High School: Geometry

Slopes of Parallel and Perpendicular Lines

This learning progression is intended for a 10th grade geometry class. The curriculum will be taught from the textbook, "Geometry" by Houghton Mifflin Harcourt. The lessons will focus on lines, the slopes of lines, and coordinate planes. The CCSS-Math Clusters used are *Prove Geometric Theorems,* which the standard HSG.CO.C.9 comes from, *Use Coordinates to Prove Simple Geometric Theorems Algebraically,* which the standard HSG.GPE.B.5 comes from, and *Interpret Linear Models,* which the standard HSS.ID.C.7 comes from. The Standards for Mathematical Processes used for the duration of this learning progression are MP1, MP6, and MP7.

For this learning progression the central focus is that students will be able to find the slopes of lines and determine if two lines are parallel or perpendicular. They will also be able to graph lines and write their equations. The purpose of this progression is to help students become familiar with slopes of lines and the relation to the equations for them. The learning targets are: I will be able find the slope of line, I will be able to classify lines as parallel, perpendicular, or coinciding, and I can use the graph of lines to write their equations in slope intercept and point slope form. These targets will help guide the students to write the equations for lines and correctly use slope intercept and point slope form. While working on the lessons the students will be encouraged to relate their knowledge of finding slopes and using the graphs of lines to write the equations for them. The procedures for finding slope and classifying the lines will require conceptual understanding.

COMMON CORE STATE STANDARDS

PROVE GEOMETRIC THEOREMS

CCSS.MATH.CONTENT.HSG.CO.C.9
Prove theorems about lines and angles. *Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints*.

USE COORDINATES TO PROVE SIMPLE GEOMETRIC THEOREMS ALGEBRAICALLY

CCSS.MATH.CONTENT.HSG.GPE.B.5
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).

INTERPRET LINEAR MODELS

CCSS.MATH.CONTENT.HSS.ID.C.7
Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

MATHEMATICAL PRACTICES

CCSS.MATH.PRACTICE.MP1
Make sense of problems and persevere in solving them.
CCSS.MATH.PRACTICE.MP6
Attend to precision.
CCSS.MATH.PRACTICE.MP7
Look for and make use of structure.

When it comes to writing the equations for the lines procedural fluency and mathematical reasoning will be practiced.

This learning segment is related to solving equations in algebra and graphing lines in previous geometry lessons. The students will work in pairs or small groups during the lessons, in which students with dissimilar academic or language needs are placed together. According to "Flexible Grouping as a Differentiated Instruction Strategy" by Janelle Cox, grouping students (flexible grouping) is a great strategy to help students reach the goals, or learning targets, by considering each students' individual needs. Students that struggle in mathematics and EL students will have the opportunity to learn from their peers in a comfortable and contributing way.

Formative assessment in the form of observation and discussion will be the primary procedure to support student learning. As the students complete the tasks with their partners I will observe how they are finding solutions and ask them questions about their understanding. I will ask, "Why is the slope undefined instead of zero?" and "What is the relationship for the slopes of lines that are perpendicular?" When they are writing the equations for lines in the coordinate plane I will ask, "What information is given when using slope-intercept form?" Through observation, the students' communication with one another and their effort to solve the problems will support their learning. Through discussion I will be able understand how well they understand the concepts in relation to the CCSS.

For the first task students will receive a worksheet with graphs of lines and points for lines that must be graphed. They will work with

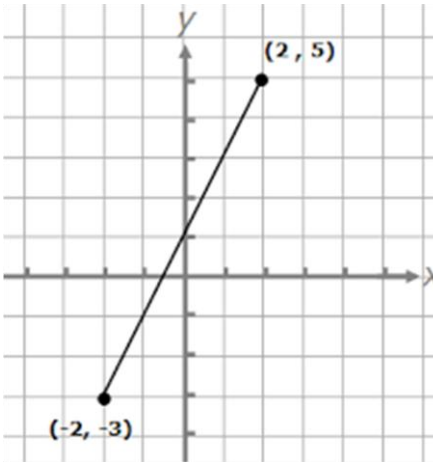
LESSON 1

<u>Learning Target</u>

I will be able to find the slope of a line.

