REFLECTION BATTLE

EVERYTHING YOU NEED TO PLAY

MATERIALS

Blank Paper

- 1 piece of blank paper per pair of students. These instructions will assume students are playing one-on-one, but students can also play in two teams.
- 8.5 × 11 inch paper is easiest to find, but if you want an extra challenge, you can use poster paper or something larger.

Pens and Pencils

- 1 of each per pair of students. This is to make sure the two students have different colors. You can also provide them with colored pencils or pens of different colors.

Scissors

- The paper fold that is needed can be horizontal, vertical or diagonal. If you choose a diagonal fold, you will need to cut your paper to form a square.

RULES

The structure of this game is similar to Battleship®. Reflection Battle is played in pairs, using knowledge of symmetry to launch missiles and destroy asteroids. The first player to hit all of the other player's asteroids is the winner.

- Pairs should start with a blank sheet of paper and fold this paper in half horizontally, vertically or diagonally. The figures here show a vertical fold.
- Player A and Player B should each draw five asteroids on his or her half of the paper. They should agree on a minimum size for asteroids. (Figure 1)
- Players should agree on the maximum size of the missiles. Player A draws a missile (small circle) on his or her side of the paper at a place where he or she thinks the missile would land on top of one of Player B's asteroids when the paper is folded over along the original fold. In other words, the missile should be aimed at the reflection of the asteroid. (Figure 2)
- Player A then should poke a small hole in the paper at the location of the missile, no wider than the agreed-upon maximum size. Player A then folds the paper in half and colors the paper through the hole, marking on Player B's half of the paper. (Figure 3)
- Player A then opens the paper to see if his or her missile hit an asteroid. Whether an asteroid is hit or not, Player B now has a turn. Player B should follow the same procedure. (Figure 4)
- The winner is the first to hit all of the opponent's asteroids.

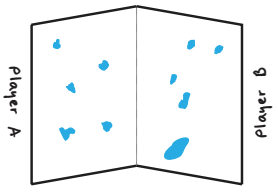


Figure 1

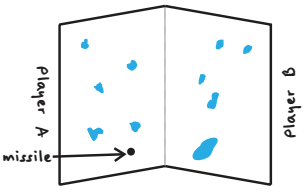


Figure 2

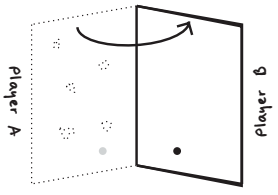


Figure 3

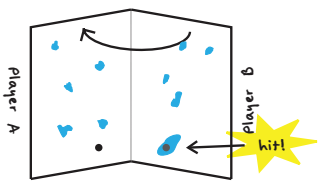


Figure 4

Notes: (1) Only missiles launched by Player A can destroy Player B's asteroids and vice versa. If Player B must initially place a missile on his or her own asteroid to hit one of Player A's asteroids, that will not destroy Player B's asteroid. (2) No rulers or other ways of physically measuring may be used during the game.

Optional: Make It Extra Mathy

Mathematical Exploration

Symmetry and Strategy

The concepts behind this game are simple, but that doesn't mean the game itself is easy. Students are already familiar with reflection and symmetry, but this game requires developing a strategy based on this knowledge. Use the following questions to help your club discover some ways to be more competitive in Reflection Battle.

- ***When playing the game, were any asteroids easier or harder to hit than others? How should you place your asteroids?***

  If asteroids are placed closer to other asteroids, they are easy targets. You have a better initial chance of hitting one of a cluster of asteroids, and after the first missile launch, you have a guide to make small adjustments to hit nearby asteroids. It is also easier to hit asteroids that are close to the line of symmetry or edges of the paper. Similar to clustered asteroids, you have something to use as a guide for placement of your missile. Students should keep their asteroids central and well spaced to make the game more difficult for their opponents.

- ***When using a diagonal line of symmetry rather than a horizontal or vertical line of symmetry, did you observe that the asteroids were more difficult to hit? How should a symmetric point be determined?***

  It is especially easy to incorrectly estimate the landing point of a missile when using a diagonal line of symmetry. Figure 5 shows a common error. Player A missed because he estimated the distance along a line parallel to the bottom edge of the paper. The line that should be used to estimate along is the line perpendicular to the line of symmetry. Figure 6 shows this perpendicular line and the equal distances on either side of the line of reflection, between point A and its reflection A'. This method of measurement is obvious to students when using horizontal and vertical lines of symmetry but less intuitive when using diagonal lines.

