Section 10.4 Images in Convex Mirrors

(Student textbook pages 431 to 438)

In this section, students investigate properties of convex mirrors, and compare the images formed to those from concave mirrors. It is quite literally, the other side of the previous section.

Common Misconceptions

- See notes for section 10.3 on page TR-4-15 of this Teacher's Resource.

Background Knowledge

The key difference here is that light cannot penetrate the mirror, so the image will be virtual. Because our eyes assume light moves in a straight line, the reflected rays will appear to converge at a point behind the mirror, where the virtual image is located.

It is not possible to get a real image from a convex mirror.

Literacy Support

Using the Text

- As mirrors and reflections are all around us, this is a natural section in which to have students connect what they read to personal experience.

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.**
- Encourage students to skim and scan the headings and first line of each paragraph before reading. Then, create a template for their notes to be filled in with details as they read.

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

- When this section is finished, have students review their notes and search the textbook for any missing points to help them resolve their opinions with facts.

Using the Images

- Have students scan the figures throughout the section. Do they have experience with any of the situations or objects shown? Have them link the figures to the text by predicting what the narrative will say about each figure.
- When viewing Figure 10.26, have students note that the reflected image appears to be inside/behind the mirror. A drawing such as M.C. Escher's "Reflection in a Glass Ball" illustrates this. At first, the person seems to be sitting inside the ball. Then, the viewer recognizes that the hand holding the ball belongs to that same person.
- As you draw a sample ray diagram, have students follow the steps shown in Table 10.5.
- Link the radar in Figure 10.29 to the EM spectrum in Figure 10.11. Note that radio waves are a different wavelength but on the same spectrum as visible light. Radio waves and light waves follow the same behaviour laws.

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

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learning**
Activity 10-4 Reflection from the Convex Surface of a Spoon, page 434	Students describe the image in the spoon as upright and larger.	Model the correct solution. Have students use colour to differentiate between rays on their diagrams.
Practice Problems, page 436	Students calculate the qualities of reflected images from given data or diagrams.	Model the sample problem on the board while students follow in their textbooks. Have students complete **BLM 10-10 Convex Mirrors Practice Problems,** which scaffolds the algebraic solutions.
Section 10.4 Review Questions, page 438	Students identify sources of light. They draw accurate ray diagrams for each type of mirror. Students identify characteristics of images made by each type of mirror. They identify potential for LED lights.	Select additional questions for practice and reinforcement from **BLM 10-11 Section 10.4 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

- Show an image such as M.C. Escher's "Reflection in a Glass Ball." Have students identify what is creating the image (a ball) and link it to a convex surface. How is the image distorted?
- Have students answer the Practice Problems on page 436. **BLM 10-10 Convex Mirror Practice Problems** provides scaffolding for these questions. Students may also find **BLM G-24 Problem Solving Using GRASP** helps them get started.
- Have students carry out Activity 10-4 Reflection from the Convex Surface of a Spoon if they have not already done so.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Activity 10-4 Reflection from the Convex Surface of a Spoon

(Student textbook page 434)

Pedagogical Purpose

This investigation provides direct experience with images in a convex mirror, drawing on students' skills in observation and scientific drawing. These provide the basis for students to identify the characteristics of an image reflected by a convex surface, calculate qualities of the image, and draw ray diagrams.

Planning	
Materials	Metal spoon
Time	15 min

Activity Notes and Troubleshooting

- Metal spoons polished (e.g., with vinegar) work best. Images will be easier to see in larger serving spoons.
- Backlighting from a window increases success.
- This activity could be combined with the Activity 10-3, which examines reflections on the front of the spoon.
- To wrap up, have students refer to their notes from Activity 10-3 in order to create a graphic organizer comparing convex and concave mirrors, and the images formed.

Additional Support

- See notes for Activity 10-3 Reflection from the Concave Surface of a Spoon on page TR-4-17 of this Teacher's Resource.

Answers

1. On the spoon, your image is upright, smaller than your face, and a bit distorted. In a plane mirror, the image is upright and the same size but not distorted.
2. In a plane mirror, the image is upright, but it is reversed compared to your orientation. In a convex mirror, the image is upright and it is reversed.

