



Classroom Activity | Grades 6-8

# Right Back at You!

## GUIDING QUESTION

How does a reflectivity tester work? How can we determine which surfaces are more reflective?

## LEARNING OBJECTIVES

Students will be able to:

- make and use a reflectivity tester.
- identify properties of materials that make them more or less reflective.
- understand and explain how a retro-reflector increases reflectivity.

## OVERVIEW

How well light is reflected is an important safety factor. Added reflectivity makes signs more visible and bicycles and walking clothes safer for their users, especially at night. In this lesson, students make a rudimentary light reflectivity tester to help them determine the relative reflectivity of various materials around the classroom. They determine what qualities make surfaces more or less reflective. As an extension, they are encouraged to learn about retro-reflectors and how they are incorporated into 3M safety products. At home, students can continue to investigate reflectivity with their parents with some simple activities.

## NEXT GENERATION SCIENCE STANDARDS

- 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 light. (MS-PS4-2)
  - The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)
  - A wave model of light is useful for explaining brightness, color, and frequency-dependent bending of light at a surface between media (MS-PS4-2)



- However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)
- ETS1.B Developing Possible Solutions
  - Models of all kinds are important for testing solutions. (MS-ETS1-4)

## LESSON TIME FRAME

This lesson requires two 45 minute sessions to complete: one session to engage students and demonstrate the reflectivity tester and a second for students to make and use their testers and discuss findings.

## BACKGROUND INFORMATION

Light, as a form of energy, can be reflected from most surfaces to some degree. It is this property of reflection that actually allows us to “see” objects when light shines on them. When we look at and see a plant for example, we are seeing light that has originated from a source and has then been reflected off the plant to our eyes. Different surfaces reflect light differently; some surfaces reflect light poorly (a dark sweater) while other surfaces reflect light very well (a mirror).

In this lesson, students will make and use a rudimentary device to determine the degree of reflectivity of surfaces. See the accompanying figure. You should construct one for yourself in advance and practice with it so you can show your students how it’s made and used. Directions can be found in the Teacher’s Materials/Prep section of this document.

Retro-reflection: One limitation of light reflection is that a beam of light reflects in a very well defined direction. The science of optics says that the angle of incidence is equal to the angle of reflection. This means that if you view a reflective surface at an angle that is not equal to the angle of incidence, you do not see the original source or image. One way around this issue is to make use of a double reflection - a reflection of light first from one surface, then a second surface that is oriented at a 90-degree angle from the first. This way, if you move the light source up and down or sideways, you can still see the image. It is, however, still limiting in the third dimension. To resolve this issue requires a third reflection and a third reflective surface oriented at a 90 degree angle from both the first and second surfaces. The effective shape of these three reflective surfaces is essentially a corner, looking from the inside, of a rectangular prism. Now, no matter what angle you shine a light beam into this corner reflector, you will always have the light reflected straight back to the source. If these surfaces are reflective mirrors, you need not “aim” the mirrors, for no matter what direction they face, light will always reflect directly back to the source. Many devices and materials make use of this property of light, which is called retro reflectivity.

See 3M website for more details about retro reflectivity:

[https://www.3m.com/3M/en\\_US/road-safety-us/resources/road-transportation-safety-center-blog/full-story/~road-signs-retroreflectivity/?storyid=328c8880-941b-4adc-a9f9-46a1cd79e637.](https://www.3m.com/3M/en_US/road-safety-us/resources/road-transportation-safety-center-blog/full-story/~road-signs-retroreflectivity/?storyid=328c8880-941b-4adc-a9f9-46a1cd79e637)



Highway signs make use of this property to reflect headlights back to the source, the car and driver. The Apollo astronauts left a retro-reflector on the surface of the moon. Scientists on Earth can measure and monitor the moon-Earth distance by reflecting a high-powered laser from the retroreflector and always count on seeing the reflected beam. This way they can measure the time-of-flight of a pulse of the laser and therefore calculate the distance.

## MATERIALS

### Teacher Materials/Prep

- Flashlight\*
- 3×5 index card
- Scissors
- Construct a reflectivity tester\*\*
- Small mirrors (optional)
- Chalk dust (optional)
- Print copies
  - Home Connections Resource to send home with students
- Print copies and cut out
  - Six Word Story Summary Student Capture Sheet

\*An ideal flashlight for this activity is a small LED flashlight. These are readily available from drug stores, grocery stores, or hardware stores. Any standard flashlight will work but the diffuse beam is less effective at making reflections visible than an LED flashlight. For eye-safety's sake, you should not use small laser pointers for this activity.

