Focusing on Light – ID: 8738

By Peter Fox

Time required
45 minutes

Activity Overview

In this activity, students explore the reflection of light by parabolic and semicircular mirrors. They begin by exploring reflection using a series of flat mirrors that are attached to one another to create a flexible mirror that can simulate a curved mirror. Students then explore reflection by a true parabolic mirror and by a semicircular mirror. They use their observations to differentiate between curved and parabolic reflectors.

Concepts

- *Difference between semicircular mirrors and parabolic mirrors*
- *Reflection of light*

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank sheet of paper*

TI-Nspire Applications

Graphs & Geometry, Notes

Teacher Preparation

This activity assumes students already have a reasonable understanding of plane mirrors. The activity requires no formal preparation but may be enhanced by including physical examples of parabolic mirrors. However, the focus of the activity should be on the presence or absence of a focal point, rather than the appearance of an image in the mirrors used.

- *A useful demonstration to include at the conclusion of this activity is to have students position a series of plane mirrors in front of a light box to create a "focal point." Students should note that the "focal point" is more of a region because the plane mirrors can only approximate a parabola.*
- *The screenshots on pages 2–5 demonstrate expected student results. Refer to the screenshots on pages 6 and 7 for a preview of the student TI-Nspire document (.tns file).*
- ***To download the .tns file, go to education.ti.com/exchange and enter "8738" in the search box.***

Classroom Management

- *This activity is designed to be **teacher-led** with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in **this** document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *Students may answer the questions posed in the .tns file using the Notes application or on notebook paper.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

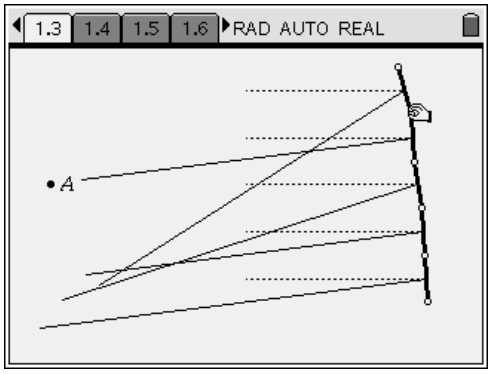
The following questions will guide student exploration in this activity:

- How are parabolic mirrors different from semicircular mirrors?
- Do all curved mirrors have a focal point?

Students will carry out the activity using simulated mirrors. Students will first explore reflection by a series of plane mirrors. Then, they will compare reflection from a parabolic mirror to reflection from a semi-circular mirror.

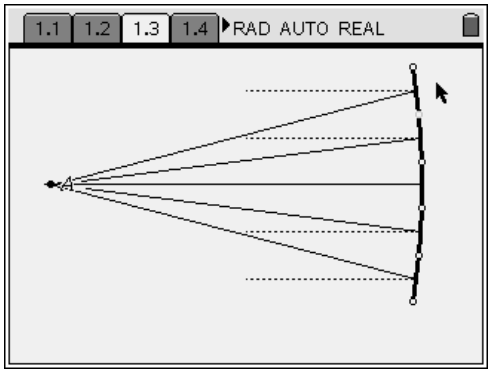
Problem 1 – Reflection from a parabolic mirror

Step 1: Students should open the file **PhyAct08_focusing_light_EN.tns** and read the first two pages. Page 1.3 shows a group of five plane mirrors reflecting a series of light rays. The dotted lines in the image are incident light rays; they cannot be adjusted. Students should adjust these mirrors so that the reflected light passes through the single point marked **A**. It may take students several tries to align the rays correctly. They should then answer question 1 on page 1.4.

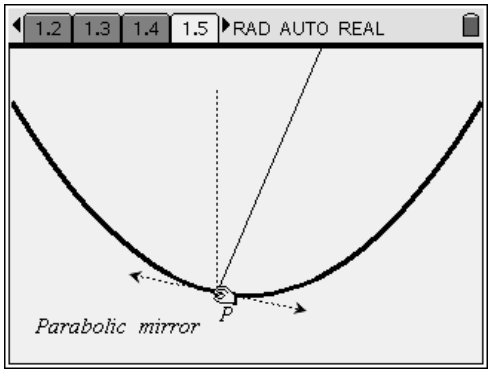


Q1. Describe the general shape formed by the plane mirrors when the reflected light passes through point **A**.

