**Points and Lines and Slopes, Oh My!**

**Duration: 90 minutes**

**TEACHERS:** Nicole Mack, Cassie McLain, Jacob Thornburg

**TOPIC & SECTION:** Section 6.6 – Parallel and Perpendicular Lines

**GRADE/SUBJECT:** Algebra 1

**LEARNING OBJECTIVES**

* Students will define the relationship between the slopes of parallel and perpendicular lines through geometric manipulation.
* Students will use equations of lines and coordinate pairs to determine the equation of a line parallel to the equation given
* Students will use equations of lines and coordinate pairs to determine the equation of a line perpendicular to the equation given.
* Students will apply knowledge of lines to construct graph containing parallel, perpendicular, and intersecting lines without being given any equation.

**ALIGNMENT OF STANDARDS**

This lesson aligns with the following North Carolina Standard Course of Study:

*Geometry & Measurement*

* Competency Goal 2 → The learner will describe geometric figures in the coordinate plane algebraically
* Objective 2.02: Use the parallelism or perpendicularity of lines and segments to solve problems

This lesson aligns with the following NCTM Standards

*Geometry Standards for Grades 6-8*

* use coordinate geometry to examine special geometric shapes, such as regular polygons or those with pairs of parallel or perpendicular sides.
* use geometric models to represent and explain numerical and algebraic relationships

This lesson aligns with the following Common Core State Standards for Mathematics:

High School: Geometry → Expressing Geometric Properties with Equations

* Use coordinate to prove simple geometric theorems algebraically
* Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point)

