Reflection — Teacher Notes

4.1 What's This About?

Students learn that infrared light is reflected in the same manner as visible light. Students align a series of mirrors so that they can turn on a TV with a remote control when the remote is not in a direct line with the TV. As a result of their experiment with reflection, students deduce that infrared light is another form of light and is a part of the electromagnetic spectrum

Suggested Grade Levels
7-12

Suggested Time Required
50 minutes

Suggested Learning Outcomes
After completing this activity, students will be able to:
- Explain that infrared light can be reflected by a mirror in the same way as visible light is reflected.
- Deduce that, since infrared and visible light behave in similar ways, both are part of a larger collection of light known as the electromagnetic spectrum.

Student Prerequisites
- Students are assumed to be familiar with the visible spectrum and to have some knowledge of the electromagnetic spectrum, and how it relates to the visible spectrum.
- Students are assumed to be familiar with the concept of reflection of visible light and mirrors.

Common Misconceptions
- Students may not realize that the infrared light beam emitted by the remote control spreads out over distance. As a result, if the light path followed by the infrared signal is too long, the remote may not be able to start the TV. Students may think the failure to turn on the TV is because the light signal "wears out" as it travels, or that it only travels a certain distance and then quits, not that the light beam spreads out with distance. This should be explained, if the situation arises.

The Activity

For this activity, challenge each student group to turn on a TV set when it is not in a direct line with a remote control. Utilize the barriers and space that you have in your classroom to create an obstacle course for your students. Each group will have different setups and answers, based on the space and materials provided. Have students try to turn on the TV with the remote

before reflecting the signal off any mirrors, to confirm that the remote does work initially. Some remotes will still work if pointed slightly away from the TV. If the TV does turn on initially, have students turn or move somewhere else so that the remote will not work without being reflected. Be sure to point out to students where the infrared light detector on the TV is, so they can try to aim the remote control at it.

Students will likely want to visually sight along the mirrors until they can see the sensor on the television. This helps reinforce the idea that infrared and visible light behave in the same way when reflected. Encourage students to be creative, but be aware of distance – the remote control's signal is not a focused beam, but spreads out as it travels (thus the signal from a distant remote may be too weak to trigger the sensor on a television set). Be careful when explaining this concept to students, who may think that the light signal "wears out" as it travels, or that it only travels so far.

SOFIA SCIENCE

SOFIA carries a 2.5-m primary mirror that weighs 1936 pounds or 880 kilograms. This mirror is used to collect and focus infrared light in the same way that visible light reflects off the mirror in a regular telescope.

Suggested TV/Student Group Setups

- TV or group in hallway, working around door
- Group behind TV
- Lab tables or other barriers between TV and group

Extension

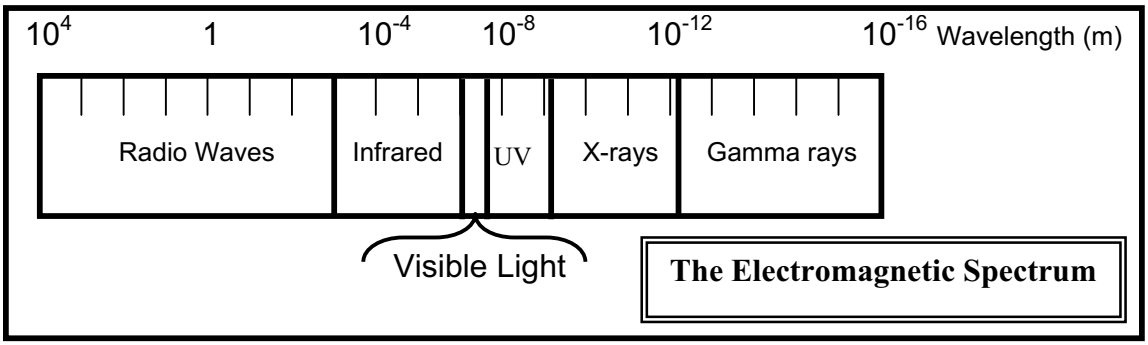
Have students replace one or more mirrors with another object. When we look at a textbook, for example, we see it because light reflects off the book and comes to our eyes. Such objects will often reflect infrared light as well. Replace one of the mirrors, for example, with a book or use a dry-wipe board for a reflecting surface.

As a follow-up homework assignment, have students duplicate this activity with their home TV sets and remote controls. Students should draw the path(s) from the remote control to the TV that worked

VCR Olympics:
Materials required: 2 VCR's with remotes, aluminum foil
Divide class into two teams. Each team must locate the IR receiver by moving a sheet of aluminum foil with a cutout the size of a postage stamp around in front of the VCR while attempting to power the unit on and off. Each team then turns on the VCR using one, two and three mirrors as reflectors. Once the teams are satisfied with their practice, time all three trials to determine a winning team.