<u>Question Examples</u>

1. Find the slope of the line.



2. Use the slope formula to determine the slope of the line AB, for A(2,1) and B(1,5).

<u>Hinge Question</u>

How do you find the slope of a line if you are only given 2 points?

<u>Formulas</u>

$\frac{Rise}{Run}$

Slope Formula- $\frac{y^2-y^1}{x^2-x^1}$

a partner or group of three to complete the task. They must use the graphs of lines to find the slope or use two points to draw a line in order to find its slope. They will begin by using the rise and run to start understanding how slope is found (MP1). Once they have a firm understanding of how to find the slope they will use the slope formula to find the slope of a line given two points, but without having to graph them (MP6). The students will need a strong understanding of finding slopes to be sure and set up and correctly solve the slope formula. This is related to their previous knowledge of simplifying fractions and will help them reach the mathematics standard HSG.GPE.B.5. While completing this task the students will be working toward mathematical practices MP1 and MP6. MP1 will be demonstrated when they find the slope using the rise and run. When students use the slope formula to find the slope given two points they will be working toward MP1 and MP6.

The second task will require the use of finding slopes learned in the previous lesson. They will also use their previous knowledge of identifying properties of perpendicular and parallel lines. The students will begin with a warm up finding slopes of two different lines that either have the same slope or slopes that are opposite reciprocals (MP6). They will then be given a handout with points for different lines where they will have to determine if they are parallel or perpendicular lines (MP7). Students will be able to see the relationship of the slopes for the lines are similar to the ones found during the warm up. They will recognize that parallel lines have the same slope and perpendicular lines have slopes that are opposite reciprocals. They will use mathematical reasoning and conceptual

LESSON 2

<u>Learning Target</u>

I will be able to classify lines as parallel, perpendicular, or neither.

<u>Question Examples</u>

Graph and find the slopes of the lines. Use the slope to determine if the lines are parallel, perpendicular, or neither.

1. $\overleftrightarrow{HJ}$ *and* $\overleftrightarrow{KM}$ for H(3,2), J(4,1), K(-2,-4), and M(-1,-5)

2. $\overleftrightarrow{QR}$ *and* $\overleftrightarrow{ST}$ for Q(-2,2), R(2,5), S(0,2), and T(3,-2)

<u>Hinge Question</u>

What is the relationship for the slopes of lines that are perpendicular?

understanding to relate their previous learning with newly learned concepts when determining if lines are parallel or perpendicular. This task is aligned with the mathematics standard HSG.CO.C.9 and the mathematical practices MP6 and MP7. Students will demonstrate MP6 when finding the slopes of the lines and will demonstrate MP7 when determining if lines are perpendicular or parallel.

The third task will start with partner/small group work on whiteboards and will end with a worksheet that shows the students ability to writer the equation for given points and lines. They will write equations in point slope form and slope intercept form, which will require them to use their recently learned concepts about slopes. While working with their partner on the whiteboards students will find the slope m, using the slope formula and use it to write equations in point slope and slope intercept forms. They will then graph the lines based on the information given to them in the equations. This activity and the worksheet will be connected to the mathematical standard HSS.ID.C.7 and the mathematical practices MP1, MP4, and MP7. Once they have a good understanding of how to use the slope intercept and point slope forms they will be given a worksheet on the new concepts just learned. This handout will show what they understand throughout the entire learning progression, since the lessons are closely related and build on each other. Students will have to use the accumulation of knowledge from all three tasks (MP6) to write the equations and classify lines as parallel, perpendicular, or coinciding (MP7). They will have to find the slope, given two points, or they will be given the slope with one point, then use the information given to write the equations for the lines (MP1).

LESSON 3

<u>Learning Target</u>

I can use the points for a line to write their equations in slope intercept and point slope form.

<u>Question Examples</u>

1. Write the equation for the line through the point (6,-4) with slope $\frac{2}{3}$ in point-slope form, then graph it.

2. Write the equation for the line with x-intercept 4 and y-intercept -3 in slope intercept form, then graph it.

<u>Hinge Question</u>

What are the differences and similarities in the point slope form and slope intercept form ?

<u>Formulas</u>

Point slope form-

$$y - y^1 = m(x - x^1)$$

Slope intercept form-

$$y = mx + b$$