

LASER BEAMING

Addresses CCSS

Level of Difficulty: 3

Grade Range: 3-5

OVERVIEW

In this activity, students will use a laser pointer and flat mirrors to explore the law of reflection.

Topic: Reflection of light

Real-World Science Topics

- An exploration of the behavior of light
- An exploration of the law of reflection

Objective

Students will gain an understanding of how light interacts with flat, reflective surfaces.

Materials Needed for Teacher Demonstration

- laser pointer or flashlight with bright, narrow beam
- flat mirror
- cornstarch or flour (optional)

Materials Needed for Student Teams

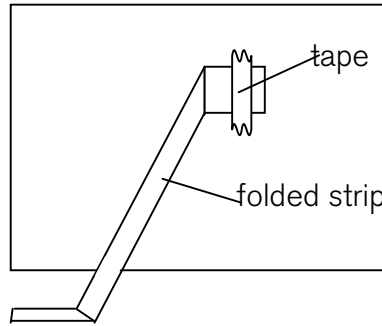
- laser pointer or flashlight with bright, narrow beam (one for the whole class)
- large table (a hard, level floor can also be used)
- butcher paper (enough to cover the table)
- flat mirrors with stands (at least three per team)
- two white index cards and tape, white paper (not foam) plate, or white paper cup (per team)
- white index card or piece of paper
- rulers
- pencils
- erasers
- protractors (optional)
- cornstarch or flour (optional)

Teacher Preparation

You will need to prepare the "target" that students will try to hit with their light beam. You can choose to form the target using white index cards, a white paper plate, or a white paper cup, as specified on the materials list.

To make a target from index cards, cut a 1"-2"-wide strip from one index card. Fold the ends of the strip in opposite directions to form a stand, and then tape one end of the stand to the second index card, as shown following:

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Draw a small circle or other shape on the front of the index card to act as the target.

To make a target from a paper plate, fold the plate in half. Stand it up on the folded edge. Draw a small circle or other shape on the upright part of the plate to act as the target.

To make a target out of a paper cup, draw a small circle or other shape on the side of the cup. Alternatively, draw the target on the inside bottom of the cup, and then lie the cup on its side.

Caution: Laser light and bright lights can cause pain or damage if they are shined directly into a person's eyes. Because of this, you may wish to handle the laser pointer or flashlight yourself rather than letting students use it. Have students set up their mirrors, and then have them ask you to shine the pointer or flashlight from the starting position to test the setup. If your students are older, you may allow them to use the pointers or flashlights themselves, but warn them not to turn them on except to test their setups, and not to shine the light into anyone's eyes.

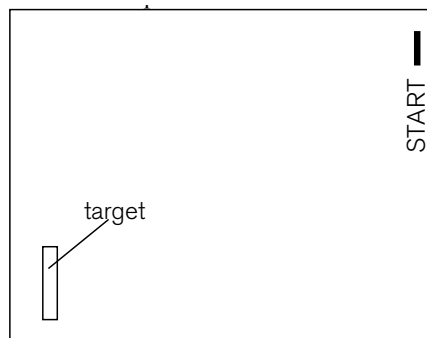
You may wish to dim the lights in the classroom to make the light beams more visible.

STEPS FOR LASER BEAMING

- 1. Warm-Up Activity:** : Demonstrate the laser pointer for students. Point out that it produces a very thin beam. Dim the lights and shine it across the room. Point out that the spot it makes on the far wall is no bigger than the spot it makes on a closer object. Explain that a laser is designed so that the light from it travels in a very narrow path, instead of spreading out in many directions like the light from a flashlight or light bulb. If you have a flashlight available, have students compare and contrast the light from the flashlight with the light from the laser. Point out that the actual beam from each device is invisible, except when it strikes another object (such as the wall). If you wish, sprinkle a small amount of cornstarch or flour into the air to produce dust. Point out to students that the dust makes the beam visible. Explain that the beam is bouncing, or *reflecting*, off of the dust particles, and that is what makes them visible.
- 2.** Hold up a flat mirror. Ask students to describe what they use mirrors for. Explain that mirrors, like dust particles, also reflect light, but mirrors reflect the light in a predictable way. Demonstrate for students how the light can be reflected off the mirror and end up in a different location. (For example, point the light at the back wall and place a mirror in its path; the light beam should be visible on the wall behind you). Adjust the angle of the mirror and have students describe what they observe about the resulting position of the reflected light spot. Explain to students that in this activity they will use mirrors to make a light beam hit a target.
- 3.** Review with students the following points:
 - Light always travels in a straight line until it hits an object.
 - When light hits a mirror, it bounces back, or reflects. There is a relationship between the angle at which the light hits the mirror and the angle at which it is reflected.