A. *The mirrors form a parabola with a gentle curvature, as shown on the right. "Curved" or "concave" are also acceptable answers. Encourage students to examine the way the light rays reflect off of each individual mirror. They should notice that the reflections off of each plane mirror follow the same rules of reflection they are familiar with.*

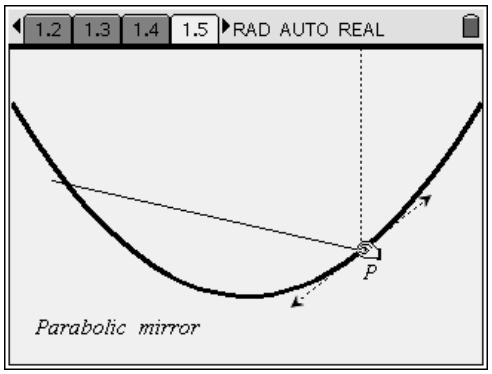


Step 2: Page 1.5 shows a flexible parabolic mirror. The mirror will retain its parabolic shape even if students make it wider or narrower. The incident light ray is shown as a dotted line. The reflected ray is a thin solid line. A tangent to the parabolic mirror has been drawn in and is representative of a flat mirror at point **P** on the curve. Students should drag point **P** around the mirror and observe how the reflected light ray changes. They should then answer question 2 on page 1.6.

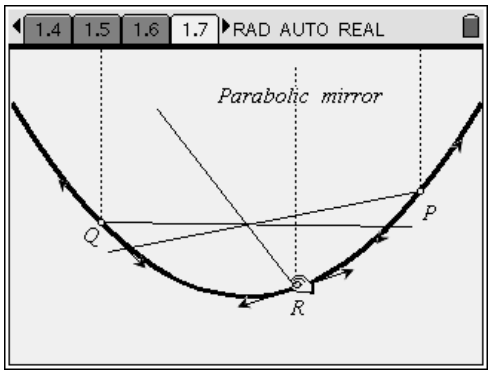


Q2. Describe what happens to the reflected ray as you move point **P** along the parabolic mirror.

A. *The reflected ray seems to rotate around a single point.*



Step 3: Page 1.7 contains an image of a second parabolic mirror with a number of parallel incident light rays striking the mirror in different locations. The multiple incident rays help identify important characteristics associated with reflected rays. Have students drag points **P, Q,** and **R** along the mirror and observe how the reflected rays move. Students should then answer questions 3–5 on pages 1.8 and 1.9.



Q3. Describe what happens to the reflected rays as you move points **P, Q,** and **R** along the parabolic mirror.

A. *The reflected rays rotate around a single point, which is the point at which all three rays intersect.*

Q4. Adjust the width of the parabola. How does this affect the reflected rays as you move the three points?

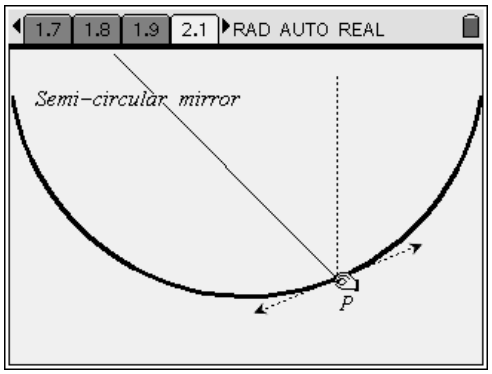
A. *Regardless of the width of the parabola, the reflected rays always converge on a single point. This point moves further away from the bottom of the parabola as the parabola gets wider.*

Q5. Based on your observations, make a general statement about how parabolic mirrors reflect incident light rays that are parallel to the parabola's line of symmetry.