Background Science

All types of light are characterized by wave properties that can be measured or observed. Visible light is only a small part of the electromagnetic spectrum. Infrared light, x-rays, radio waves, ultraviolet light, and gamma rays are often overlooked by students, but are also parts of this spectrum. Of course, this means that infrared light shares the same wave-like properties as visible light. For example, you know from looking in a mirror that visible light is reflected off the surface of a mirror. All waves undergo reflection at a barrier, or at the boundary when they move from one kind of medium (e.g., air) to another (the mirror). During reflection, the wave always bounces off the barrier at the same angle as it approaches the barrier. For example, if the wave heads straight for the barrier, it reflects straight back. If it moves toward the barrier from the left, it will reflect off to the right at the same angle. For more detailed information on reflection and mirrors, see: http://www.physicsclassroom.com/Class/refln/reflntoc.html The fact that infrared light, which is used by the remote control in this activity, is also reflected off the mirrors provides evidence in support of the idea that infrared light behaves like visible light.



The infrared light (IR) beam emitted by the remote control, spreads out as it moves away from the remote control. As it gets farther away, the same overall intensity of IR is spread out over a larger area. As a result, the IR will appear fainter the farther away from the source a detector is. In fact, the apparent brightness is inversely proportional to the square of the distance (the same inverse square law that applies to all electromagnetic radiation). For example, when viewed two times farther away, the light will appear four times fainter. Because of this, if the path the infrared light beam has to travel is too long, the signal that reaches the detector on the TV may not be strong enough to turn on the TV.

When you press the button of a remote control, an electrical connection is made that tells a computer chip inside the remote which button was pressed. The chip then produces a morse-code-like electrical signal that is different and distinct for each button. Transistors inside the remote control amplify the signal and send it to a Light-Emitting Diode, or LED, a kind of small light bulb. The LED converts the electrical signal into infrared light. Because the LED emits infrared light, which our eyes cannot detect, we do not see any light passing between the remote control and the TV (or VCR). But, the TV (or VCR) has a detector which can see infrared light. Depending on the exact nature of the signal (its wavelength, frequency, or intensity), the TV (or VCR) carries out the desired command. Note that many camcorders can also detect infrared light. If you aim a remote control at a camcorder and push a button, you should see infrared light flashing in the viewfinder. For more information about how remote controls work, see:

http://www.howthingswork.com/inside-rc.htm

MATERIALS AND EQUIPMENT

- TV and remote control (with working batteries!) for each student group
- 1-4 mirrors for each student group – mirrors can vary in size (no smaller than 4x4 inches; the larger the mirror, the better)
- HELPFUL, BUT NOT NECESSARY: A way to mount the mirrors so that they stay in the same places (not dependent on being held by students who move slightly without realizing it). Holders, taping to boxes, taping to a wall, lumps of clay, etc. will all work as holders.

4.2 REFLECTION

Name_____ Date_____ Period_____

Your challenge:
Using a remote control, turn on a TV when you are not in a direct line with it.

Rules:
1. You have only ONE SHOT to successfully turn on the TV – no practice shots!
2. You must use all the mirrors provided to your group.

Questions:
1. Before trying to use the remote, draw a diagram showing where the TV and remote control are, where you need to place the mirrors so the remote control can turn on the TV, and where any barriers (such as walls, lab benches, or doors) are located.

2. With the mirrors arranged as in the drawing above, press the On button on the remote. Were you able to turn on the TV the first time? If not, why do you think you did not turn on the TV?

3. How did you know when you had the mirrors set up the right way before you tried it?

4. What does this experiment tell you about the similarities between visible and infrared light?

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4.3 REFLECTION

Name_____ Date_____ Period_____

Your challenge:
Using a remote control, turn on a TV when you are not in a direct line with it.

Rules:
1. You have only ONE SHOT to successfully turn on the TV – no practice shots!
2. You must use all the mirrors provided to your group.

Questions:
1. Before trying to use the remote, draw a diagram showing where the TV and remote control are, where you need to place the mirrors so the remote control can turn on the TV, and where any barriers (such as walls, lab benches, or doors) are located. Include the path the infrared light beam follows from the remote control to the TV.

   Drawings will vary, but should show the mirrors placed in such a way that the incoming IR beam at each mirror reflects off at the same angle as it approached the mirror (the angle of incidence should equal the angle of reflection).

2. With the mirrors arranged as in the drawing above, press the On button on the remote. Were you able to turn on the TV the first time? If not, why do you think you did not turn on the TV?

   Answers will vary, but may include that the mirrors were not aligned properly, or that the path the infrared light beam had to travel was too far and the infrared light beam was too faint to turn on the TV by the time it got to the TV.

3. How did you know when you had the mirrors set up the right way before you tried it?

   Make sure you could see with your eyes that all the mirrors were lined up in such a way that you could see the infrared detector on the TV when you look at the first mirror the remote control's light will hit. Then aim the remote control at that spot on the first mirror.

4. What does this experiment tell you about the similarities between visible and infrared light?

   Both visible and infrared light reflect off of mirrors in the same way. Both behave the same way, and must, therefore, be similar kinds of light. In fact, both act like waves, and both are part of the electromagnetic spectrum.

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