Section 10.2 Properties of Light and Reflection

(Student textbook pages 411 to 418)

In this section, students will be introduced to the concept of using a ray diagram to form an image. They will learn to make qualitative and quantitative observations about reflection in a plane mirror.

Common Misconceptions

- Students may think virtual images actually exist somewhere. A "mirage" is a useful tool for clarifying this. It is a pair of parabolic mirrors, with a small circular opening on the top of one mirror. If you project an image on the bottom mirror, a virtual image is projected above the apparatus. You can put your fingers through this virtual image. Although it is a curved mirror, it effectively convinces students.

Background Knowledge

Specular reflection is light reflecting off a surface that is mirror-like, as the lake in figure 10.12. Diffuse reflection identifies a surface that does not reflect light but scatters it so that no clear image is formed. Paint, for example, can be glossy (causing specular reflection) or flat (causing diffuse reflection).

Literacy Support

Using the Text

- It is important to go over the principal terms used in ray diagrams (page 412 of the student textbook) with Figure 10.14, as they form the basis for all discussion and understanding for this unit. Have students complete **BLM 10-6 Drawing Ray Diagrams** and add it to their notes for reference throughout this unit.
- Explain that, when it says that the incident ray and reflected ray lie in the same plane, it means that there is a single flat surface that could contain both rays of light. This idea goes back to Euclid's axioms, which defines a line connecting two points, and a plane as something that contains two lines.

Before Reading

- Have students browse the headings in this section, noting pages on which they might find facts and arguments to support (or refute) their point of view as recorded on **BLM 10-1 Unit 4 Anticipation Guide.**

During Reading

- As they read, encourage students to write jot notes related to their opinions on each statement in **BLM 10-1 Unit 4 Anticipation Guide.**

After Reading

- Review their opinions when the section is complete. Ask: "Have any changed? Were any put into question without being resolved?"

Using the Images

- Figure 10.16 shows a surprising observation. Why exactly is the writing laterally inverted (right to left) but not inverted vertically (upside down)? We'll give you a hint: it has nothing to do with the path of the rays. The arguments that make the image to appear laterally inverted should hold for vertical inversion as well. It is likely that the image is inverted on our retinas, but our eyes can correct for it to eliminate vertical inversion. However, they don't seem to do so for images in curved lenses or mirrors. This is an area that might be of some interest to students who are wondering about parts of science that are not yet fully understood by scientists.

Specific Expectations

- **E2.2** use an inquiry process to investigate the laws of reflection, using plane and curved mirrors, and draw ray diagrams to summarize their findings
- **E2.3** predict the qualitative characteristics of images formed by plane and curved mirrors, test their predictions through inquiry, and summarize their findings
- **E3.3** describe, on the basis of observation, the characteristics and positions of images formed by plane and curved mirrors, with the aid of ray diagrams and algebraic equations, where appropriate

- Figure 10.17 on the stealth bomber shows an interesting application of reflection; if you can scramble up enough of the angles, the beam will be reflected back at all angles instead of making a coherent picture. Apparently a stealth bomber has a radar cross section smaller than that of a golf ball.
- As you draw a sample ray diagram, have students follow the steps shown in Table 10.1.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check questions, page 414	Diagrams show equal angles of incidence and reflection.	Have students complete **BLM 10-6 Drawing Ray Diagrams,** which scaffolds the process. Have students follow the steps in Table 10.1 (student textbook page 416) as you draw a sample ray diagram on the board. Have students carry out Inquiry Investigation 10-A Applying the Laws of Reflection.
Activity 10-2 A Reflection Obstacle Course, page 413	Students are able to position the mirrors to redirect the beam around corners, to hit the target.	Have students take a picture of the obstacle course to create a 2-D diagram, then use a protractor to adjust the angle of the mirrors until the incident and reflected angles are equal. Have students trace the desired path with string.
Section 10.2 Review Questions, page 418	Students list the four characteristics of an image. They recognize that angles are measured in relation to the normal. Students recognize that all EM radiation obeys the laws of reflection. They draw accurate ray diagrams.	Select additional questions for practice and reinforcement from **BLM 10-7 Section 10.2 Review (Alternative Format).** Consider scaffolding questions to provide clues to students about length of answers and key words that should be used. Allow students to answer with diagrams or graphic organizers.

Instructional Strategies

- DI Encourage bodily-kinesthetic learners to practice "mirror writing" with plane mirrors; writing on paper while watching the mirror, not the paper. Can they write normally? Can they write so that the words are legible in the mirror? Explain that the writing has been laterally inverted. Alternatively, demonstrate this with a computer by selecting "flip", or turn over a piece of paper or overhead transparency to show lateral inversion.
- DI Bodily-kinesthetic learners may benefit from recognizing that many of the laws governing light apply to many objects. Demonstrate or show a video of a bounce (e.g., in handball or mini golf), then draw a ray diagram to show that the angle of incidence equals the angle of bounce (reflection).
- As students enter the class, have a projector and screen set up, enticing students' natural playfulness to create shadow puppets. Encourage students to recognize that the objects creating shadows may be far apart even though the shadows interact. Also encourage them to experiment with making the shadows larger and smaller. What is the relationship to the light source? Draw a ray diagram of this set up on the board.
- As a class, develop a mnemonic device for the characteristics of an image such as "lost" (i.e., location, orientation, size, type).
- Have students carry out Activity 10-2 A Reflection Obstacle Course.
- Have students carry out Inquiry Investigation 10-A Applying the Laws of Reflection. See the notes on page TR-4-22 of this Teacher's Resource.
- Have students carry out Inquiry Investigation 10-B Studying the Laws of Reflection. See the notes on page TR-4-23 of this Teacher's Resource.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Activity 10-2 A Reflection Obstacle Course (Student textbook page 413)

Pedagogical Purpose

This lab provides a working demonstration of the laws of reflection from a plane mirror. It provides a bodily-kinesthetic differentiated learning experience to show that the angle of incidence equals the angle of reflection in a plane mirror.

