Multiple Reflections

Overview

We know that when light reflects off a plane mirror, the image appears left/right reversed. Once you bring in another mirror and change the angle between them, it is much harder to keep track of what orientation each image will have. In this activity, students will use the letter R – a letter which is neither horizontally nor vertically symmetric. When the letter R is reflected several times, this lack of symmetry helps us figure out how it has been reflected.

Students Will Learn…

- If you make the angle between the mirrors smaller, you see more images.
- The relationship between the number of images and the angle between the mirrors is $\#\text{ images} = \frac{360^\circ}{\text{angle between mirrors}} - 1$. You can use a protractor to verify this relationship.

What You Need

For each 2-3 students:

- ❑ 1 set of hinged mirrors
- ❑ 1 protractor
- ❑ Copy of "The Pirate Handout"

For each student:

- ❑ Copy of "STUDENT HANDOUT: Multiple Reflections"

GO: Multiple Reflections

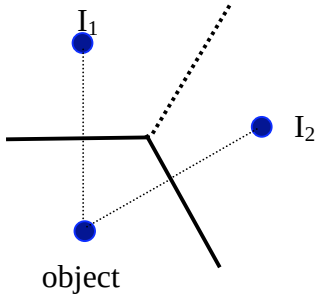
1. Remind students that mirrors cause objects to appear reversed as they saw in "Right is Right, or is it Left?" Ask them what they would think would happen if an object was reflected by plane mirrors three times? Four times? Five times?

2. Distribute the "STUDENT HANDOUT: Multiple Reflections" for students to complete. Assist students as needed.

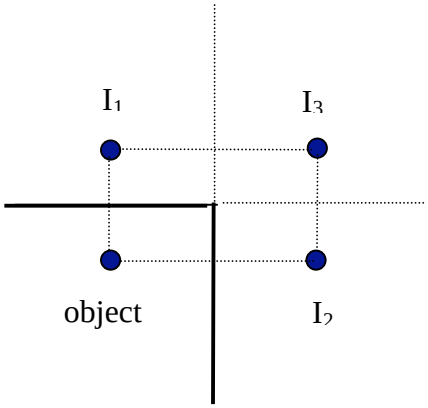
What's Really Happening Here…

Multiple reflections are difficult to understand and visualize. If you have one flat mirror, light from the object will reflect off the mirror once and leave the system. When you have more than one mirror, you can create multiple reflections. These multiple reflections can lead to multiple images.

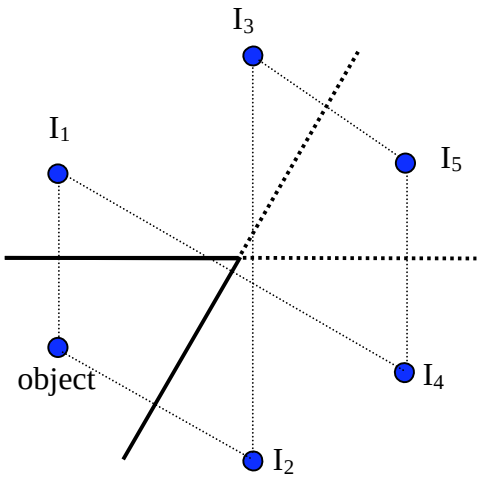
Consider the two mirrors (solid lines) shown at right at an angle of 120 degrees to each other. The object is a small ball. The images, I_1 and I_2, form exactly on the opposite side of each mirror, the same distance from the mirror, just as you would expect for reflection from a single mirror. The two mirrors each yield an image. You will also notice that I_1 and I_2 lie equal distances from the dotted line (representing a "reflection" of the mirror surface itself).



When the angle is decreased, more reflections will occur. Let's look at two mirrors that are perpendicular to each other. One image will form from a single reflection from each mirror. You might recall from "Right is Right, or is it Left?" that perpendicular mirrors yield two reflections. These two reflections create the third image, I_3. You can see these reflections by looking into the mirror as shown below.



Let's take it one step further and look at what happens when the angle between the mirrors is 60 degrees. I_1 and I_2 are direct reflections from the object. I_3 is a double reflection and can be seen by reflecting I_2 across an extension of the top mirror. I_4 is a second reflection of I_1 across the angled mirror. I_5 is a composite of reflections from I_3 and I_4. You can see the reflections get very intricate and complicated very quickly.