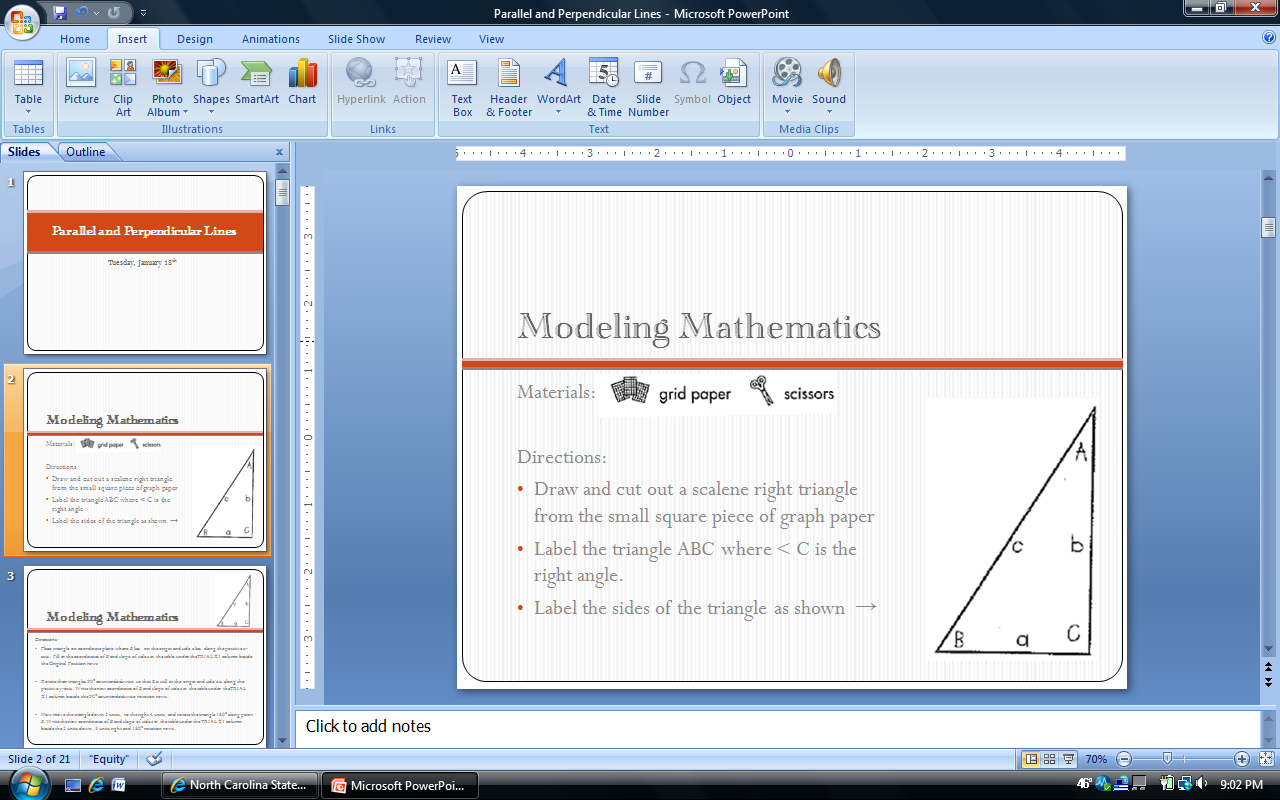
**MATERIALS**

-“Parallel and Perpendicular Lines” PowerPoint Presentation

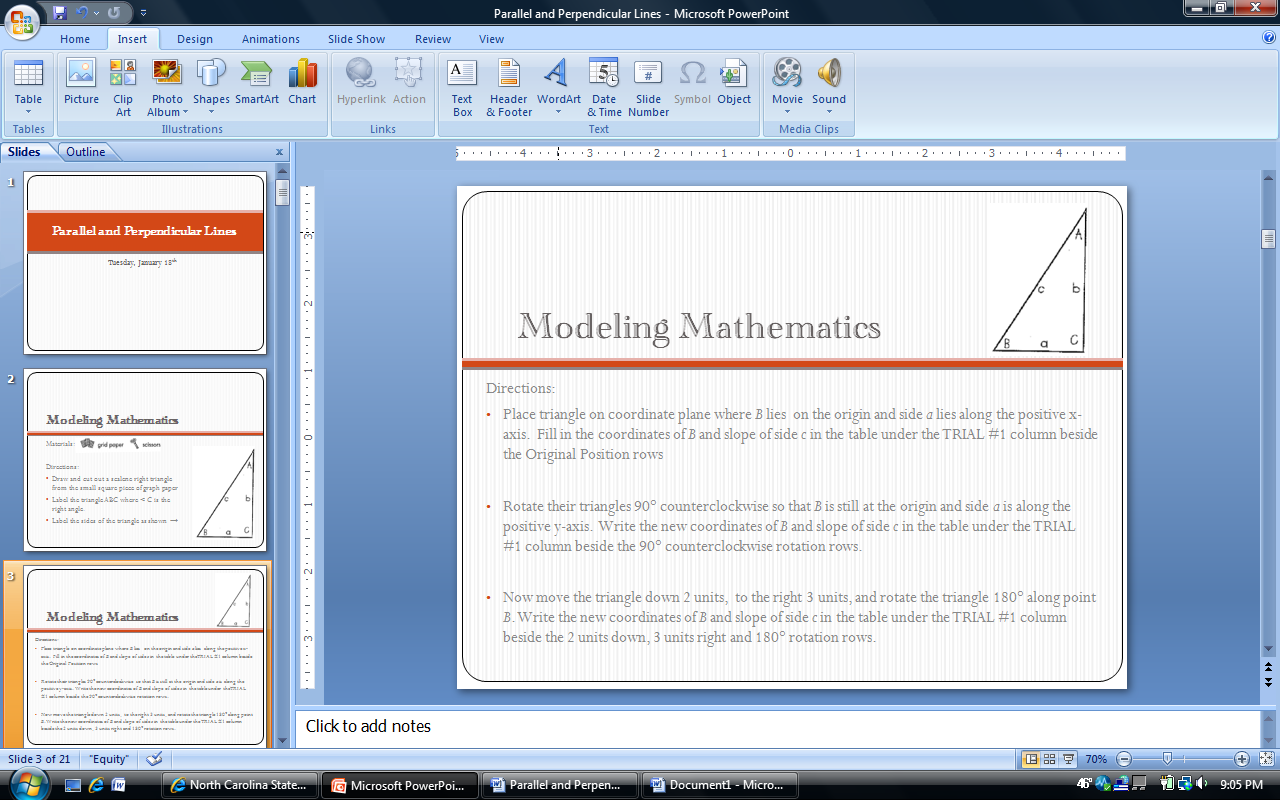
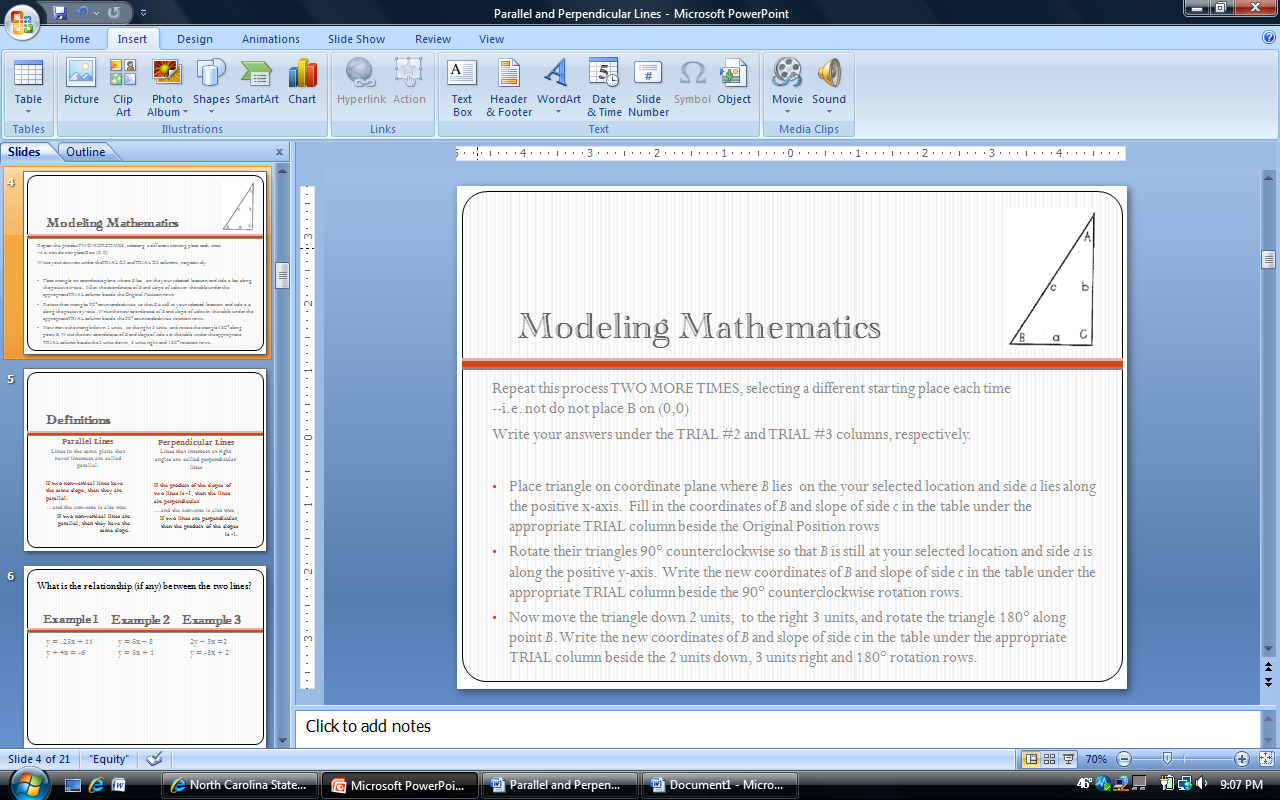
-graph paper