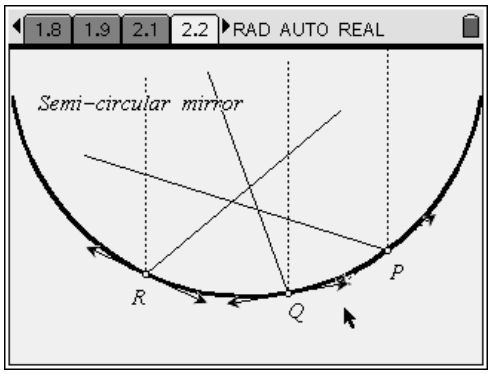
A. *A parabolic mirror reflects incident light rays to a single point. Explain to students that this point is called the "focal point" of the mirror. Encourage students to manipulate the simulation to explore the relationship between the curvature or width of the mirror and the location of the focal point.*

Problem 2 – Reflection from a semicircular mirror

Step 1: Page 2.1 shows a semicircular mirror. The incident light ray appears dotted. The reflected ray is a thin solid line. A tangent to the parabolic mirror has been drawn in and is representative of a flat mirror at point **P** on the curve. Have students drag point **P** around the mirror and watch how the reflected light ray changes.



Step 2: Page 2.2 contains an image of a second semicircular mirror with three incident light rays and the corresponding reflected rays. Have students drag points **P, Q,** and **R** along the mirror and observe the results. Students should then answer questions 6 and 7 on pages 2.3 and 2.4.



Q6. Based on your observations, make a general statement about how semicircular mirrors reflect incident light rays that are parallel to the mirror's line of symmetry.

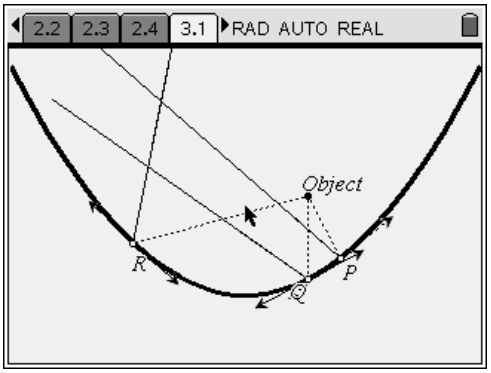
A. *The reflected rays do not intersect at a single point.*

Q7. In a reflecting telescope, a curved mirror reflects incident light rays toward a single point in the eyepiece. Are these mirrors most likely parabolic mirrors or semicircular mirrors? Explain your answer.

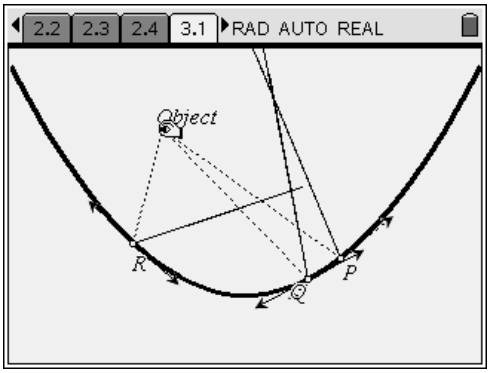
A. *They are most likely parabolic mirrors. Semicircular mirrors do not reflect light toward a single point, but parabolic mirrors do.*

Problem 3 – Reflection of non-parallel incident rays

Step 1: Page 3.1 shows a parabolic mirror reflecting incident light rays originating from a single **object**. The incident rays are not parallel to one another. Have students drag points **P, Q,** and **R** around the parabolic mirror and observe the results.



Step 2: Next, have students move the **object** around the screen and observe the results. Then, have students answer question 8 on page 3.2.



Q8. Describe how the parabolic mirror reflects light coming from a single object that produces incident rays that are not parallel.