Learning Check Answers (Student textbook page 434)

1. Venn diagrams should show that both concave and convex mirrors have spherical shapes, but these types of mirrors are opposites. A convex mirror is shaped like the outside of a section of spherical surface, and the centre of a convex mirror protrudes outward from the edges. A concave mirror is shaped like the inside of a section of a spherical surface, and the centre of a concave mirror is indented relative to the edges.
2. Diagrams should be similar to Figure 10.26. Parallel rays hit a convex mirror and reflect outward, away from each other. Extend the rays backward, behind the mirror, until they meet. The point at which they meet is the focal point of the mirror.
3. Diagrams should be similar to the last diagram in Table 10.5. The image distance is smaller than the object distance. The image is smaller than the object. The orientation of the image is upright (the same as the object). The image is virtual.
4. Diagrams should be similar to the last diagram in Table 10.5. The image distance is smaller than the object distance. The image is smaller than the object. The image is upright. The image is virtual.

Section 10.4 Review Answers (Student textbook page 438)

Please also see **BLM 10-11 Section 10.4 Review (Alternative Format).**

1. Diagrams should be similar to the last diagram in Table 10.5. 1: Draw from the top of the object to the mirror, parallel to the principal axis, back as though it was coming from the focal point. 2: Draw from the top of the object, toward the focal point but stop at the mirror, and go back parallel to the principal axis. 3: Draw from the top of the object toward *C*, and at the mirror it reflects back along itself.
2. The focal point for a convex mirror is behind the mirror.
3. The value is negative because the focal point is behind the mirror
4. The focal point and the centre of curvature are behind the mirror and the object is in front of the mirror, so the object cannot be between or beyond *F* and *C*.
5. Convex mirrors collect light from a very wide range. An employee or security guard can see a large area of a store or other room by looking in one mirror.
6. $d_i = -1.875$ cm (behind mirror); $h_i = 2.5$ cm (upright). Diagrams should be similar to the last diagram in Table 10.5.
7. Light from different parts of the spherical surface is reflected to different points. It does not focus light in a way that creates an image that is the same as the object.
8. The smaller, convex mirror allows the driver to see a wider range of the area behind the car.

Inquiry Investigation 10-A Applying the Laws of Reflection

(Student textbook page 439)

Pedagogical Purpose

This investigation introduces students to ray diagrams and reviews principles of making predictions and writing a lab report.

Planning		
Materials	Blank sheet of paper (letter size) Ruler Small plane mirror Ray box	Pencil Small object (e.g., pencil) Putty (or mirror stand) Protractor
Time	25 min	
Safety	The edges of the mirror may be sharp. Be careful to avoid cuts. Be careful not to drop the mirror. Have a sharps container and clean up kit on hand.	

Background

This investigation is well supported by the concepts and explanations in Section 10.2 of the student textbook.

Activity Notes and Troubleshooting

- A Mira (from the math department) can be used in place of a mirror. This can make drawing of images significantly easier.
- Have students work individually.
- This is a good first lab, because it lets you establish traffic flow and other logistic issues inside your classroom for more complex labs in the future. You may wish to have students read and sign copies of **BLM G-1 Safety Contract** if they have not already done so.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Additional Support

- DI This is an excellent activity for visual, bodily-kinesthetic, and logical-mathematical learners.
- DI Logical-mathematical learners may wish to work "backward" from a ray diagram and calculations to culminate in a mirror set up.
- Model the procedure for students to copy.

Answers

1. Example: The mirror was not set up at exactly a right angle to the paper.
2. Example: Very well.
3. Example: Plans might include the use of a protractor to ensure equivalency of incident and reflected rays or use black paper to better see the light beam from the ray box.

Inquiry Investigation 10-B Studying the Laws of Reflection

(Student textbook pages 440 and 441)

Pedagogical Purpose

This activity introduces students to simple ray diagrams and reflection in a planar mirror. It also provides practice measuring angles and drawing normals, which becomes increasingly important with curved mirrors and lenses.