\*\*To construct a reflectivity tester, make a hole in the left half of a 3×5 index card with scissors so your flashlight can snugly fit into the hole. The index card should be hung enough around the flashlight so it stays attached without you having to hold the card itself. To use the flashlight as a reflectivity tester, hold the flashlight a few centimeters away from a flat surface so the beam shines on the surface and reflects light to the backside of the index card. If the surface is reflective, you should see the reflected light through the index card. The index card acts like a screen so you can see the reflected light. You'll see that as you shine the flashlight at different colors for example, these various colors will be visible through the index card. Moving the beam of the flashlight from a dark surface to a lighter surface produces a brighter (reflected) light on the index card.

### Student Materials

- Six Word Story Summary Student Capture Sheet
- Home Connections Resource
- Notebook and pencil



## Materials per Student Group

- Flashlight
- 3×5 index card
- Scissors
- Variety of flat surfaces found in any classroom
- Materials to test for reflectivity\*\*

\*\* These materials could include items such as CDs, aluminum foil, construction paper, various earth materials, books, and cloth samples. (The reflectivity tester is sensitive enough to show a difference of reflectivity between the front and the back of a CD.)

## CLASSROOM ACTIVITY

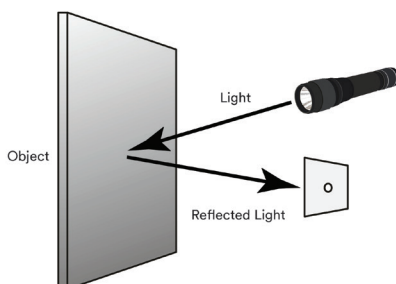
### Day 1

#### Engage

1. Turn on a standard flashlight and shine it around the classroom. If you have a mirror handy, shine the flashlight into the mirror so the beam reflects into students' faces. Ask students to describe what is happening to the beam of light when you shine it on the mirror. In addition, sprinkle some chalk dust in the beam of the flashlight so students can see the light reflecting off of the chalk dust. If you don't have chalk dust, substitute something small and reflective such as confetti or small pieces of aluminum foil. Ask students to explain why they're able to see the chalk dust or confetti. Be sure they can articulate that the light from the flashlight is reflecting off of the particles of dust and back to their eyes.
2. Ask students for examples of other situations where light is reflected from a surface or object and impinges on our eyes. Make note of student responses so you can tailor the lesson to the appropriate levels of understanding, including any misconceptions, about light and reflection.

#### Explain

1. Put the following diagram on the board or chart paper and have students copy it to their notebooks.





2. Refer to the diagram as you review the activities you demonstrated in Engage section above. Ask students what fraction of the light they think is reflected from the surface of an object. Students might suggest that not all of it is. Use this opportunity to continue a discussion about reflectivity and absorption of light on common objects. Tell students you are going to provide them with materials to make a device that will let them find out the relative reflectivity of objects. Tell them you are using the term ‘relative reflectivity’ here because this device is very basic and it cannot actually measure reflectivity as a number but only provides a general sense of how the reflectivity of one surface compares with another.
3. Display the reflectivity tester you made, show students how you made it, and demonstrate how to use it.

## Day 2

### Explore

1. Show students the materials they have to build the reflectivity tester as well as the possible objects to test. Divide students into groups depending on the materials you have available and let them begin making their testers. (Directions to construct the reflectivity tester can be found in the Teacher Materials/Prep section of this document.)
2. Once the testers are completed, send teams to go around the room to make relative comparisons of the reflectivity of a wide variety of materials. Have students document the results in their notebooks. If you were to select a subset of items, you could challenge groups to rank the items from least reflective to most reflective, then have groups compare rankings.
3. Bring students together to discuss their findings. Were groups in agreement about the reflectivity rankings of the set of items? Using this simple device, were they able to make any discoveries about the nature of reflections or about surfaces that they did not know before?

### Extend

1. Ask students if they have any clothing or accessories that make use of reflective material or contain reflective tape. Examples might include jackets, hats, backpacks, shoes, helmets, bicycles, etc. Invite discussion about how these materials work and what their purpose might be. If students have such items with them at school, they could be used to continue this investigation of light reflections.
2. Students could use the Internet to research some of the many products 3M makes that are light reflective. You can view them here: [https://www.3m.com/3M/en\\_US/p/c/ppe/apparel/reflective-fabrics/i/safety/personal-safety/](https://www.3m.com/3M/en_US/p/c/ppe/apparel/reflective-fabrics/i/safety/personal-safety/) Can they think of any novel ways to use such products?