STUDENT HANDOUT: Multiple Reflections

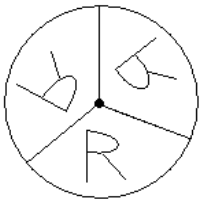
What You Need

- ❑ 1 set of hinged mirrors
- ❑ 1 copy of "The Pirate Handout"
- ❑ 1 protractor

What To Do

1. Open the hinged mirror and look into it. Slowly change the angle and observe the number of reflections of yourself that you see. If you want to see more reflections, do you make the angle between the mirrors larger or smaller?

2. Place the large R on the table. Open the mirror and place it on the R as shown in the picture at right. Adjust the angle between the mirrors until you see exactly one complete reflection of the R in *each* mirror. (You will see three R's – the original plus two reflections.) Use your protractor to measure the angle between the mirrors and record it in the data table on the next page. In the last column, sketch the pattern you see similar to the sketch below.



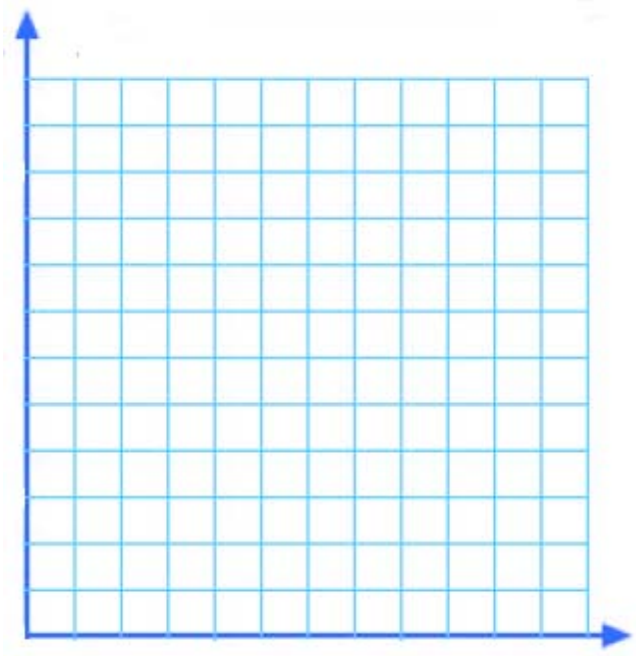
3. Move the mirrors until you see three complete reflections of the R in the mirrors. Measure the angle of the mirrors and record the angle in the data table below. In the last column, sketch the pattern you see. Be sure to pay attention to which images of the R are reversed and which are not.

4. Repeat moving the mirrors, increasing the number of reflected R's by one each time, until you see 7 reflections.

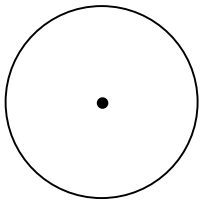
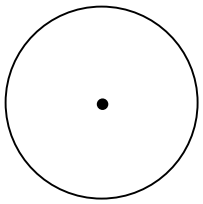
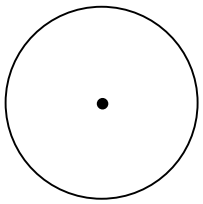
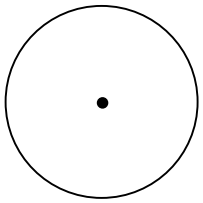
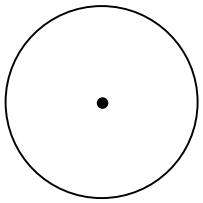
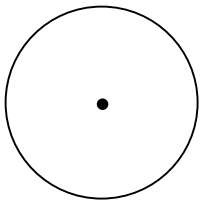
5. Create a graph of the number of reflections (y-axis) versus mirror angle (x-axis). Describe the shape of the graph in words.

6. By looking at your data and at the graph, see if you can predict the angle between the mirrors when you would see eight reflections. Predict the angle for nine reflections.

7. Can you come up with a formula that relates the number of reflections you see to the angle between the mirrors?



DATA TABLE

Number of Reflections	Angle Between Mirrors	Sketch
		
		
		
		
		
		

The Pirate Handout
(a.k.a., The "Rrrrr" Handout)

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