Planning		
Materials	Blank sheet of letter size paper Ruler Putty (or support stand) Pointed object shorter than the mirror The day before, ask students to bring suitable pointed objects to class.	Pencil 5 cm × 15 cm plane mirror Ray box Protractor
Time	15 min to prep 30 min in class	
Safety	The edges of the mirror may be sharp. Be careful to avoid cuts. Be careful not to drop the mirror. Have a sharps container and clean up kit on hand.	

Background

This lab is an extension of both section 10.2, and of the previous investigation. The main principle is that an object's image will appear to be the same distance behind the mirror that the object is actually located in front of the mirror.

Activity Notes and Troubleshooting

- Model this procedure for students.
- To reduce cuts and danger from broken glass, choose mirrors with built-in stands, plastic Miras from the math department, or metal or plastic mirrors typical of locker accessories.
- Consider reading the steps aloud as the whole class performs the steps in synchronization.
- For the Research question, students will need to use a second mirror.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Additional Support

- DI This is an excellent investigation for bodily-kinesthetic and intrapersonal learners.
- DI Logical-mathematical learners may wish to work "backward" from a ray diagram and calculations to culminate in a mirror set up.
- Replace the ray lines with string.
- Extension—Encourage students to repeat the investigation with a curved mirror.

Answers

1. An infinite number.
2. The angles are equal.
3. **a.** Example: 5 cm
   b. Example: 5 cm
   c. The distance from a point to the mirror is the same as the distance from the image point to the mirror.
4. Use a protractor to draw a line perpendicular to the mirror. Then use a ruler to draw the incident ray that joins a point on the object (P) to the point where the normal intersects the mirror (M). Then use a protractor to draw the reflected ray at an equal angle on the opposite side of the normal.
5. Measure the distance from the object to the mirror (the distances are the same).
6. Diagrams should show that a point can be drawn perpendicular to each mirror's surface; in two places.
7. Example: When the angle between the two mirrors is 180°, one image results. At an angle of 120°, two images result. At 90°, three images. Four images appear at 72°, while five images result at 60°. Three images are formed when two mirrors are joined at 90° because two images are formed by a single reflection in each of the mirrors, and a third image (at the point behind the intersection of the two mirrors) is formed by a double reflection in both mirrors.

Inquiry Investigation 10-C Testing for Real and Virtual Images (Student textbook page 442)

Pedagogical Purpose

This investigation gives students first-hand experience with real and virtual images, as well as introducing characteristics of a concave mirror. It also requires them to draw conclusions from their observations.

Planning		
Materials	3 concave mirrors with different curvatures Plane mirror White cardboard for screen	 Convex mirror Window
Time	45 min	
Safety	The edges of the mirror may be sharp. Be careful to avoid cuts. Be careful not to drop the mirror. Have a sharps container and clean up kit on hand.	

Background

This is another way of reinforcing the concept that images from curved mirrors may have different attitudes, sizes, and can be real or virtual. In this case, because the images captured are real (on a screen) they will also be inverted.

Activity Notes and Troubleshooting

- Allow students to explore the concave mirror and try to capture an image on the screen before carrying out the procedure.
- If the day is cloudy or if classroom windows are not conveniently placed, arrange an alternate light source at the front of the darkened room. Ensure that students have a clear line of sight.
- Choose concave mirrors with different focal lengths so that some will form an image on the screen and some will not.
- Have students practise their observation skills by first having them analyze pictures of optical illusions such as those where left and right are reversed, or colours are distorted.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Additional Support

- Extension—Have students determine whether the figure is latterly inverted (backward) as well as upside down.

Answers

1. Students should find success with the concave mirrors.
2. Example: The image is smaller than the mirror.
3. Example: Convex mirrors only produce virtual images. Concave mirrors can produce real or virtual images. A real image is produced if the object is further away from the mirror than the mirror's focal length. No image is formed if the object is the same distance from the mirror as its focal length. If the object is closer to the mirror than its focal length, a virtual image will be formed.
4. Example: The image will be smaller than the mirror and it will be real or virtual depending on the relative location of the object and the focal length of the mirror.