-scissors

**STUDENT INVESTIGATION ACTIVITY**

**Estimated Time: 25-30 minutes**

*Mathematics Modeling Activity*

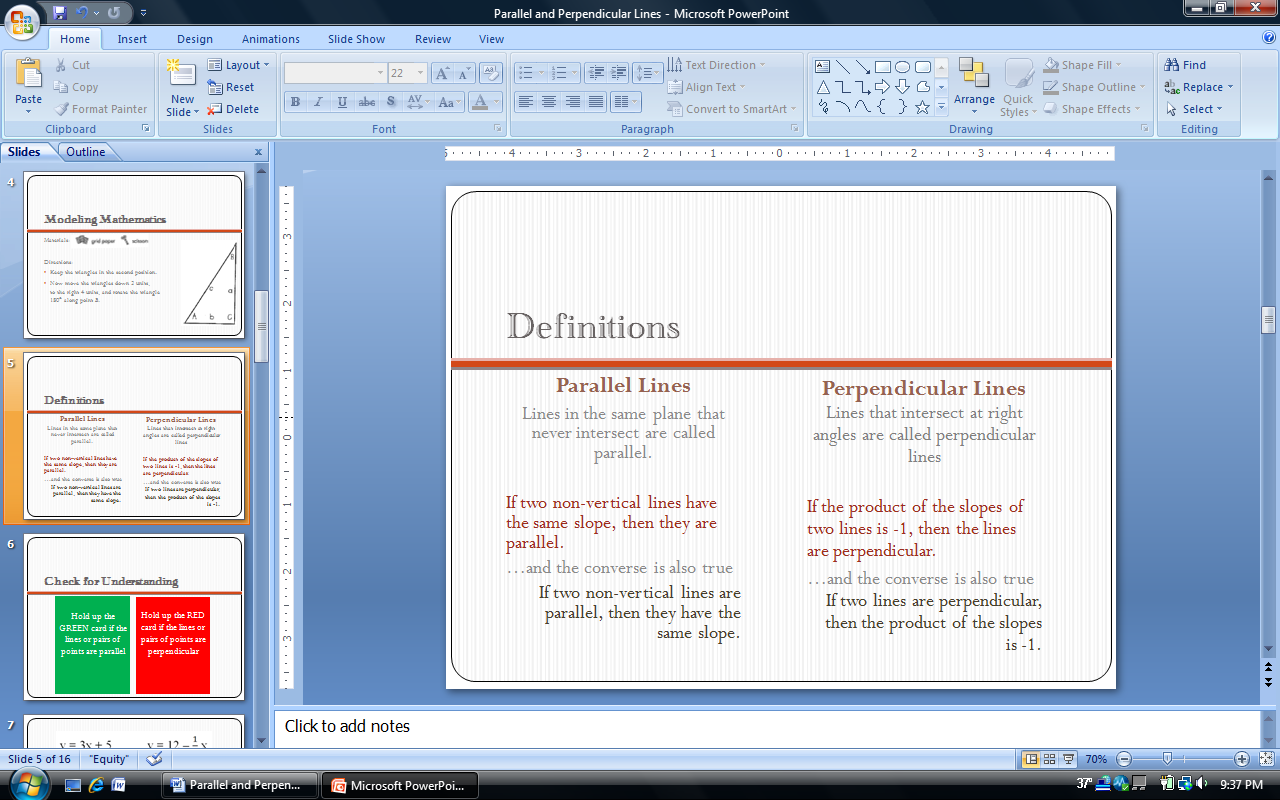
* Give each student a small piece of graph paper from which they can cut out their own scalene right triangle. Make sure the students know what it means for a triangle to be scalene—where no two sides are equal.
* Tell the students to label their triangle ABC where < C is the right angle. Also have the students name the sides of the triangle as shown on the PowerPoint slide
* Now have them place their triangles on their coordinate plane where *B* lies on the origin and side *a* lies along the positive x-axis.
* Tell the students write the coordinates of *B* and find their slope of side *c*. They should write these numbers under the TRIAL #1 column beside the Original Location rows.
* Now have the students rotate their triangles 90° counterclockwise so that *B* is still at the origin and side *a* is along the positive y-axis.
* Tell the students to once again name the coordinates of *B* and to find their slopes for side *c*. They should write these numbers in the table under the TRIAL #1 column beside the 90° counterclockwise rotation rows.
* Tell the students to keep their triangles in the second position. Now tell them to move their triangles down 2 units, to the right 3 units, and rotate their triangles 180° along point *B*.
* Tell the students to once again name the coordinates of *B* and to find their slopes for side *c*. They should write these numbers in the table under the TRIAL #1 column beside the 2 units down, 3 units right, and 180° rotation rows.
* Instruct students to complete this entire process two more times, selecting different starting places each time. Students should fill in their answers under the TRIAL #2 and TRIAL #3 columns, respectively.

After students complete all three trials, proceed with the following questions:

* **Teacher**: “What is the relationship between the first position of *c* and the second?”
* *Anticipated Student Response*: “They are perpendicular to each other”
* **Teacher**: “What is the relationship between the slopes of *c* in each position?”
* *Anticipated Student Response*: “The slopes are negative reciprocals of each other”
* **Teacher**: “What is the relationship between the second position of *c* and the third?”
* *Anticipated Student Response*: “They are parallel to each other”
* **Teacher**: “What is the relationship between the slopes of *c* in each position?”
* *Anticipated Student Response*: “They have the same slope”

**TEACHER INSTRUCTION**

**Estimated Time: 5-10 minutes**

Through the mathematical modeling activity, students have created definitions of parallel and perpendicular in regards to slope. Teacher will now post the notes for students to copy that formalize the definitions that were just formulized in the class discussion following the activity.

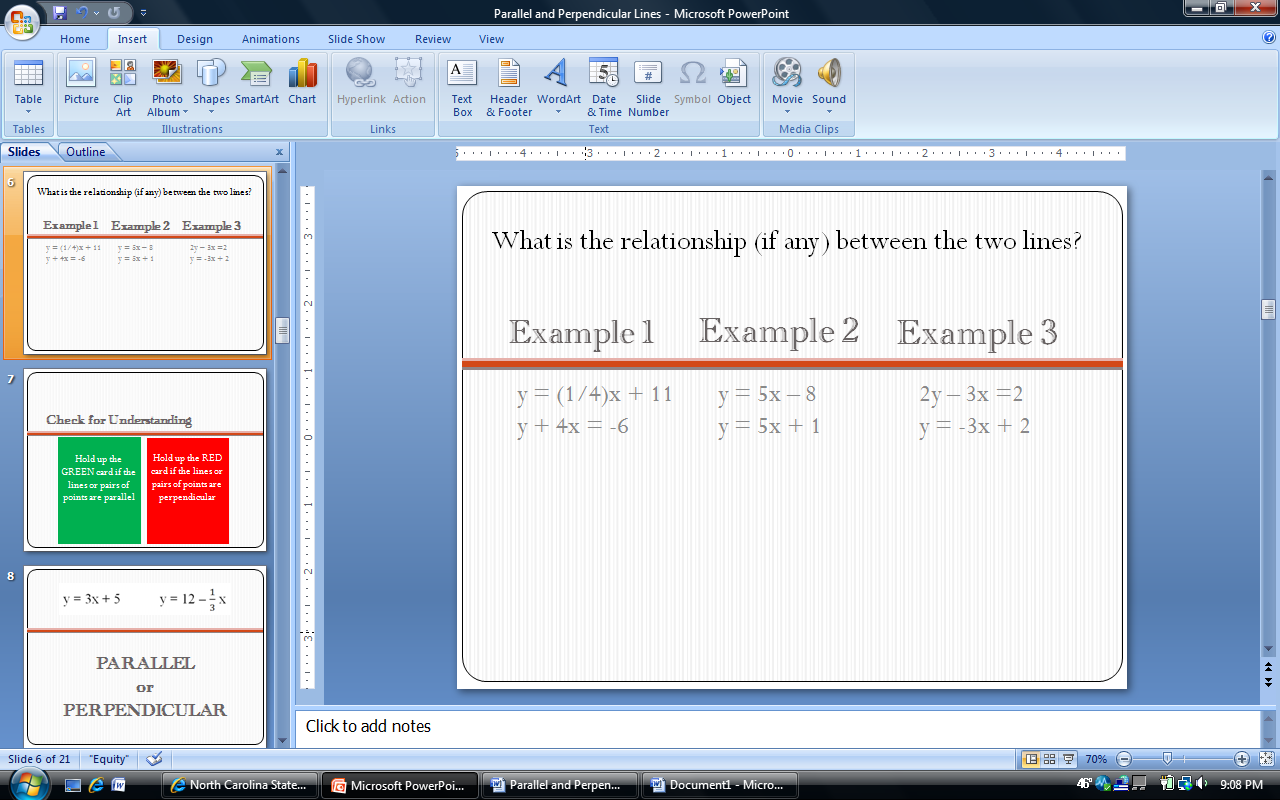
Definitions:

