Guided Inquiry

Let Students "Discover" the Laws of Physics for Themselves

by David E. Meltzer and Amy Woodland Espinoza

This lesson on the law of reflection will help you understand how guided inquiry should be used.

There is ever-increasing interest in hands-on activities that allow middle-school science students to explore and discover physical principles on their own. The basic idea behind this "guided inquiry" is that students will gain a better grasp of scientific ideas if they perform activities that permit them to figure out these principles before the instructor actually states them explicitly in a lecture.[1] Of course, students need careful guidance from instructors if this is to succeed in practice. Here we present, as a model of such a guided inquiry activity, a lesson dealing with the law of reflection.

Preparing for the activity

Before beginning this lesson, students must understand the concept of angles including how to measure them using protractors. They also need to understand the definition of a right angle. In most classes, only a brief review and a bit of practice is needed, but more time may have to be spent on this phase if students are unclear on these concepts.

Students must also understand how to use ray boxes and mirrors. Ray boxes (available from many suppliers or from your local high school or university) use a light source and slotted screens to produce one or more pencil-thin rays of light. When placed on a white surface (such as a sheet of paper) in a darkened room, the rays can be easily viewed along any desired

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path. Small mirrors supplied with the boxes allow for the production and viewing of reflected rays. Before teaching the lesson, give students 10 to 15 minutes to practice with the ray boxes and mirrors.

Introducing reflected beams

Start the lesson by allowing students to predict the path of a reflected beam. First, supply groups of three or four students with a diagram of a light beam heading toward a mirror (Figure 1a). Then, project the same diagram onto a screen using an overhead projector and have a few volunteers sketch their prediction of the path of the reflected light beam, labeling each prediction A, B, C, and so on. Give the class plenty of time to consider the predictions and ask if anyone else has a prediction that differs from those already drawn. A diagram of students' typical predictions is shown in Figure 1b.

Students then test the validity of the predictions by placing their ray box on top of their copy of the diagram and examining the actual path of the reflected ray. At this point, no measurements are made; students simply observe. As a class, discuss which prediction was closest to the actual path.

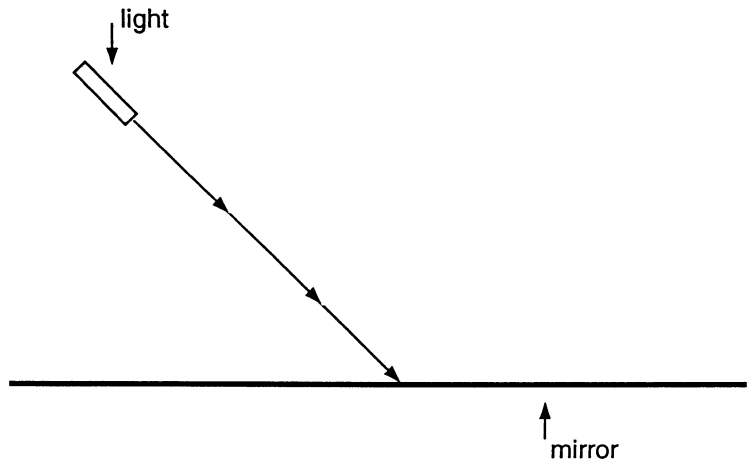
Learning the terminology

In order to provide common language with which to discuss the observations students just made, as well as those to come, take a few minutes to draw and discuss angles of incidence (Figure 2a). Then, draw and discuss angles of reflection (Figure 2b). As you move from one diagram to the next, erase the "angle of incidence" diagram before moving on to the angle of reflection to avoid giving any hint of the relationship between these two angles.

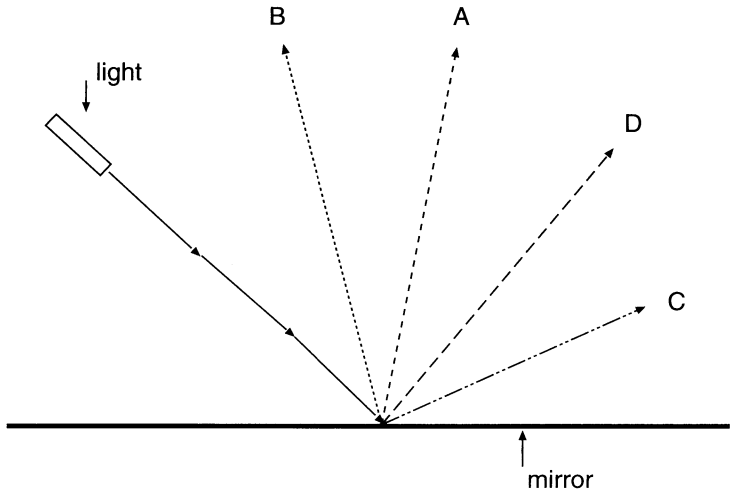
After discussing the terminology, tell students that there is a simple relationship between the magnitudes of the angle of incidence and the angle of reflection that they will learn from carrying out a simple experiment. Through the activity at the end of this article, students will find that the two angles seem to be the same and will thus "discover" the law of reflection, which states that the angle of incidence is equal to the angle of reflection.