A. *The reflected rays do not converge on a central point. Encourage students to discuss the significance of this. They should realize that it is impossible to use a parabolic mirror to produce a real image of an object placed within or close to the curvature of the mirror. As an extension activity, you can challenge students to move points **P**, **Q**, and **R** so that the three reflected rays meet at a single point. You can also ask students to see if they can place the object in a position so that all the reflected rays emerge parallel.*

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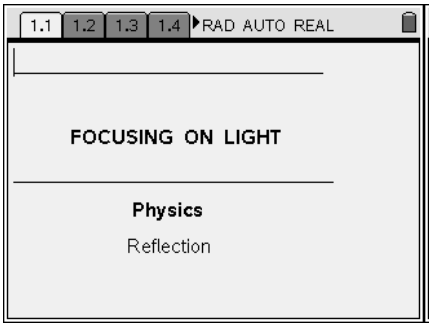
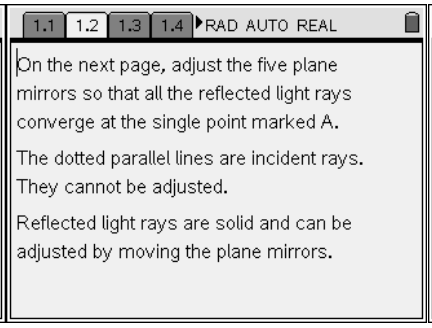
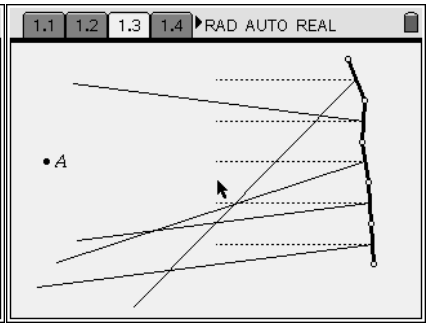
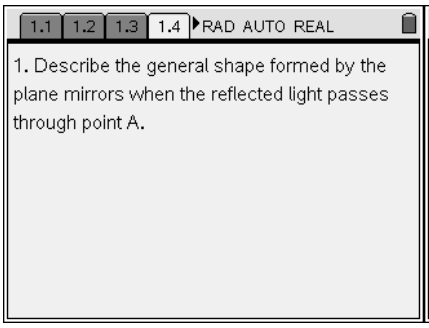
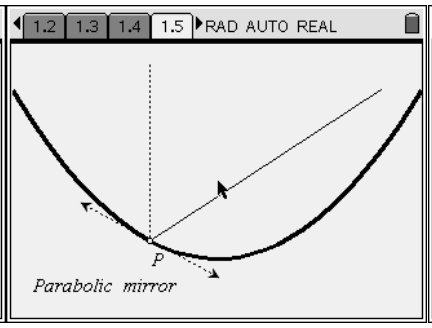
(Student)TI-Nspire File: *PhyAct08_focusing_light_EN.tns*