Lines in the same plane that never intersect are called *parallel lines*.

If two non-vertical lines have the same slope, then they are parallel. If two non-vertical lines are parallel, then they have the same slope.

Lines that intersect at right angles are called perpendicular lines

If the product of the slopes of two lines is -1, then the lines are perpendicular. If two lines are perpendicular, then the product of the slopes is -1.



Now students will apply the definition of parallel and perpendicular by comparing the slopes of lines to see how they are related.

Teacher should go through each of the three examples. With each step, ask students to advise you what to do. Once getting the equations in a comparable form, ask the students have students describe the relationship between the lines (i.e. if the lines are parallel, perpendicular, or neither.)

Example 1 → perpendicular Example 2 → parallel Example 3 → neither

y = (1/4)x + 11 y = 5x – 8 2y – 3x = 2

SLOPE = (1/4) SLOPE = 5 2y = 3x + 2

y = (3/2)x + 1

y + 4x = -6 y = 5x + 1 SLOPE = (3/2)

y = -4x – 6 SLOPE = 5

SLOPE = -4 y = -3x + 2

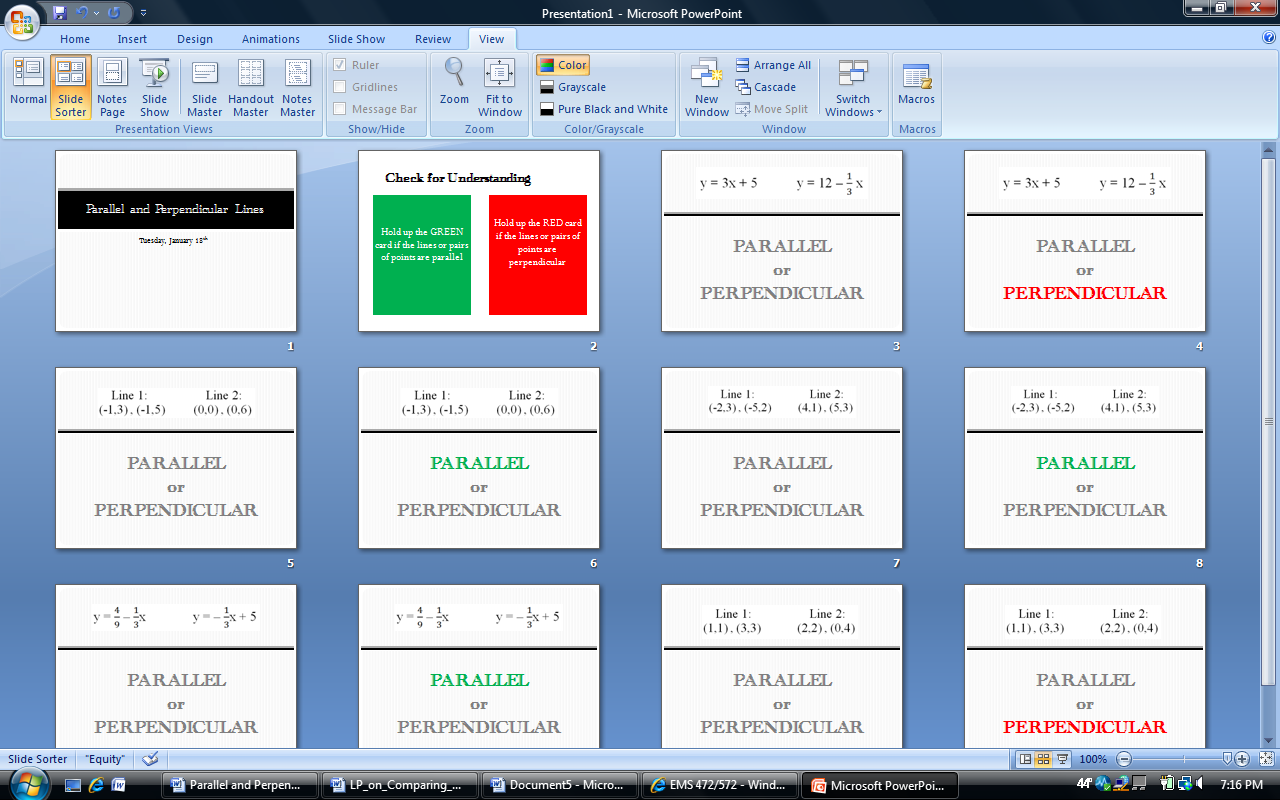
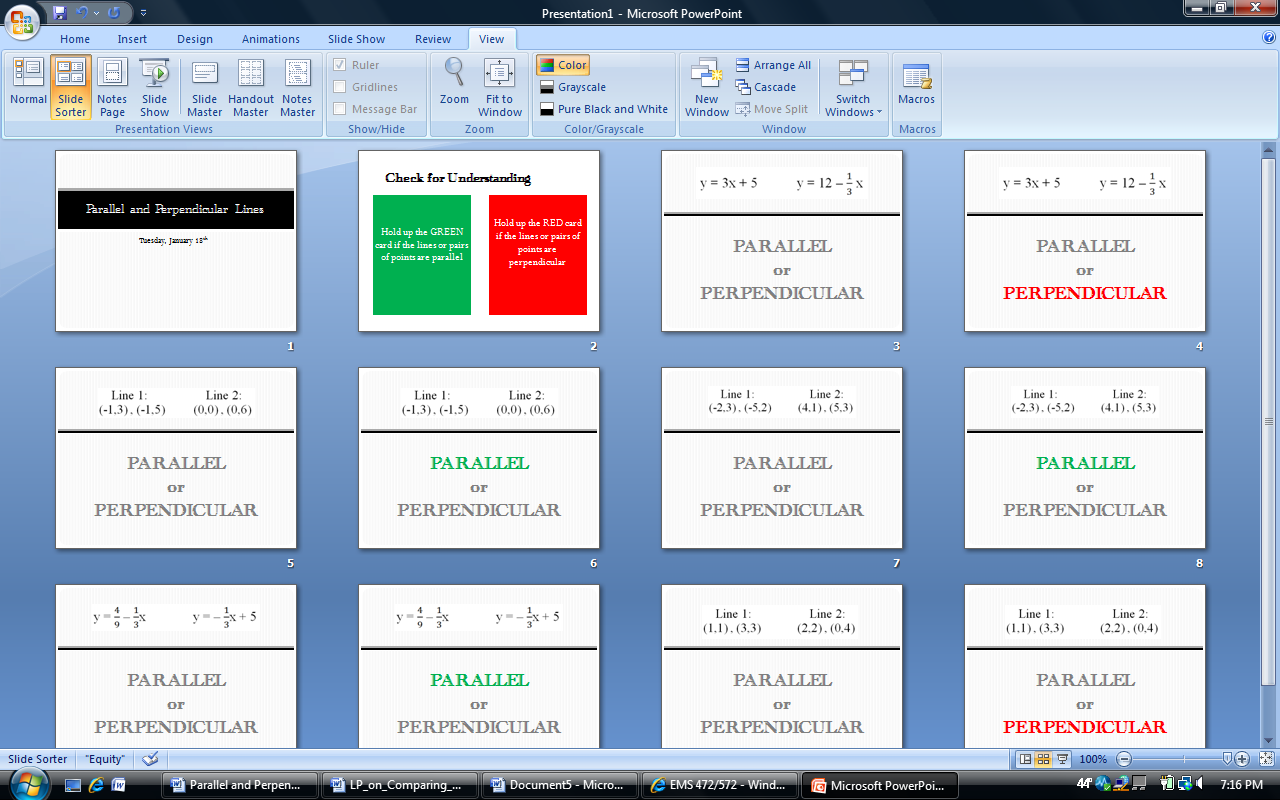
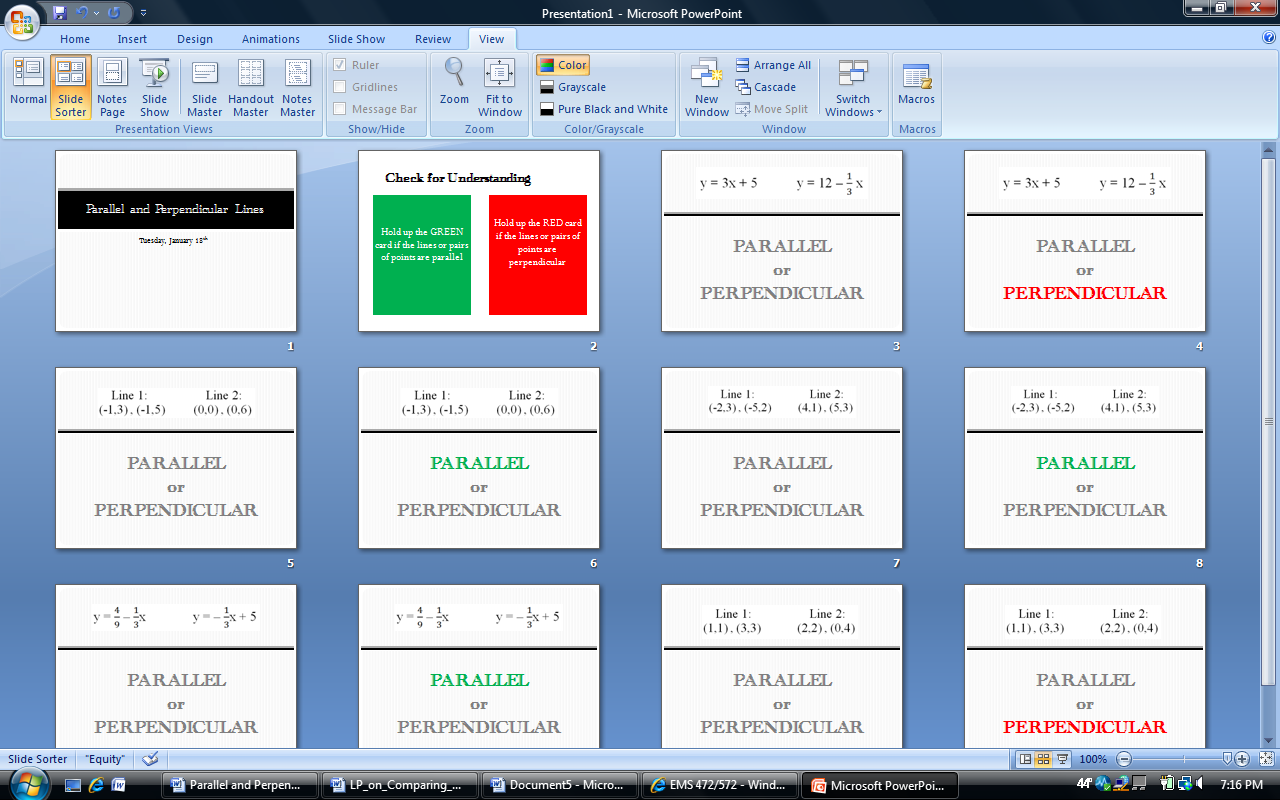
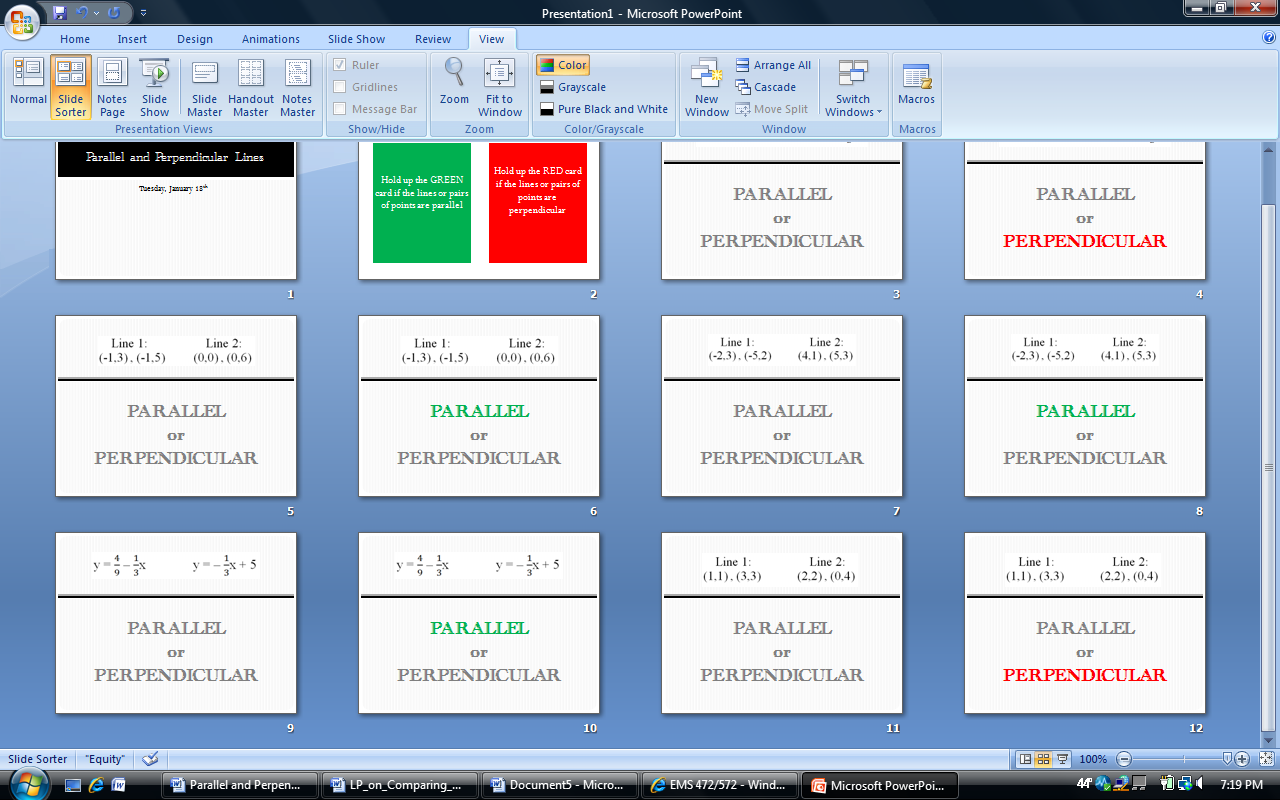
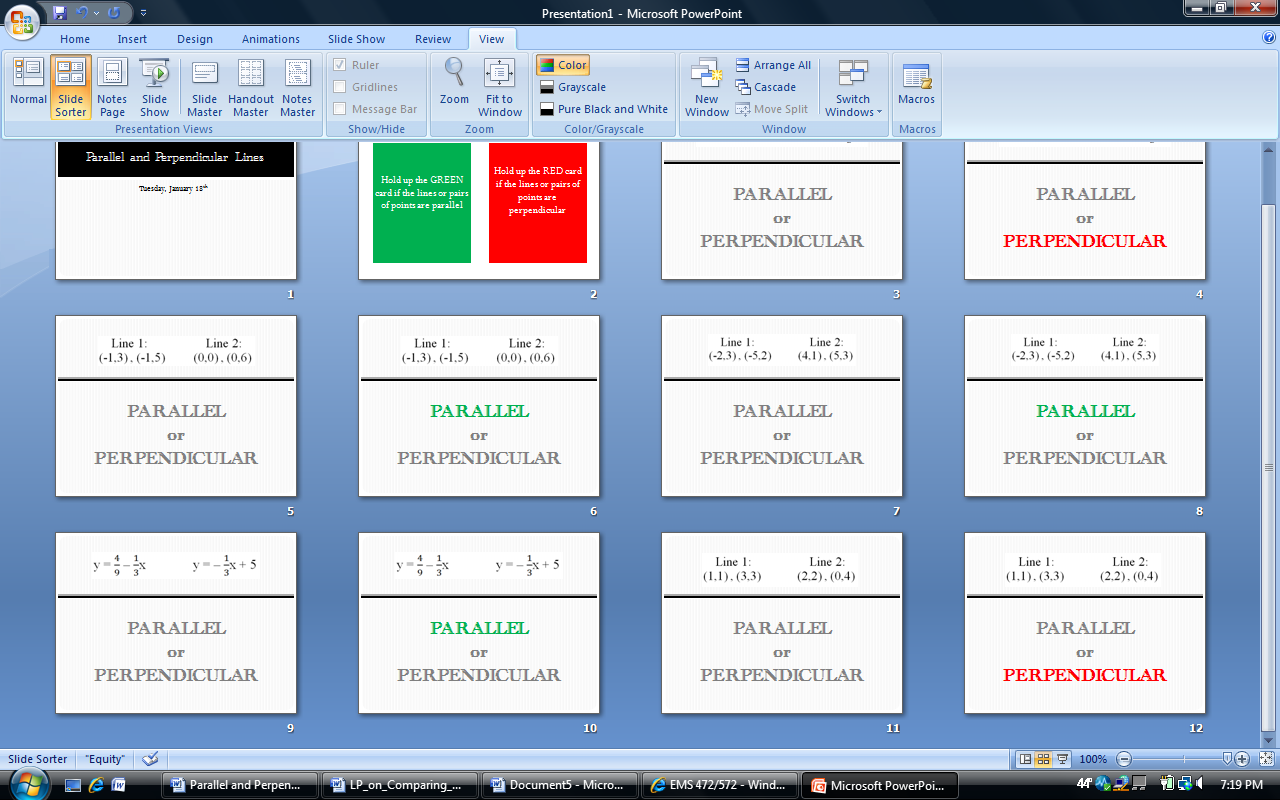
SLOPE = -3