Figure 1. Introducing angles of incidence and reflection

1a. Experiment setup



1b. Examples of student predictions



Guiding students toward discovery

While students carry out the steps of the activity, circulate around the room offering assistance as needed. When each group is finished, moderate a class discussion on their findings. Have a representative from each group report their measurements for the angles of incidence and reflection, and create a chart on the board listing the values. The chart should list both the angle of incidence and the angle of reflection found by each student group, with a separate row for each group's results to allow easy comparison of the students' observations. Even though students are measuring the same diagram, there will probably be some minor variations in their measurements; this provides students with a better understanding of experimental uncertainties. Ask students for their comments on the relationship between the two angles and let them draw their own conclusions as much as possible. They should soon reach a consensus that the angles seem to be about the same. Confirm this observation, and tell students that they have just discovered the law of reflection.

Assessment and application

Assessing students' understanding of the law of reflection is easy. Simply provide students with a diagram of a light beam (incident beam) aimed at a mirror (Figure 3), and ask the following questions:

- What is the angle of incidence?
- What would be the angle of reflection?
- Were you right? Use the ray box to check your answers.

To determine the angle measure-

Figure 2.

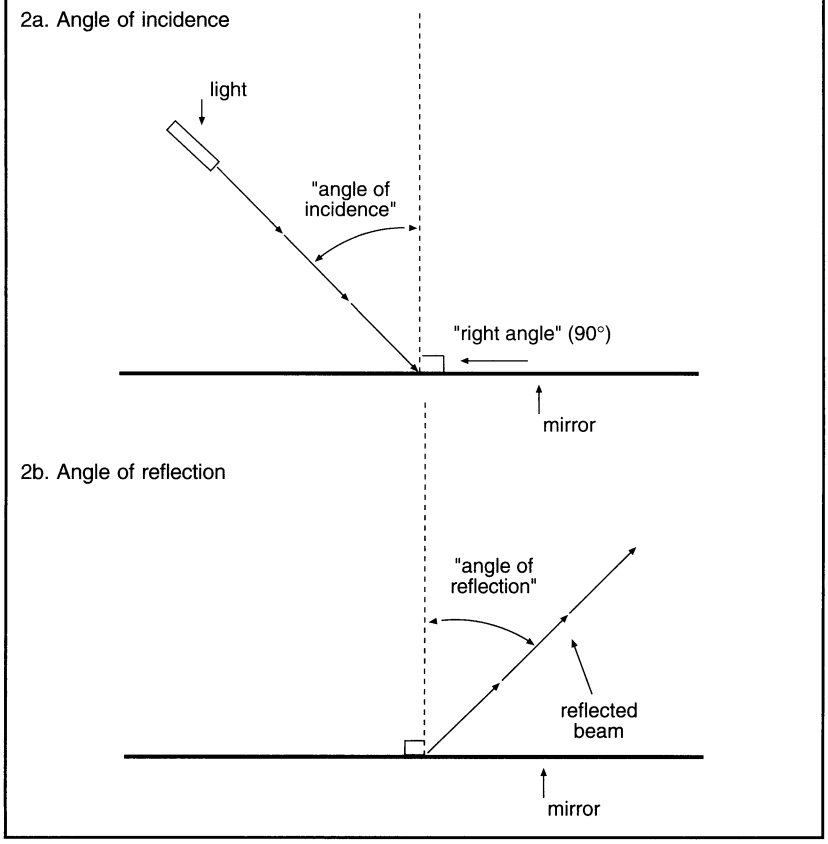
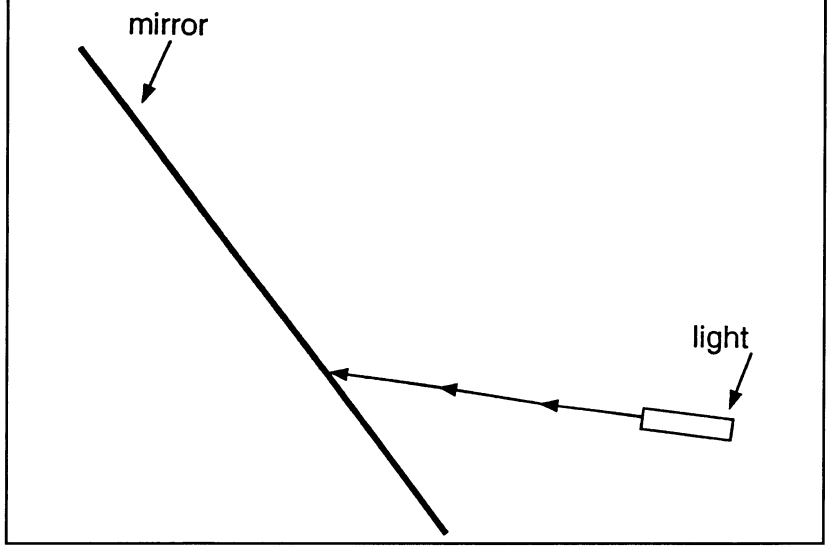


