Equations of Attack

GRADE: 6-8

PERIODS: 1

STANDARDS:

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Students will plot points on a coordinate grid to represent ships before playing a graphing equations game with a partner. Points along the *y*-axis represent cannons and slopes are chosen randomly to determine the line and equation of attacks. Students will use their math skills and strategy to sink their opponent's ships and win the game. After the game, an algebraic approach to the game is investigated.

Tell students that they will be playing a strategy game in which they must sink their opponent's ships. To win the game students will need to use their knowledge of graphing and linear equations.

Break the class up into pairs. Depending on the ability levels of your students, you may choose to allow them to pick their own partners or separate them into pre-determined pairs that are matched for mathematical ability. Distribute the Equations of Attack activity sheet, Slope Cards activity sheet, 2 different-colored pencils, a coin, and scissors to each pair of students. **Note:** If your class is just beginning to explore linear equations, you may wish to create your own set of slope cards with only integers (e.g., 2 and –3) and unit fractions (e.g., $^1/_4$, but not $^3/_4$). Likewise, to challenge more advanced students, consider including decimal slopes (e.g., 1.5).

Equations of Attack Activity Sheet

Slope Cards Activity Sheet

Read through the questions and game rules with students. You may also want to go through an example of the game on the board before students begin. Draw a ship at (1,5) and one at (2,7). Tell students to assume that you drew a slope card with a value of 3, and that you have the odd-numbered cannons. Ask students which cannon would be the best to use given the location of the ships and the slope. Show students that if you choose 1 as your cannon location, the line you draw intersects (and sinks!) the ship at (2,7).

Since students will have to write the equations for their lines of attack, you may wish to write the equation for this line on the board:

$$y = 3x + 1$$

If students struggle with the example, you may choose to do another example or two. Since the player has the odd-numbered cannons, the other possible lines of attack would be:

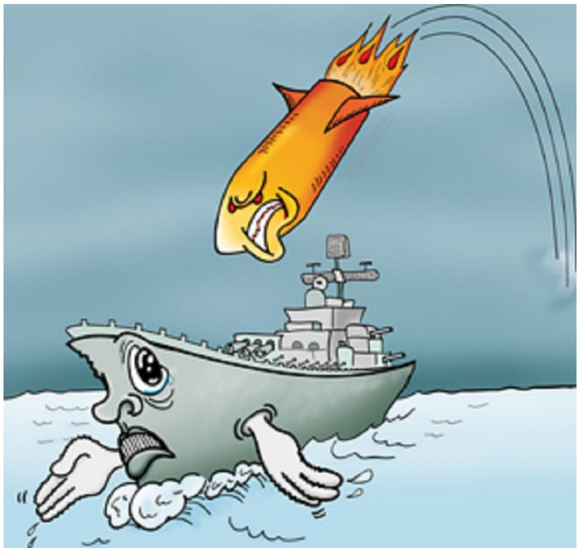
- $y = 3x + 3$
- $y = 3x + 5$
- $y = 3x + 7$
- $y = 3x + 9$

If some students in your class seem to understand while others continue to struggle, have a student who understands come to the board and draw the line of attack to determine whether either of the two ships is sunk.

In general, the equations will be:

$$y = (\text{slope})x + (\text{cannon position})$$

However, try not to share this with students. They should discover this pattern and its meaning on their own.



Playing the Game

Have students start by cutting out and stacking the slope cards face down. As students move on to plotting their ships, walk around and make sure they plot them correctly. They may try to color in blocks or choose locations between points rather than at the lattice points. You may choose to check the game boards (ship and cannon locations) before students start, to ensure the desired results.

In playing the game, students should use their color to draw their line on the game board, from their cannon and using the correct slope, to see if the line intersects any of their opponent's ships. Do not correct students if they draw their lines incorrectly—this should come up in the second half of the lesson when they use algebra to figure out the paths of the cannonballs. However, if you notice a large number of students drawing lines incorrectly, you may choose to pause play and do another example or two on the board. Encourage students to use vocabulary words, such as *slope* and y-*intercept*, and to name the points as (x, y) coordinate pairs. As students are playing their games, remind them to list their equations in Question 1. Student pairs can share an activity sheet or record their answers separately.

Discussing the Algebra

When all students have played several rounds, stop the play to ask a few questions:

- How do you choose which of your cannons to use?