**CHECK FOR UNDERSTANDING**

**Estimated Time: 20 minutes**

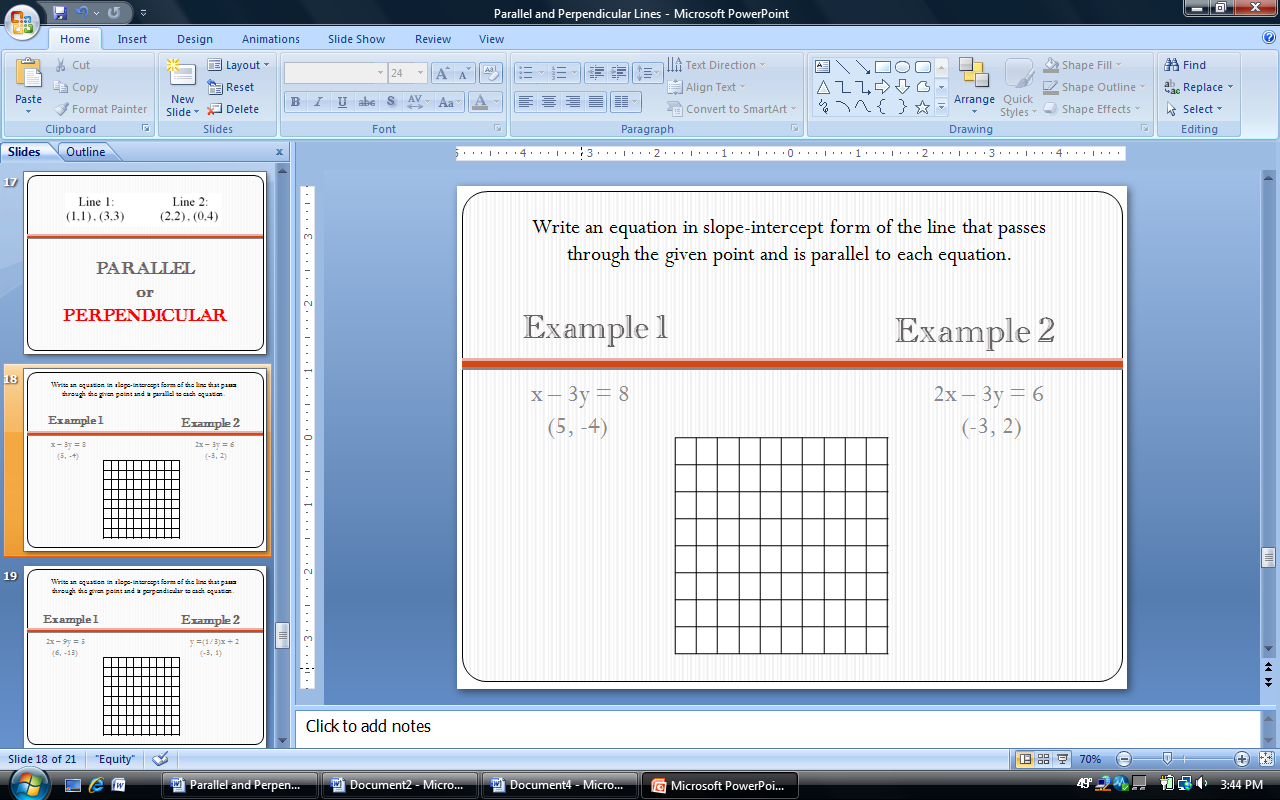
Let students pair up. Give each pair a red card and a green card. Teacher will show pairs of lines or pairs of points and the students will determine if the lines are parallel or perpendicular. Teacher should instruct students not to reveal their decision until directed to do so. When directed, students will hold up a green card if they are parallel or a red card if they are perpendicular.

Question s Answers

1. 
2. 
3. 
4. 
5. 

**TEACHER INSTRUCTION**

**Estimated Time: 15-20 minutes**

The check for understanding showed that the students understood how to determine if a line is parallel and perpendicular. Now, they will learn how to construct a line that is parallel or perpendicular to a given equations

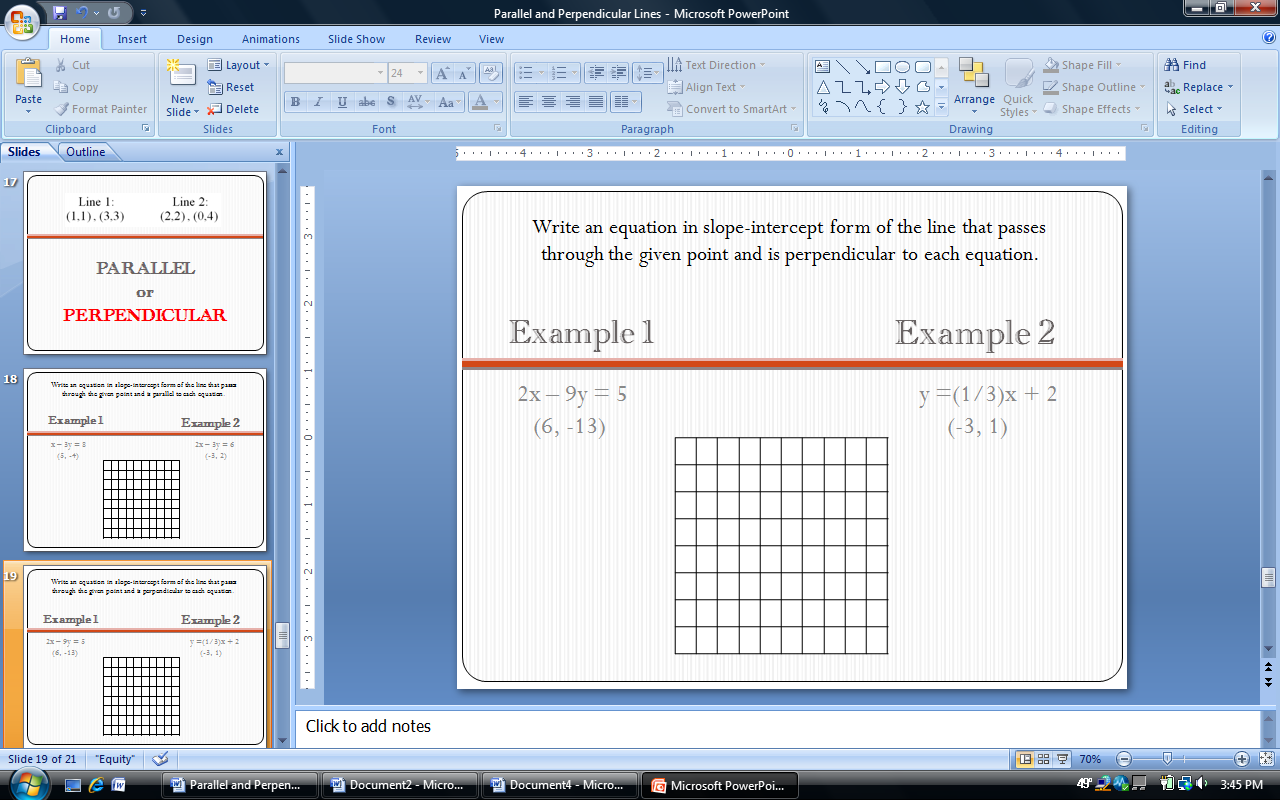
Write an equation in slope-intercept form of the line that passes through the given point and is parallel to each equation. Teacher should go through the first example. They will walk students step-by-step through each step. After each line is in slope-intercept form, graph both equations on the grid and show students that they form parallel lines. Then the student will complete the second example on their own. Teacher will select one student to write their answer on the board for others to see.