Planning		
Materials	Targets 2 mirror stands Remote control for a television	2 plane (flat) mirrors Flashlight Television
Time	10 min to set up 30 min to perform	
Safety	Never direct a light source at someone's eyes.	

Background Knowledge

Most TV remote controls use infrared light to signal the television. Some signals will be affected by conditions in the classroom, and some materials are better than others at reflecting this class of light.

Activity Notes and Troubleshooting

- Set up two or three alternative paths through the obstacles, and have small groups rotate through the set-ups, pausing in between to record their findings (i.e., six groups result in three groups recording while three other groups use the apparatus).
- The easiest set-up has the targets in place and a flashlight/TV remote in a fixed location. This means that students will not be able to change its direction or get around obstacles.
- Ensure the remote will reflect off of the mirror, and that the signal is not powerful enough to activate the television regardless of the direction it is pointed.
- An infrared remote for any device may be substituted.
- Ask if any students have turned on the TV without pointing at it. They may have stumbled upon the value of reflection from mirrors, wall hangings, or even wall paint.
- Have students work in groups of four with one person holding the remote, one holding each mirror, and one observing the light rays and directing adjustment of the mirrors.
- Water misted from a bottle will help show the path of light in the air. Avoid chalk dust and other fine particulate as it is irritating and may cause breathing problems.
- Metal mirrors are safer, but may not reflect infrared light from the TV remotes.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**
- Use **BLM A-39 Co-operative Group Work Rubric** to assess students' group work.

Additional Support

- DI ELL This is an excellent activity for bodily-kinesthetic, interpersonal, and English language learners.
- DI Logical-mathematical learners may wish to start by drawing a ray diagram for the obstacle course, then test their calculations by setting it up.
- If success is not found with the television remote, have students practise hitting the target with a flashlight or laser pointer first, so they can follow the path of the light. Alternatively, have them stretch string along the path to figure out how reflection should happen.

- Allow students to use a digital camera to record the set-up, creating a 2-D image that is easier to transcribe into a ray diagram.
- Use a protractor to record the angles of incidence and reflection at the mirrors.

Answers

1. Mirror 1 is placed at an angle from the flashlight (so that the light doesn't reflect directly back onto the flashlight). Mirror 2 is placed so that the light that is leaving mirror 1 hits mirror 2 and the light leaving mirror 2 hits the target.
2. When you aim the remote control at Mirror 1, the electromagnetic waves hit the mirror and reflect onto Mirror 2, which then reflect onto the television to turn it on. This is similar to the flashlight hitting the target, using 2 mirrors.

Learning Check Answers (Student textbook page 414)

1. If light did not travel in straight lines, you would not know where a ray of light would hit on a surface.
2. Students' diagrams should be similar to Figure 10.14, and should show that $\angle r = \angle i$.
3. Diagrams should be similar to Figure 10.14, where $\angle i = 45°$ and $\angle r = 45°$.
4. Example: You would have a strong light shining on a white screen. You would put the cat much closer to the light than the screen. This would make the shadow of the cat look very large and scary.

Section 10.2 Review Answers (Student textbook page 418)

Please also see **BLM 10-7 Section 10.2 Review (Alternative Format).**

1. **a.** The incident ray is aimed perpendicular to the reflecting surface.
   b. zero degrees
2. image distance; image orientation; image size; image type (virtual or real)
3. All rays from one point on an object will reflect in such a way that when they are extended backward, they will all cross at the same point. Thus any two rays will meet at the same point at which any other two rays will meet.
4. The image distance is the distance between the mirror and the image. The object distance is the distance between the mirror and the object.
5. The shape of a stealth aircraft is designed so that most incident rays will not hit perpendicular to the surface, and the paint allows energy to be mostly absorbed, not reflected. These features foil radar, which is based on the laws of reflection: all types of electromagnetic waves travel in straight lines, and reflect so that the angle of reflection is equal to the angle of incidence. The reflected ray lies on the same plane as the incident ray and the normal.
6. The image distance is the same as the object distance. The orientation of the image is the same as the orientation of the object, but the image is reversed (lateral inversion). The image size is the same as the object size. The type of image is a virtual image.
7. Diagrams should be similar to the last diagram in Table 10.1. The four characteristics of the image are the same as those listed in question 6.
8. For object A, 1 image point needs to be drawn. For B, 2 image points need to be drawn. For C, 7 image points need to be drawn. For D, 3 image points need to be drawn. For each object, the number of rays that need to be drawn is three times the number of points. For each point, 1 ray is perpendicular to the reflecting surface, 1 is the incident ray, and 1 is the reflected ray.