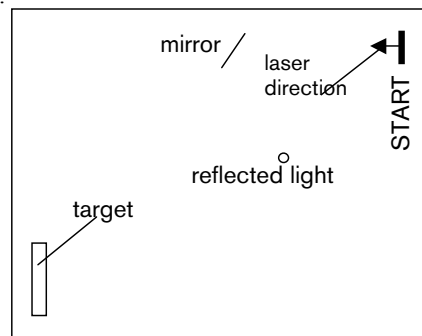
Remind students to keep these points in mind as they design and test their mirror setups.

- 4.** Divide students into groups. Set up each group on a separate table or section of floor. Cover the table or floor with a piece of butcher paper. Tell students they can write on the paper to mark where they place the mirrors. They can also write on the paper to trace out the predicted and actual light paths. Draw (or have students draw) a short line (a few inches long) along one edge of each piece of paper to indicate the position of the laser pointer. Mark this line “START.” Place the target at another location on the paper. Make sure each piece of paper has a different arrangement between the START line and the target. The picture below shows one example of an initial setup.



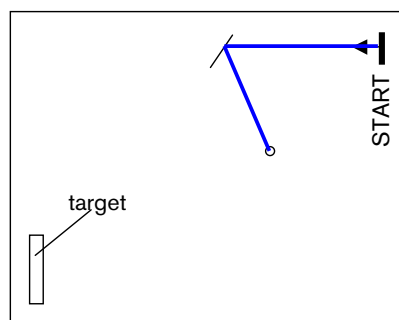
STEPS FOR *LASER BEAMING*

5. Explain to students that they will first observe the behavior of light when it reflects off a single mirror, and then they will use this information to predict where to place their mirrors to get the light to hit the target. Give each group one mirror and a blank index card or sheet of paper. Starting with one group, place the laser pointer on the START line and turn it on. Have one student in the group place the mirror in the path of the beam, and have a second student use the card or paper to locate the position of the reflected beam. Have a third student use a pencil to mark the position and direction of the beam from the pointer; the position and orientation of the mirror; and the position of the reflected beam (an example is shown below).



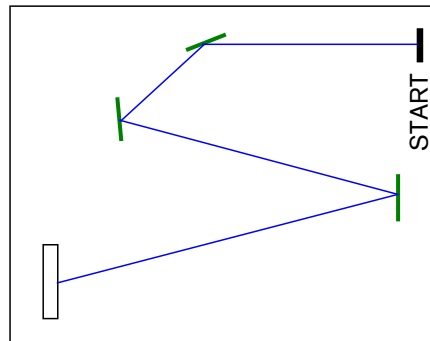
If you wish, you may sprinkle a small amount of cornstarch or flour in the air to make the beam visible. Repeat this process for each of the groups. Allow other students to look on while you shine the beam for each group. Note: For more mature classes, you may allow students to operate the lasers themselves to carry out their investigations. Be sure to remind students that they should never look directly into the laser beam or shine the beam into another person's eyes.

6. Once students have marked the positions of the mirror, laser, and reflected beam, have them use rulers to draw the paths of the light beams (if you used dust to make the beam visible in Step 5, have students compare their observations of the beam with their drawn paths). If necessary, remind students that light always travels in a straight line unless it hits something. The blue lines in the image below show an example of how students may construct the paths of the beams.



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- If students are familiar with how to use protractors, have them measure the angles between the original beam and the mirror and between the reflected beam and the mirror. Have them record the angle measurements on the paper. If students do not know how to use protractors, have them compare the two angles qualitatively and record their observations.
- Pass out the remaining mirrors to each group. Challenge students to work together to figure out a way to use their mirrors to direct the light beam from the START line to the target. Encourage them to use rulers and (if appropriate) protractors to predict the path of the light before and after it strikes each mirror. (If they wish, they can erase any marks they made during Steps 5 and 6.) Students do not need to use all of the available mirrors, but they should use at least two mirrors. When a group thinks their setup is complete, have them ask you to help them test it. To test the setup, place the laser pointer on the START line, pointing in the direction indicated by the group. Turn on the pointer and have the group observe the target. If the reflected beam appears on the target, the team's setup is correct, and they can record it on their worksheets. If the reflected beam does not appear on the target, have students use the index card or piece of paper to locate the reflected beam and mark its location. Then, have students revise their setup to fix any errors. If you wish, use cornstarch or flour to make the beams visible, and have students compare the actual beam paths to the predicted paths. An example of a correct path that uses three mirrors is shown below. The green lines are mirrors, and the blue lines show the paths of the light beams.



- Wrap-up Activity:** Once each group has successfully directed its beam to the target, have each group demonstrate its setup to the class. Ask students to share their experiences. Prompt discussion by asking some of the following questions:
 - Were you able to determine the relationship between the original and reflected beams? What relationship did you observe?
 - Did you get the beam to hit the target? How many times did you have to revise your setup to get it to work?
 - What challenges did you encounter, and how did you resolve your challenges?

STEPS FOR *LASER BEAMING*

Laser Beaming Extension Activities

1. To make the activity more challenging, place obstacles (e.g., books, rocks, or toys) on the paper and have students use the mirrors to direct the light around the obstacles to the target.
2. To introduce the concept of refraction, have students use prisms or lenses in addition to mirrors to direct the light beams.
3. Have students use curved mirrors instead of flat mirrors to direct the light beams. Have them compare and contrast the effects of the curved mirrors on the path of the light.

LASER BEAMING BACKGROUND INFORMATION

What is light?

Light is a form of energy. Scientists typically model light as either a wave or as a stream of particles. Which model they use depends on which properties of light they are studying.

A beam of light, such as the light produced by a flashlight, is actually a collection of a many light waves. Each wave travels independently of the rest, but they all obey the same physical laws.

What happens when light hits a surface?

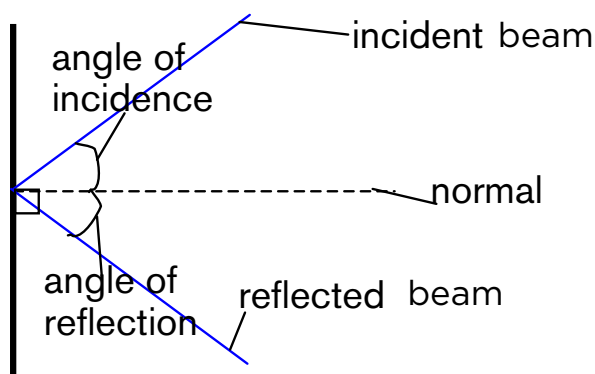
Three things can happen when light hits the surface of an object. It may bounce, or reflect, off the surface. It might also pass through the surface into the object. When this happens, the light ray typically bends, or refracts. Also, depending on the properties of the surface material, some (or all) of the light energy might be absorbed by the material.

What physical law describes how light reflects?

If a beam of light reflects off of a surface, the law of reflection describes the path the reflected beam will take. To understand the law of reflection, we must first define a few terms:

- The *incident beam* is the beam of light that strikes the surface.
- The *reflected beam* is the beam of light that reflects off the surface.
- The *normal* is an imaginary line that is perpendicular to the surface.
- The *angle of incidence* is the angle between the incident beam and the normal.
- The *angle of reflection* is the angle between the reflected beam and the normal.

The diagram below illustrates these terms.



LASER BEAMING BACKGROUND INFORMATION

According to the law of reflection, the angle of incidence is equal to the angle of reflection for every light ray that strikes a surface. Although the law of reflection is defined in terms of the angles relative to the normal, the same angle equivalence holds for the angles between the beams and the surface itself. That is, the angle between the incident beam and the surface is equal to the angle between the reflected beam and the surface.

Key Vocabulary

incident beam: a beam of light that strikes a surface

reflected beam: a beam of light that bounces off a surface

normal: an imaginary line that is perpendicular to a surface

angle of incidence: the angle between an incident beam and a normal

angle of reflection: the angle between a reflected beam and a normal

law of reflection: a physical law that states that the angle of incidence of a light beam is equal to the angle of reflection of the beam

LASER BEAMING TEACHER HANDOUT

1. Think about how the light beam reflected off the single mirror. What did you observe about the angle between the mirror and each beam?

[Sample answer: Both angles were about the same.]

2. Draw a picture showing how you set up your mirrors to make the light hit the target.

[Images will vary.]

3. In your own words, describe how your group figured out where to put the mirrors.

[Sample answer: We knew that light travels in a straight line, and that the angle between the first beam and the mirror is the same as the angle between the reflected beam and the mirror. We drew straight lines to represent the light paths, and we used a protractor to draw the angles so that they were the same.]

4. Did you have to change your setup from your original prediction? If so, why?

[Sample answer: Yes, we had to change our setup once. We measured the angles wrong on one of the mirrors the first time.]

LASER BEAMING STUDENT HANDOUT

Name:

Date:

1. Think about how the light beam reflected off the single mirror. What did you observe about the angle between the mirror and each beam?
2. Draw a picture showing how you set up your mirrors to make the light hit the target.
3. In your own words, describe how your group figured out where to put the mirrors.
4. Did you have to change your setup from your original prediction? If so, why?