3. Students could also use the Internet to research retroreflectivity, how it works and its many uses. This 3M website: [https://www.3m.com/3M/en\\_US/road-safety-us/resources/road-transportation-safety-center-blog/full-story/~road-signs-retroreflectivity/?storyid=328c8880-941b-4adc-a9f9-46a1cd79e637](https://www.3m.com/3M/en_US/road-safety-us/resources/road-transportation-safety-center-blog/full-story/~road-signs-retroreflectivity/?storyid=328c8880-941b-4adc-a9f9-46a1cd79e637) briefly describes retro reflectivity and why 3M uses the principle to make some of its products. Students might have experience with retro reflectivity in the eyes of animals, especially at night when a car's headlights or a flashlight seems to brightly light up the eyes of an animal.
4. Visit this 3M website for more information on reflectivity: [http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSu7zK1fslxtUMY\\_9o821ev7qe17zHvTSevTSeSSSSSS--](http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSu7zK1fslxtUMY_9o821ev7qe17zHvTSevTSeSSSSSS--) If you have access to small mirrors, students could make a retroreflector and test its properties. Good quality, square plastic is good for this purpose. A diagram at this site illustrates how to arrange three mirrors at right angles to each other to make a cube corner retroreflector.

### Evaluate

You can evaluate your students using the following three-point rubric:

1. Explain how a reflectivity tester works.
2. Your reflectivity tester was a simple instrument you made and used to investigate a certain property of materials. This property could be considered a variable in an investigation. What was this variable?
3. You and your team ranked different items based on this property. Create a simple system that would show how the various items ranked.
4. Explain how retroreflection works and give an example of it.

## REFLECTION

Young scientists will reflect on their learning by completing the Six Word Story Summary. Print off the Six Word Story Summary Student Capture Sheet, cut them out, and distribute one to each student. Alternatively, students may create this reflection activity in their science journal:



## SIX WORD STORY SUMMARY

**Exit Ticket:**

Summarize your learning in **six** words.

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## HOME CONNECTIONS

Activities to do with your young scientist

1. Activity: With a flashlight (small LED flashlights work best), make a reflectivity tester as described by your young scientist. In addition to a flashlight, all you will need is an index card and something to make a small hole in the index card. Let your student show you how it is used with various objects around the house.
2. Research:
  - You and your young scientist could use the Internet to research 3M's line of reflective fabrics and products at this website: [https://www.3m.com/3M/en\\_US/p/c/ppe/apparel/reflective-fabrics/i/safety/personal-safety/](https://www.3m.com/3M/en_US/p/c/ppe/apparel/reflective-fabrics/i/safety/personal-safety/) that use reflective materials. Look around the house to see if you have any items that might make use of reflective material. Use your reflectivity tester to check them out. At night, how far away from these reflective materials can you get and still see reflected light? Does the angle between the light beam and your eye make any difference in the amount of reflected light you see?
  - Check this website to find an explanation of light reflecting straight back regardless of the orientation of the reflecting surface. [https://www.3m.com/3M/en\\_US/scotchlite-reflective-material-us/industries-active-lifestyle/active-lifestyle/how-retroreflection-works/](https://www.3m.com/3M/en_US/scotchlite-reflective-material-us/industries-active-lifestyle/active-lifestyle/how-retroreflection-works/)
  - Check this website to learn more about how 3M technology is used to provide visibility and reflective solutions for industry and active lifestyles. [https://www.3m.com/3M/en\\_US/scotchlite-reflective-material-us/industries-active-lifestyle/](https://www.3m.com/3M/en_US/scotchlite-reflective-material-us/industries-active-lifestyle/)



## SCORING KEY FOR EVALUATE

1. A reflectivity tester works by shining a flashlight at a surface and seeing how much light gets reflected back up to an index card that is attached to the flashlight.
2. Variables depend on properties of materials investigated.
3. Answers may vary.
4. Retroreflection occurs when a surface returns a large portion of a directed light beam back to its source. Examples could include the light of a car hitting a reflective street sign or vest worn by a pedestrian and returning the light back to the driver to make the sign and pedestrian visible.