Figure 3. Assessment diagram



ments, students must first remember to draw a line perpendicular to the mirror. A useful follow-up experiment is to supply a diagram with the reflected beam indicated, and then ask students to draw the incident beam. They could then check their answer using the ray box.

After students have successfully completed the laboratory-type experiments described previously, ask them to use the principle they have just learned. Supply each group with a mirror and a flashlight and instruct students to direct a reflected beam of light to shine on some object placed at random on their table. A more complicated activity is to give students two or three larger mirrors and ask them to direct a flashlight beam at an object located inside the (darkened) room. Through trying to carry out the tricky task of getting the beam to hit the target after two or three separate reflections, students gain a much better understanding and appreciation of the law of reflection.

Acknowledgment

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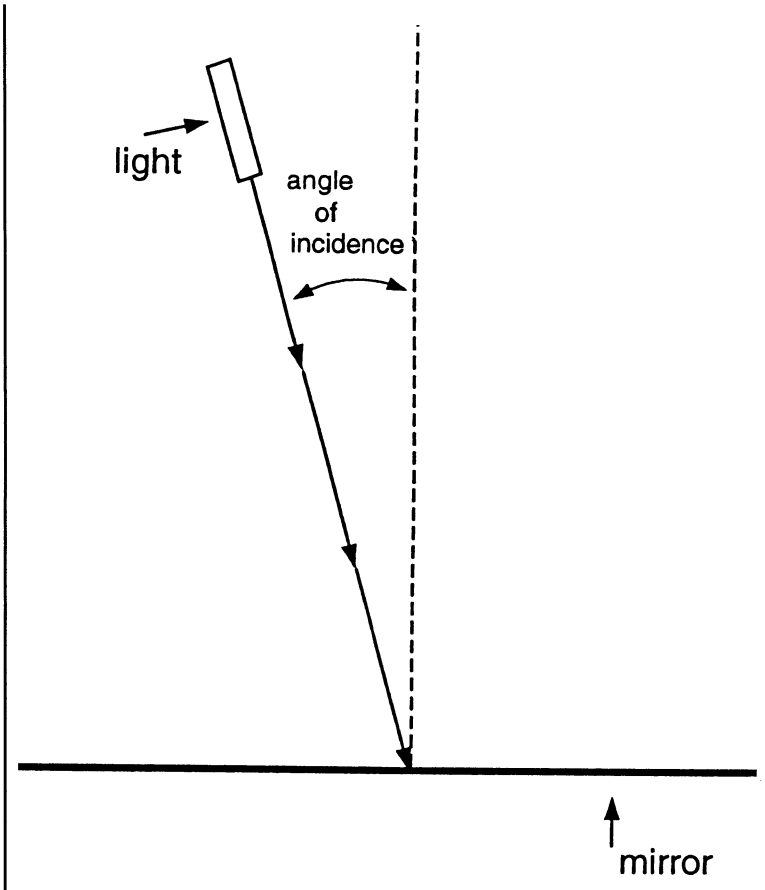
Reference

1. Lunetta, V.N. and S. Novick. 1982. *Inquiring and Problem-Solving in the Physical Sciences, A Sourcebook.* Dubuque, Iowa: Kendall/Hunt.

Discovering the laws of reflection



Materials

(For each group of three or four students)

- Protractor
- Ray box (if you don't have enough ray boxes for each group, students can share)
- Mirror
- Diagram of angle of incidence (above)
- Pen or marker

Procedure

1. Using a protractor, measure the angle of incidence as depicted in the diagram.
2. Record your measurement.
3. Place your ray box and mirror on the diagram and position them so that the incoming light ray follows exactly the same path as shown on the diagram and hits the mirror at exactly the same angle.
4. Use a pen or marker to trace the path of the reflected ray onto your diagram.
5. Use the protractor to measure the angle of reflection.
6. Record your measurement and be prepared to report your two measurements to the class.
7. How do your measurements of the two angles compare to each other? Is one angle obviously larger than the other, or do they both appear to be about the same? Be prepared to discuss your answer with the rest of the class.