Example 1 Example 2

x – 3y = 8 y – (-4) = (1/3)(x – 5) 2x – 3y = 6 y – 2 = (2/3)(x – (-3))

-3y = -x + 8 y + 4 = (1/3)x – (5/3) -3y = -2x + 6 y – 2 = (2/3)x + 2

y = (1/3)x – (8/3) y = (1/3)x – (17/3) y = (2/3)x – 2 y = (2/3)x + 4



Write an equation in slope-intercept form of the line that passes through the given point and is perpendicular to each equation. Teacher should go through the first example. They will walk students step-by-step through each step. After each line is in slope-intercept form, graph both equations on the grid and show students that they form perpendicular lines. Then the student will complete the second example on their own. Teacher will select one student to write their answer on the board for others to see.

Example 1 Example 2

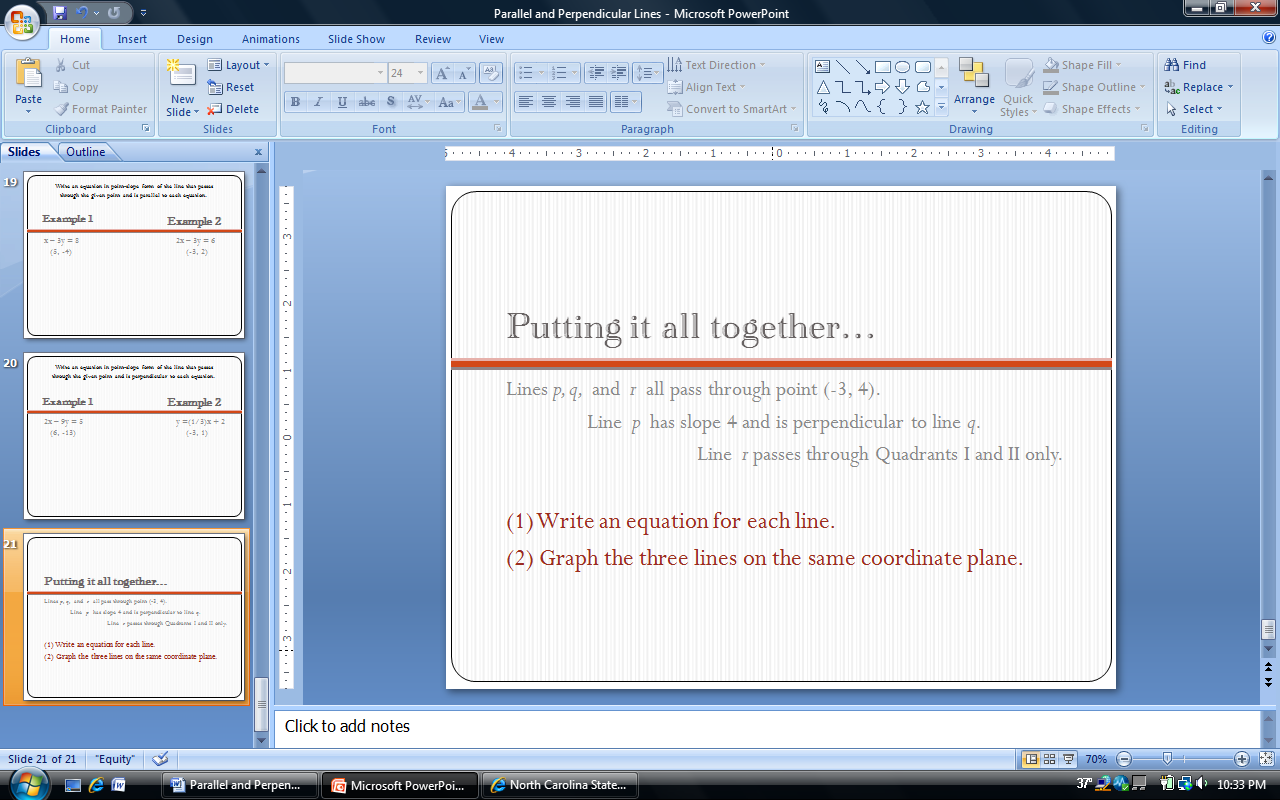
2x – 9y = 5 y – (-13) = (-9/2)(x –6) y = (1/3)x + 2 y – 1 = -3(x – (-3))

-9y = -2x + 5 y + 13 = (-9/2)x + 27 y – 1 = -3x + 9

y = (2/9)x – (5/9) y = (-9/2)x + 14 y = 3x + 10

**CLASS DISCUSSION & ASSESSMENT**

**Estimated Time: 10-12 minutes**



*Think*: Allow students to begin by working on this problem independently. Give them about five minutes to complete the graph and write the three equations.

*Pair*: Allow students to turn to a nearby classmate to compare their graphs and equations. If their answers are different, encourage them to explain their reasoning to each other. Give students about two minutes to compare their answers.

*Share*: Bring several student graphs and equations to the projector. With the several examples up on the screen, ask students to explain their step-by-step thinking of how they determined this was the correct graph.

**INDEPENDENT PRACTICE**

Homework: Chapter 6.6 Exercises on pages 367-386

Problems # 18, 20, 26, 30, 34, 38, 42, 44, 46, 48

**SOURCES**

North Carolina Standard Course of Study, High School Grades, Algebra 1

http://www.ncpublicschools.org/curriculum/mathematics/scos/2003/9-12/45algebra1

National Council for Teachers of Mathematics, Standards for Grades 6-8, Geometry  
http://www.nctm.org/standards/content.aspx?id=3778

Common Core State Standards for Mathematics, High School, Geometry

http://www.corestandards.org/the-standards/mathematics/high-school-geometry/expressing-geometric-properties-with-equations/

Textbook, Chapter 6: Analyzing Linear Equations, Parallel and Perpendicular Lines



**Original location** TRIAL #1 TRIAL #2 TRIAL #3

coordinates of *B*:

slope of *c*:

**90° counterclockwise rotation**

coordinates of *B*:

slope of *c*:

**2 down, 4 right, 180° rotation**

coordinates of *B*:

slope of *c*: