Section 10.3 Images in Concave Mirrors

(Student textbook pages 419 to 430)

In this section, students investigate the properties of concave mirrors, discovering that in the curved mirror, the image is not located where it would be a plane mirror, nor does it have the same relative size. They further their understanding of ray diagrams in order to find the location and characteristics of an image.

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

Common Misconceptions

- Some students interpret ray diagrams literally, interpreting light from an object as concentrated and unidirectional. Light leaves an object in all directions. Only some of the light hits the mirror (or eye).

Background Knowledge

These relationships may prove useful:

- The distance to the centre of curvature (where the centre of the sphere or cylinder would be) is twice the focal length of the mirror
- The variable *F* refers to the focal point, while f is the focal length
- The focal point is always located at the halfway point of the curvature in the vertex.

Three rays are used in drawing a ray diagram so that students have a way to check their work. The image is located where two rays combine to a point. If the three rays do not meet at exactly the same point, either the student made an error or you have identified an aberration in the lens. This is especially likely if the lens is a semi-circle, for example, one that the student may have used a protractor to trace out. In this case, the image could be located anywhere within the triangle made by the converging rays.

The negative sign in the magnification equation indicates the image is inverted. A negative distance represents a virtual image, one that is behind the mirror. Note that this is the opposite convention for lenses later on, but in both cases, you can have an upright and virtual image or an inverted and real image. Those two descriptors are fixed pairs. There is, for example, an inverted virtual image in a curved mirror.

The radar dish in Figure 10.23 illustrates that different forms of radiation are reflected by different materials, because the paint on the radar dish does not reflect sunlight, it must be focussing radio waves at the central point, not sunlight. Interestingly the description of radar is correct, with the side effect that radar can be obstructed by anything close. This is because the radar waves will be reflected while the circuits are switching over to receiver mode. When Environment Canada began automating its weather services, this problem was discovered at several remote locations, where the automatic system could not differentiate between a clear sky and white out conditions in a blizzard.

Literacy Support

Using the Text

- Students may find it easier to follow you drawing the ray diagrams for the different cases listed on pages 421 to 424 than just by looking at the text drawings. The reason why the drawings are in different colours is that some students have an easier time associating different colours with the different rules for reflection. You can help this by writing out the relevant rule for drawing a line on the ray diagram in the same colour as you draw it on your actual diagram, and encouraging students to do the same.

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 10.18, the sky mirror, is just a large concave mirror. It is similar to a security mirror, or even the concave mirrors on the wing mirrors of a truck. In these cases, the concavity allows people to see a wider angle of view than would be possible in the normal, plane mirror.
- Figure 10.20 highlights a critical understanding/misconception. The rules for ray diagrams involve drawing three rays of light to find where they converge. The reason why we use these three rays is because they are easy to draw. Any three rays or, for that matter, any two rays of light would work so long as you are meticulous about making certain the angle of incidence equals the angle of reflection.
- As you draw a sample ray diagram, have students follow the steps shown in Tables 10.2, 10.3, and 10.4.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learning
Activity 10-3 Reflection from the Concave Surface of a Spoon, page 421	Students describe the image in the spoon as smaller and upside down.	Model the correct solution. Have students use colour to differentiate between rays on their diagrams.
Learning Check questions, page 425	Students describe, and draw the characteristics of images reflected by concave surfaces.	Have students carry out Activity 10-3 Reflection from the Concave Surface of a Spoon if they have not already done so.
Practice Problems, page 427	Students are able to 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 10-8 Concave Mirrors Practice Problems,** which scaffolds the algebraic solutions.
Section 10.3 Review Questions, page 430	Students draw a ray diagram from given data. They explain the difference between real and virtual images and link that to + and − values.	Select additional questions for practice and reinforcement from **BLM 10-9 Section 10.3 Review (Alternative Format).**

Instructional Strategies

- ELL To help students keep the terms *convex* and *concave* straight, encourage them to recognize the *cave* in *concave*. Concave lenses form a "cave" within their curvature. *Convex* is the opposite shape.
- Ensure that the focal length is half the distance between the vertex and the centre of curvature in order for ray diagrams to work for students.
- As a class, construct a solar mirror as shown in the Case Study. Try to cook a marshmallow, which will inflate for great effect. Materials such as aluminum foil and cardboard will work, though glass mirrors are more efficient.
- Have students answer the Practice Problems on page 427. **BLM 10-8 Concave 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 10-3 Reflection from the Concave Surface of a Spoon, or pair this with Activity 10-4 Reflection from the Convex Surface of a Spoon after completing the next section.
- You may wish to have students carry out Inquiry Investigation 10-C Testing for Real and Virtual Images at this point, or wait until they complete the next section. See the notes on page TR-4-25 of this Teacher's Resource.
- To assess students' diagrams, use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric.**

Activity 10-3 Reflection from the Concave Surface of a Spoon

(Student textbook page 421)

Pedagogical Purpose

This investigation provides direct experience with images in a concave 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 concave surface, calculate qualities of the image, and draw ray diagrams.

Planning	
Materials	Metal spoon
Time	15 min

Background

The spoon provides probably the most readily available curved surface. This activity illustrates the relationships explained in Sections 10.2 and 10.3 of the student textbook.

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. For most spoons, the focal point is only 1-2 cm from the surface, so students will see the real, inverted image, but they may not be able to see the upright, enlarged image.
- Note that in the next section, students examine the reflection on the back of the spoon. Both activities could be combined in order to compare and contrast a convex and concave surface.

Additional Support

- DI Logical-mathematical learners may wish to work "backward" from a ray diagram and use calculations to culminate in a mirror set up.
- ELL English language learners could repeat this activity at home, explaining what they learn to family members to reinforce concepts.
- To help students identify the orientation of the image, have them place a unique feature on one side of their body. For example, a pencil behind one ear.
- Conduct this activity in a think-pair-share format so that students first perform the procedure individually, then share their observations and help each other correct any misunderstandings or procedural errors.

Answers

1. On the spoon, your image is upside down, 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. In a concave mirror, the image is upside down but is not reversed.

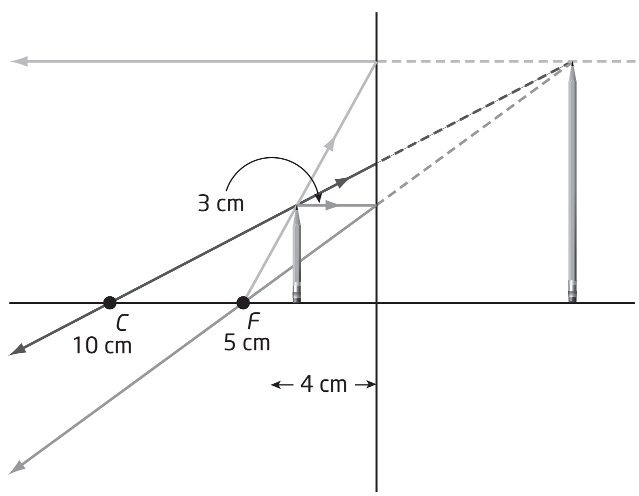
Learning Check Answers (Student textbook page 425)

1. Students' diagrams should be similar to the last diagram in Table 10.2. The image distance is larger than the object distance. The image is larger than the object. The orientation of the image is the same as the orientation of the object. The image is virtual.
2. Diagrams should be similar to the last diagram in Table 10.3. The image distance is larger than the object distance. The image is larger than the object. The image is inverted (upside down compared to the object). The image is real.
3. The person must be between the focal point and the mirror. The focal point is half the distance from the mirror than *C*. Therefore, the person must be within 35 cm from the mirror.
4. Diagrams should be similar to the last diagram in Table 10.4. The image distance is smaller than the object distance. The image is smaller than the object. The image is inverted. The image is real.

Section 10.3 Review Answers (Student textbook page 430)

Please also see **BLM 10-9 Section 10.3 Review (Alternative Format).**

1. Students' diagrams should show that *F* is halfway between the mirror and *C*.
2. 1: Draw from the top of the object to the mirror, parallel to principal axis, and back through the focal point. 2: Draw from the top of the object, through the focal point to the mirror and back parallel to the principal axis. 3: Draw from C to the top of the object toward mirror, and back along itself.
3. If the image is in front of the mirror, d_i is positive. If the image is behind the mirror, d_i is negative.
4. The object is between *F* and *C*.
5.



6. d_i = 9.17 cm (in front of mirror); h_i = −1.67 cm (inverted). Diagrams should be similar to Figure 10.21.
7. If your face is farther from the mirror (30 cm) than the focal point (25 cm), then your image would have to be inverted. Since your image is upright, the focal length of the mirror must be more than 30 cm.
8. Rays actually meet at a real image. A screen placed at the location of the real image would show the image. No rays ever go toward or away from a virtual image. No image forms on a screen placed at the location of a virtual image.