INITIATE Lesson Plan: *Where the Two Roads Cross*

Lesson plan at a glance...

Name: Where the two roads cross

Course: Algebra 1

Grade Level: 9th

Prerequisites: Understanding of how to use a ruler and protractor as well as remembering the process for writing the line of an equation learned in a previous unit.

Preparation: Determine the students who will be in each group. Make sure the smart cars and tablets are prepared for each group (borrow additional cars/tablets from other teachers if necessary).

Instruction:
Time: 1 class period

Standard(s): A.CED.2a, A.REI.6a, F.LE.2

In this lesson plan…

Lesson Overview

In this lesson students will write a system of equations to model the problem in order to determine where the two roads intersect each other and then as a result be able to graph both roads, find where they intersect, and use measurements to determine how to turn from the first road onto the second road.

Driving Questions

Overarching Driving Questions for Bowsher Wide Project:

- How can we make smart cars safer and more convenient?
- How can we protect them from cyberattacks?

Lesson Specific Question:

- How do smart cars determine the correct angle required to make a turn from one road onto another road?

Materials and Equipment

- Smart Cars
- Tablets
- Pencils
- Measuring tapes
- Graph paper
- Rulers

Preparation Tasks

	Connect the smart cars with the tablets	3 minutes

The Lesson

Warm-up Activity: Introduction of the lesson plan	5 minutes

Activity 1: What's the line?	10 minutes
Activity 2: Graph your path.	8 minutes
Activity 3: Does the car follow the path?	20 minutes
Wrap-up Activity: Why is this important?	3 minutes

Warm-up Activity: Introduction of the lesson (5 minutes)

Activity Overview: In this activity, students will be introduced to the idea of using the smart car to find the location of an intersection, and then successfully complete a turn to get them onto the new road.

Activity: Lesson Explanation
Explain to the students that today they will be working on writing and graphing a system of linear equations in order to determine how to get their car from the starting point on the graph to the ending point.

Activity 1: What's the Line? (10 minutes)

Activity Overview: In this activity, students will write the equation for the two lines, each one representing a different road, so that they can graph these lines, and determine the intersection point and required turning angle.

Activity: Equation Writing
Detroit Ave follows the line $x + 3y = -3$
Arlington Ave contains the points (2, -8) and (4, 4)
Write the equation for the line that is Arlington Avenue.

*Equation for Arlington Ave. should be $y = 6x - 20$

Solve the system.
Using the equation for Detroit Ave. and the line you wrote for Arlington Ave., solve the system of equations to find the point where the two roads will intersect.

*Intersection point should be (3, -2)

Teaching Tips:

- *Ensure that all the cars are already connected to the tablets before class starts.*

Activity 2: Graph the Path (8 minutes)

Activity Overview: In this activity, students will graph their two lines (one for Detroit Ave. and one for Arlington Ave.) and verify that the point they found by solving algebraically

Activity: Graphing the Roads
On their graph paper, students will graph Detroit Ave. and Arlington Ave. using the equations for both. They will then check that their roads intersect at the point of intersection they found in activity 1.

Teaching Tips:

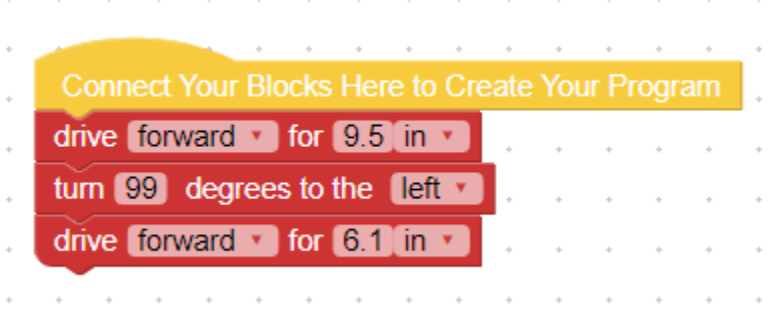
- *Use large sheets of graph paper for students to plot out their roads so that the car will be able to drive the specific route.*

Activity 3: Does the Car Follow the Path? (20 minutes)

Activity Overview: In this activity, students will measure the distance required for each part of the trip, find the angle needed to turn, and test out their program.

Activity: Finding the Measurements (8 minutes)
Now that you have your roads graphed, measure the distances required for your car to start on Detroit Ave. at the point (-6, 1), turn left onto Arlington Ave. at the intersection point and then stop at the point (4, 4) on Arlington Ave. Use your protractor to determine the angle that will be required to turn left onto Arlington Ave. from Detroit Ave.

Program and Test the Car (12 minutes)
Now that you have all of your measurements, program the smart car to run on the path and test your program. Did it work?



*Students final program should look similar.

Teaching Tips:

- *Make sure students know how to use a protractor and have an understanding of what information is required to properly program the car.*

Wrap-up Activity: Why is this important? (3 minutes)

Activity Overview: In this activity, students will reflect on why it is import for Smart Cars to have an understanding of where roads intersect.

Activity: Class Discussion
Ask students whose cars were able to successfully complete the turn at the intersection and stop at the given point. What issues did we have completing this? Why does this matter for Smart Car programmers?

Video of autonomous car going through different intersections (play until 1:10 seconds) Autonomous Vehicle - Intersections

Assessment:
Given a system of equations, students will be able to accurately solve the system both algebraically and graphically.

Learning Objectives and Standards

Learning Objectives	Standards
Students will be able to accurately write a system of equations that will be used to solve for the point of intersection between Detroit and Arlington Avenues.	A.CED.2 Create equations in two or more variables to represent relationships between quantities, graph equations on coordinate axes with labels and scales. a. Focus on applying linear and simple exponential expressions.
Students will be able to use an algebraic method (substitution or elimination) to solve their system and they will then graph their system to verify that their answer was accurate.	A.REI.6 Solve systems of linear equations algebraically and graphically. a. Limit to pairs of linear equations in two variables.
Students will be able to write the equation for the line given the two input-output pairs that will represent Arlington Avenue.	F.LE.2 Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs.

Additional Information and Resources

Project-based Learning Features

Feature	Where does this occur in the lesson?
Driving Questions	At the beginning of the lesson, students will be presented with the task of driving their smart car to a specific intersection and turning. What information will we need complete this task? How does this make smart cars safer?
Technology Incorporation	In activity 3 students will be programing their car to successfully run the course they have found using systems, distance measurements, and angle measurements.
Collaborative Opportunities	In activities 2 and 3 students will be working in their small groups. In activity 2 they will see if they have agreed upon their results from activity 1 and will then graph their lines (roads) on their large graph paper and then gather the necessary measurements they will need in order to write their program. Then in activity 3 they will design the program for their smart car and actually run the program to see if it worked.
Assessment Techniques	In activity 2, students will verify that they were able to correctly find the point of intersection by graphing their two lines. In activity 3, they will ensure that they found all of the correct measurements by running their program for the smart car and making sure if correctly follows the road. Once we have completed the activities, students will be given a problem in which they will need to write their system of equations, graph their system, and solve for the point of intersection.

Computational Thinking Concepts

Concept	Where does this occur in the lesson?
Decomposition	Activities 1 and 2 have students work through the process of writing a system of equations, then solving the system, and then graphing the system.
Abstraction	In activity 2, students will need to graph their system of equations and then find appropriate measurements to make their car drive the intended route. They will need to remove the wrong

	turning angle based on how the car comprehends how to turn.
Algorithm Design	In activity 3, students will design the program that is necessary for their smart car to travel from the starting point, turn left at the intersection, and continue on the road until they reach the ending point.

Administrative Details

Contact info: Sandy Zielinski szielins@tps.org

Sources: Bloxter, Ohio Content Standards, YouTube

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Template adapted from: https://edu.google.com/resources/programs/exploring-computational-thinking/

Name: _____ Date: _____ Period: _____

Using the Smart Car with Systems of Equations

Activity 1: Detroit Avenue follows the line $x + 3y = -3$, Arlington Avenue passes through the points (2, -8) and (4, 4).

a. Write the equation for the line that Arlington Avenue follows.
b. Solve the system of equations algebraically.

Activity 2:

a. In your groups, check to see if all group members have the same equation for Arlington Avenue and the same solution for the system. If not, check each other's work to see where the mistake was made.
b. Once everyone agrees on the line and the solution, graph Detroit Avenue and Arlington Avenue on your graph paper and then transfer your graphs onto your large graph paper.
c. What is the intersection point from your graph? Does this match your solution from activity 1?
d. Find the measurements for distance that your car will be traveling in centimeters using your rulers. Record these measurements on your graph paper and on your large graph paper.
e. Find the angle measurements needed for the car to turn left from Detroit Avenue onto Arlington Avenue. Record these measurements on your graph paper and on your large graph paper.

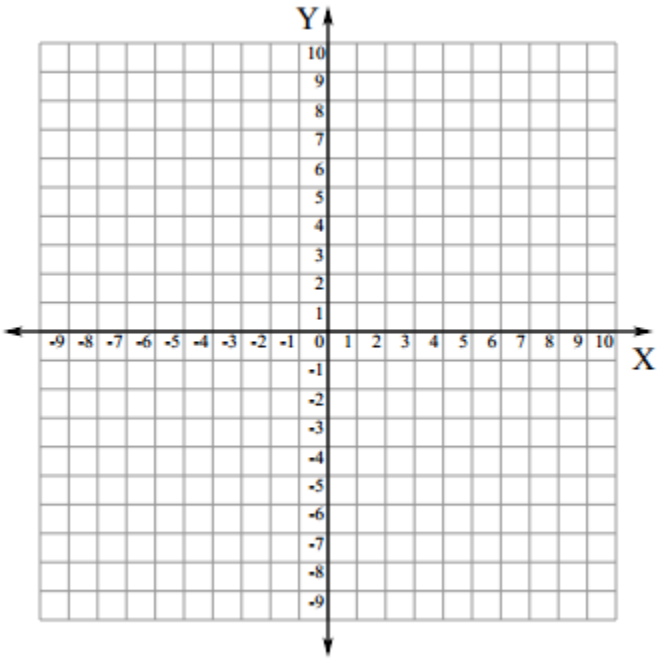
Activity 3:

a. Your car is going to start on Detroit Avenue at the point (-6, 1) and head towards Arlington Avenue. Once it reaches the point of intersection, your car should stop for 3 seconds. Then have your car turn left on Arlington Avenue and drive until it reaches the point (4, 4).
b. Design a program with the necessary commands to get your smart car to travel on the path that you have graphed.
c. If your car does not reach the destination, what needs to be changed in your program? Make adjustments and run the car again until it successfully reaches the end point.

1. a. The line for Arlington Avenue:

   b. The solution for the system of equations:
   (Show your work here)

2. Draw the graph of Detroit Avenue and Arlington Avenue. Label this graph completely including the street names, the point of intersection, and all of the measurements that you found during activity 2.



3. a. Now that you have programed and tested your smart car, did you have to make any changes to your original program to get the car to travel the correct route? What were those changes?

   b. What did your final code look like? List the steps below including the measurements.

Name: _____ Date: _____ Period: _____

Solving Systems Algebraically and Graphically

1. Write and solve a system of equations for lines A and B that satisfy the following conditions: Line A passes through the points (-1, 1) and (2, 4) and Line B is $6x + y = 9$

2. Solve the following system of equations by graphing.

$$x + 3y = -6$$
$$y = 4x - 2$$