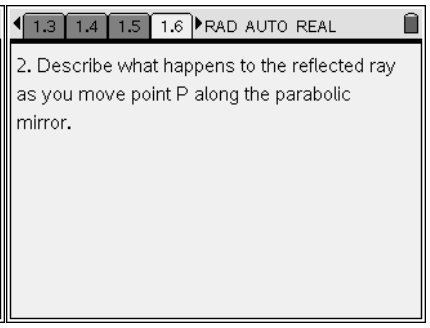


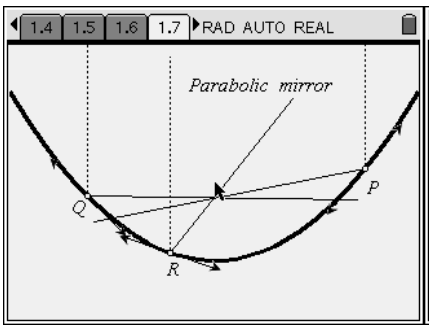


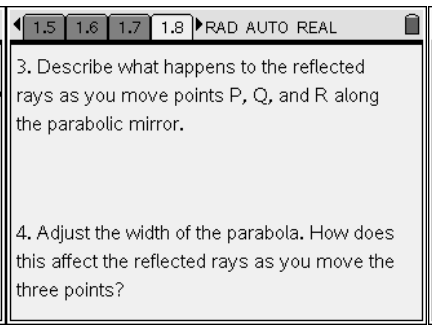


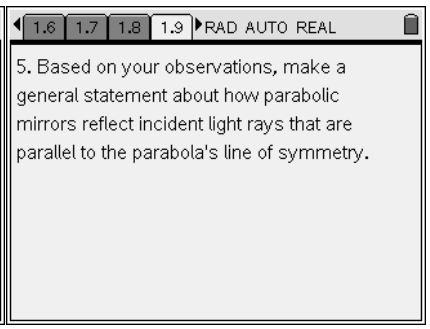


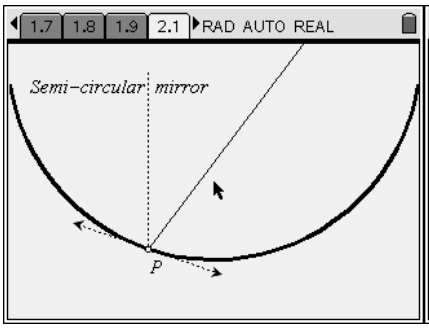


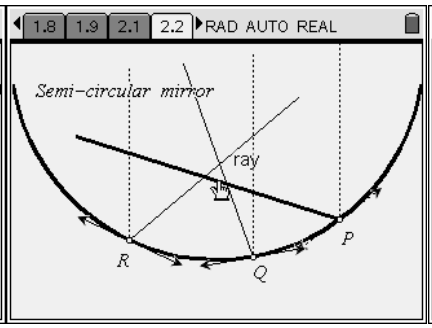


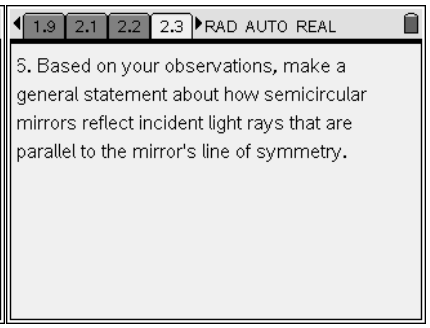


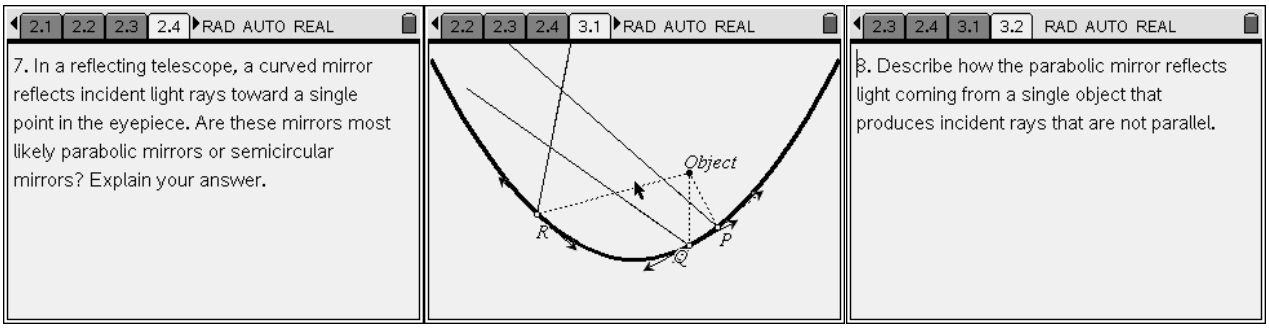











2.1 2.2 2.3 2.4 RAD AUTO REAL
7. In a reflecting telescope, a curved mirror reflects incident light rays toward a single point in the eyepiece. Are these mirrors most likely parabolic mirrors or semicircular mirrors? Explain your answer.
2.2 2.3 2.4 3.1 RAD AUTO REAL
Object
R
Q
P
2.3 2.4 3.1 3.2 RAD AUTO REAL
8. Describe how the parabolic mirror reflects light coming from a single object that produces incident rays that are not parallel.