inside the box according to the diagram below:



Instructions

1 Demonstrate the law of reflection. Review how to use a protractor to measure and draw angles. If students have not learned how to use a protractor, they may need additional instruction prior to this challenge.

2 Set up the challenge by reading the scenario to the students:

Tech Ops – our surveillance team has been closely watching a house in the center of town. Headquarters believe it is being used by a foreign country's intelligence service. Your team has determined that there is top secret information being stored in one of the inner rooms inside a safe. We don't know what this intel could be used for or why they have it, but it is imperative we find out what they know.

This is where you come in. In order to gain access into the house, we will cut the electricity to disable the home's security system and then have our team enter the house. This also means there will be no lights on inside. Using lots of flashlights could draw too much attention. However, our surveillance team has noticed that there are several mirrors in each room. We can use the mirrors to our advantage if we can shine a light from across the street into the house through the front-facing window and angle the mirrors the right way. If we hit the mirrors at the right angle, we will be able to light a path all the way to the safe. You will need to use your knowledge of reflection to determine the best set up for our laser light.

3 Show students one of the cardboard boxes and explain that this is a model of the safe house. The cardboard glued inside are the walls of the safehouse. The light beam will start at the hole in the side of the box, and it needs to end on the picture of the safe. Students will be given 3 mirrors to start with and must figure out where to place them for the laser to travel from the hole to the safe box picture.

4 Pass out materials (safehouse box, 3 standing mirrors, protractor, ruler, pencil). Students will use their knowledge of the law of reflection as well as a protractor to measure and draw (pencil) out the path the light will take on the bottom of the box. Remind students to mark specifically where (and at what angle) the mirrors are placed as they can sometimes shift during the activity.

5 Then, once students have drawn the light's path and placed their mirrors in the safehouse, their group will be given a flashlight or laser to test their measurements and adjust as needed.
Note: The laser will need to be placed on a book or another flat, raised surface so it shines through the hole.

6 Once a group's laser has successfully lit the safe, they have accomplished the mission!

Adaptations to Increase Accessibility and Extend the Learning

1. Increase/decrease the size of the box and/or the number of walls inside the safehouse.

2. Increase the number of mirrors that must be used by students.

3. Change the location of the walls (or don't glue them down) so that students are forced to try different angles for the light.

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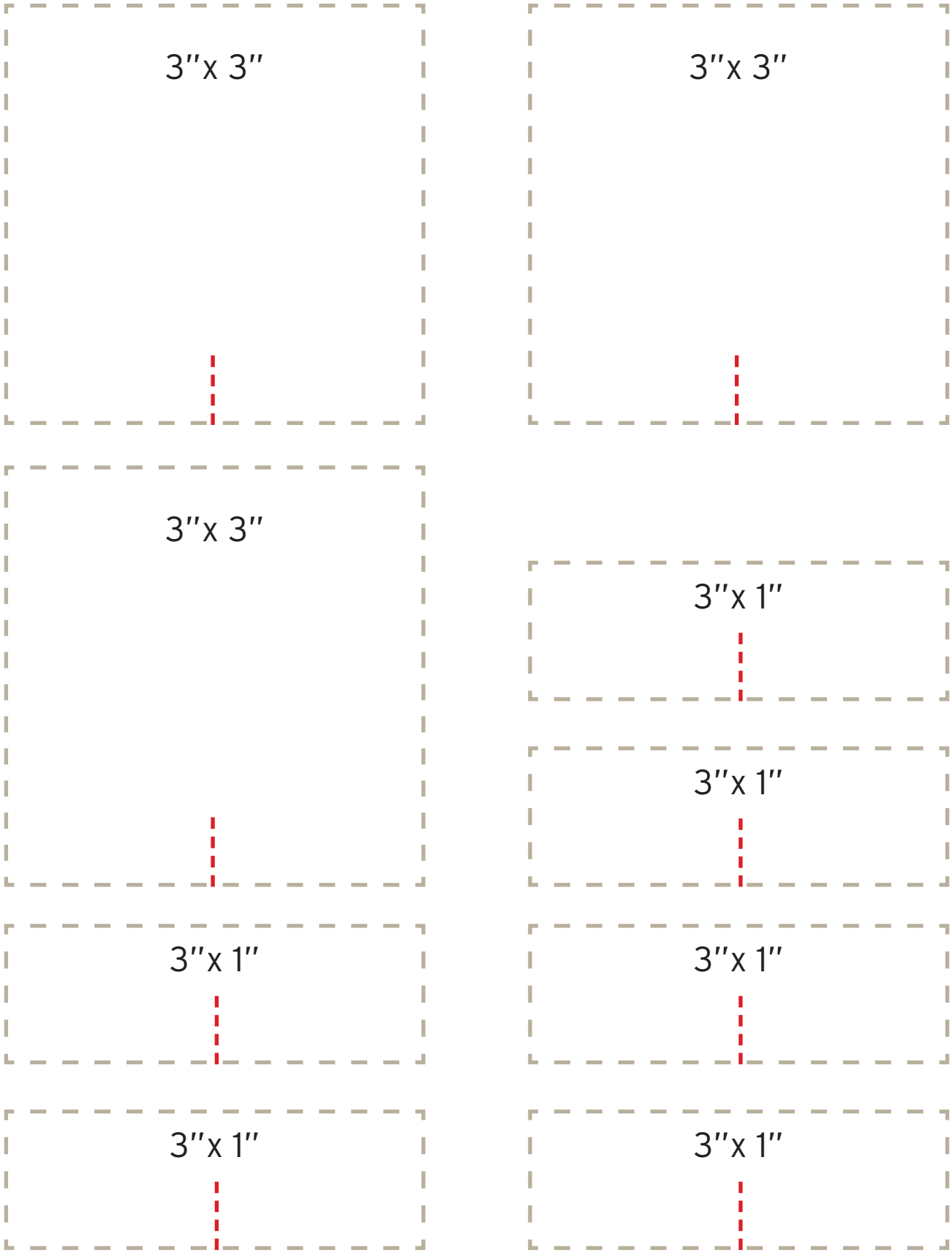
ACCOMPANYING WORKSHEETS

Cardboard Stencils



Cardboard Stencils

4"x 4"

4"x 4"

4"x 4"

2"x 2"