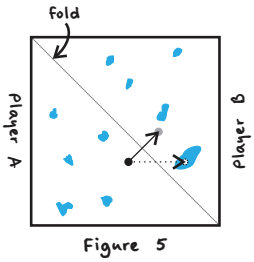


Figure 5

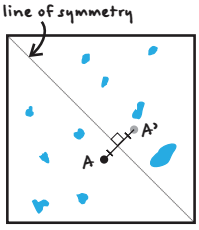


Figure 6

The Coordinate Plane

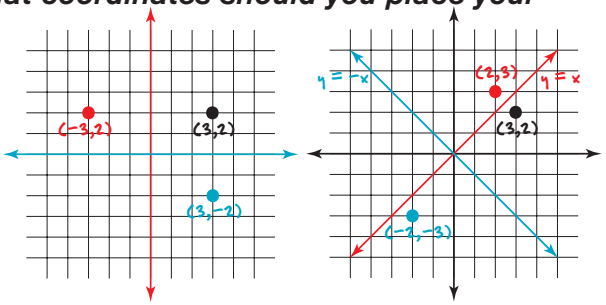
This game is a great way to explore plotting points on a coordinate plane and looking at how the coordinates change when points are reflected over the x-axis, y-axis or the line $y = x$ or $y = -x$. The following lesson questions will guide students to think about playing this game using coordinate geometry as their helper!

- ***On a coordinate plane, if the horizontal line of symmetry is the x-axis and the vertical line of symmetry is the y-axis, what is the equation representing the diagonal line of symmetry?***

  There are two possible answers for this, depending on how you fold the paper. The line will have a slope of either +1 or −1. Since the line of reflection will go through the origin, the two possible equations for the diagonal line of symmetry are $y = x$ and $y = -x$.

- ***If your opponent's asteroid is at (3, 2), then at what coordinates should you place your missile for a horizontal, vertical and diagonal line of symmetry?***

  Reflecting over the horizontal will give you point (3, −2), reflecting over the vertical will give you (−3, 2), reflecting over $y = x$ will give you (2, 3) and reflecting over $y = -x$ will give you (−2, −3).



- ***In general, how does a coordinate change when reflected over the x-axis, y-axis, the line y = x and the line y = −x?***

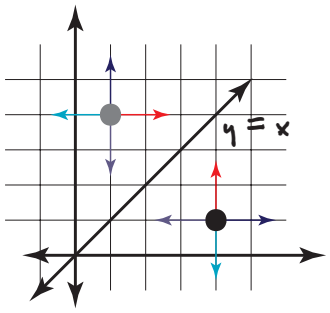
  If the original point is (a, b), then the table shows the resulting point after reflection.

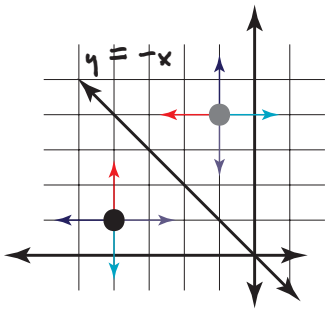
Line of Reflection	New Point
Horizontal	(a, $-b$)
Vertical	($-a$, b)
Diagonal ($y = x$)	(b, a)
Diagonal ($y = -x$)	($-b$, $-a$)

- ***If you are playing with a diagonal line of symmetry, as a general rule, in which direction should you move your missile to adjust the reflected point in a particular direction?***

Diagonal Line $y = x$	
Move Point	**Reflection Moves**
Positive x direction	Positive y direction
Negative x direction	Negative y direction
Positive y direction	Positive x direction
Negative y direction	Negative x direction

Diagonal Line $y = -x$	
Move Point	**Reflection Moves**
Positive x direction	Negative y direction
Negative x direction	Positive y direction
Positive y direction	Negative x direction
Negative y direction	Positive x direction





Differentiation, Scaling and Extensions

Change the Difficulty Level

Possible ways to scale Reflection Battle have been mentioned in the rules and lesson, but to reiterate, the easiest way to scale is by changing the line of reflection and/or the paper size.

- To make it easier: use a horizontal or vertical line of symmetry and smaller paper sizes.
- To make it harder: use a diagonal line of symmetry (make sure the paper is square) and/or use a larger piece of paper—poster paper, for example.
- One other option for scaling is to allow students to use tools for measuring. This can teach them about measuring perpendicular to the line of reflection and making sure the points are equidistant from the line of reflection.

Change How You Play

Play the same game over and over by making some slight changes or making it more competitive. A couple of ideas to keep it interesting are:

- After going through the coordinate plane lesson, have students sketch a grid on their papers or use graph paper. Then they can play the same game but use their knowledge of reflections on a coordinate plane. *Hint:* Some wrapping paper comes with grid lines on the back, making it a great resource for this game.
- Who has the best eye for reflections? Set up a single elimination bracket for your club, to find the Reflection Battle champion!