  [Answers may vary, but students may discuss the different slopes. If the slope is a negative, they may choose a cannon that is higher on the *y*-axis, and vice versa. Students may also discuss the location of their opponent's ships.]

- Can you tell that your equation will sink a ship before you graph it? How?

[Yes, but not all students may realize how at this point.]

Use the second question above as a segue into having students answer the remaining questions on the activity sheet. After all students have had sufficient time to answer the questions, go over them as a class.

Through discussion in their pairs and as a class, students should be able to answer Question 4. The easiest way to find the answer without graphing is to substitute the coordinate pair of the opponent's ships into the equation.

If students have trouble coming up with this strategy, ask them what the *x* and *y* mean in a linear equation. It is often surprising how few students know the answer to this question. Each (*x*,*y*) pair that is a solution of the equation represents a point on the line. You can use the prior example with ships at (2,5) and (2,7), slope = 3, and cannon (*y*-intercept) = 1, to show what happens when you substitute in the 2 different points:

equation: $y = 3x + 1$

plug in: (1,5)	plug in: (2,7)
$5 \quad 3\cdot1 + 1$	$7 \quad 3\cdot2 + 1$
$5 \quad 3 + 1$	$7 \quad 6 + 1$
$5 \neq 4$	$7 = 7$
Since the point does not make the equation true,	Since the point does make the equation true,
(1,5) is not a point on the line.	(2,7) is a point on the line.
The ship is not sunk.	The ship is sunk.

- Colored pencils or markers
- Coins or counters
- Scissors
- Equations of Attack Activity Sheet
- Slope Cards Activity Sheet

Assessments

1. Students could write a story about their ships, explaining how to find an equation of attack given their cannon's location, slope, and the enemy ship location.
2. Collect the Equations of Attack activity sheet from students, and grade them for accuracy and completeness.
3. Give students a new location for an enemy ship and a slope. Ask them what cannon location they would choose and why. Then ask them to state the equation of the line that they would use to sink the ship.

Extensions

1. This activity could lead into an investigation of how the slope of a line determines the direction. Have students investigate the strengths and weaknesses of certain kinds of slopes in the game. For example, very large slopes have limited use because they cross very few lattice points in the first quadrant.
2. Students could investigate finding the equations of attack by plotting ships and cannons on Geometer's Sketchpad (or a similar geometry program), having the program find the equations, and then looking for patterns.

3. Students could play on a game board that uses all 4 quadrants, and negative *y*-values for cannon locations. Ask students to compare the strategies they used when only playing in the first quadrant with the new strategies they develop for playing in all 4 quadrants.
4. Add a rule about limited cannon range. For example, "Cannonballs can only travel 5 units across the game board." This introduces distance into the game. Students can again first play using trial and error. Cut out paper strips five units long to help students at first. After a few rounds of play, have students investigate solutions using the distance formula or the Pythagorean theorem.

Questions for Students

1. Is there a ship placement that is totally safe from the cannons? If so, where? If not, why?

[The answer to the question depends on the slope cards students are given. For example, if all the possible slopes are positive, then none of the points along the *x*-axis can ever be hit.]

2. Do you prefer to find if the ships are sunk by graphing or by using algebraic substitution?

[Answers will vary. Discuss with students the pros and cons of both methods. For example, graphing is quicker for most students, so they might find the time it takes to find a solution using algebra to be a con.]

Teacher Reflection

- Were students able to play the game with the given instructions? If not, how could you better explain the game before they start?
- Did students have difficulty writing the coordinate pairs for their ships? How could you provide instruction for this?
- Were students able to write the equations of the lines? How could you better scaffold this skill?
- Did students understand how to graph using the slope cards and cannon locations?
- Did students come up with their own strategies for the game, or did they need intervention?
- Did students work well in pairs? How would you pair students differently next time?

Learning Objectives

Students will:

- Plot and name points on a coordinate grid using correct coordinate pairs
- Graph lines given slope and *y*-intercept
- Practice writing equations given slope and *y*-intercept
- Determine algebraically if a point lies on a line

Common Core State Standards – Mathematics

Grade 8, Expression/Equation

- CCSS.Math.Content.8.EE.B.5
  Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.

Grade 8, Functions

- CCSS.Math.Content.8.F.B.4
  Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.