

INTRODUCE

Project the sketch for viewing by the class. Expect to spend about 15 minutes.

1. Explain, *Today you are going to use Sketchpad to explore objects that are symmetric.* Draw the letter W on the board. *How can we draw a line that divides the W into two symmetric halves?* Ask a volunteer to use a ruler or other straight object to draw the line. Explain that this line is called the *line of symmetry*.

If you have a small mirror available, demonstrate how you can stand the mirror on the line of symmetry to view a complete W (half the W is on the board, the other half is reflected in the mirror). Explain that objects with this property are said to have *mirror symmetry*.

What other objects can you name that have mirror symmetry? Students might suggest other letters of the alphabet or objects like squares, rectangles, tables, chairs, etc.

2. *Do you think your face has mirror symmetry? If it did, where would its line of symmetry be?* Students will likely note that their faces are not perfectly symmetric, but the vertical line that divides their nose and mouth in half does split their face into two roughly identical parts. *In this activity, you'll look for mirror symmetry in a variety of places, including pictures of buildings, butterflies, and human faces.*

3. Open **Crop and Reflect.gsp**. Go to page "Eiffel Tower."

Demonstrate steps 3–7 of the worksheet but do not find the line of symmetry for the Eiffel Tower. Students will do this themselves in step 8.

4. After you've demonstrated step 7 of the worksheet, drag points *A* and *B* to show how varying the position of \overline{AB} changes what is reflected. Also drag \overline{CD} to the right of \overline{AB} ; doing so alters the reflection so that the opposite half of the picture is reflected.

DEVELOP

Expect students at computers to spend about 25 minutes.

5. Assign students to computers. Distribute the worksheet. Tell students to work through step 15 and to do the Explore More if they have time. Encourage students to ask their neighbors for help if they are having difficulty with the construction.

6. Let pairs work at their own pace. As you circulate, here are some things to notice.
- In worksheet step 8, students position \overline{AB} so that it is the line of symmetry for the Eiffel Tower. Many students will be quick to position this segment without exploring the effects of dragging it into positions where it is *not* the line of symmetry. Encourage students to experiment by asking questions like, *Where can you position the segment so that the Eiffel Tower disappears?* [near the left edge of the picture] *Where can you position the segment so that only a very small part of the Eiffel Tower appears?* [a little farther away from the left edge of the picture] *Where can you position the segment so that two Eiffel Towers appear?* [near the right edge of the picture]. Thinking about such questions will give students more experience in visualizing the effects of reflection.
 - In worksheet steps 10–12, students find the line of symmetry for the Leaning Tower of Pisa. This example, as well as the picture of the butterfly, expands students' conceptions of mirror symmetry by demonstrating that a line of symmetry need not be vertical or horizontal.
7. Step 17 encourages students to copy a head-on image of their face into Sketchpad and check it for mirror symmetry. (On newer Mac computers with a built-in iSight camera, students can use the free application Photo Booth to snap a headshot of themselves. This picture can then be dragged directly from Photo Booth into Sketchpad.)

SUMMARIZE

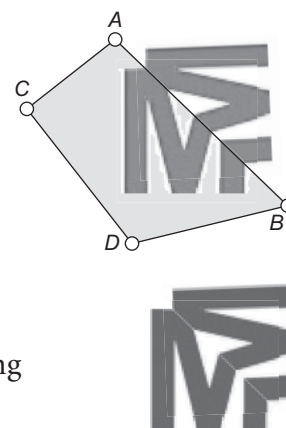
Project the sketch. Expect to spend about 10 minutes.

8. Gather the class. Open **Crop and Reflect.gsp** and go to page "Eiffel Tower."

Delete the pictures of the Eiffel Tower. Then, copy and paste the letter O from the "Explore More" page onto the "Eiffel Tower" page. Ask students to think about how they can crop the O so that it takes two reflections to obtain the complete letter again. By cropping the O so that only one quarter of it is visible, students can reflect it to show half an O. By reflecting this half across another mirror line, students can obtain the complete O. A similar two-step reflection works with the letter X.

EXTEND

1. Encourage students to find other pictures on the Internet that display mirror symmetry. Students can copy these pictures into Sketchpad and then crop and reflect them. Be aware, however, of copyright restrictions that may apply if you wish to share or print your students' work. A good Internet resource for public domain photos and illustrations is Wikimedia Commons.
2. If your students have access to digital cameras, they can take pictures of objects with mirror symmetry, import the pictures to their computers, and use Sketchpad to crop and reflect them.
3. Go to page "Extend." Working in pairs, students can play a game in which they crop and reflect a portion of a letter (not, in this case, a symmetric portion), and then challenge their partner to identify the letter. In the pictures at right, a student has cropped the letter M and then pressed *Hide Quadrilateral* so that the line of reflection is not visible. The student's partner must then try to determine the letter by visualizing the line of symmetry.

**ANSWERS**

9. The cloud pattern in the sky and the rows of trees are not perfectly symmetric in the original picture.
14. The Leaning Tower is not perfectly symmetric. Notice that there is a single door on the ground level.
16. Of the letters on the Explore More page, only M, V, and C have mirror symmetry. Considering the entire alphabet, the set of letters symmetric about a vertical mirror is {A, H, I, M, O, T, U, V, W, X, Y}. Depending on the font, the set symmetric about a horizontal mirror is {B, C, D, E, H, I, K, O, X}. Also depending on the font, the letters O and X may be symmetric about a diagonal mirror.
17. Students will most likely discover that their faces are not perfectly symmetric.