Crests and Sags

A Solidify Understanding Task

Purpose: To determine the appropriate placement of a storm drain system and to determine the appropriate design speed on two different stretches of highway involving a sag and a crest curve.

Career Field: Geomatics and Civil Engineering, NCDOT Survey Division

WTCC Associate Program of Study and Contact Person: Beth Ihnatolya cihnatolya@waketech.edu

NC Math 4 Standards:
Include cluster headings

Unit Alignment:
Indicate where this lesson would be used in the course
NC Math – Modeling real-world applications with quadratics
WTCC Math 171

Common Core State Standards for Mathematical Practice
Indicate which of the standards are highlighted in this lesson

1. **Make sense of problems and persevere in solving them.**
2. **Reason abstractly and quantitatively.**
3. Construct viable arguments and critique the reasoning of others.
4. **Model with mathematics.**
5. **Use appropriate tools strategically.**
6. **Attend to precision.**
7. **Look for and make use of structure.**
8. Look for and express regularity in repeated reasoning.

Prerequisite Skills

- Determine the slope of a line by understanding the ratio of similar triangles.
- Describe the difference between negative, positive, zero, and undefined slope.
- Solve an equation for different variables.
- Understand quadratic function terminology.
- Determine new units based on unit conversion.

Time Required
The time required to complete this activity is approximately two class periods.

Materials Needed

- Student Activity Sheet
- Scientific Calculator
- Access to Desmos

Vocabulary

- Grade the slope written as a percent – A grade of 4% equates to a slope of 4/100 (rise over run)
- Vertical Curve – NC DOT use parabolas to model the up and down travel along a road
- Station: 100 feet
    - Projects start at station 0+00
    - Stations are written as the number of hundreds + remaining. Ex: The first station is 1+00 and the second station would be written as 2+00.
    - If you are 11+ 62.5 stations from the start of a project, you are 1162.5 feet from the start of the project.
- Use Stations for x when creating the parabolic model of the vertical curve and use the % slopes. For example, L = 4 and g1 = -5.1.

The Teaching Cycle:

Assign the Desmos Activity before starting the activity (Maybe give two days to complete). You can find the activity here https://teacher.desmos.com/activitybuilder/custom/62debda8400e2671d8e482e3

Launch:

Ask students about hydroplaning and what could potentially cause hydroplaning. Ask them what factors may be considered examining a highway system where hydroplaning could potentially be a problem. Then ask students about accidents involving cars with items in the road. Have them think about what factors are considered regarding road design and reconstruction so that cars are able to avoid objects in the road. Show them the launch video. [Insert launch video here].

Explore:

Task 1: To determine if the roadway drainage is placed appropriately on the first highway and if/what changes need to be made to decrease the number of hydroplaning vehicles.

Complete on the first day. What is not completed in class can be completed as a homework assignment.

Have students get into pairs to discuss answers to the preliminary discussion questions for task 1. After about 10 minutes have them combine with another pair to see if they can come up with a consensus on answers for those questions. If students are going down a rabbit hole in answering the questions, prompt them to create a picture and use their knowledge on quadratics on what could be used to answer the questions.

Once the students are confident with their solutions to the preliminary discussion questions, have them complete the task 1 questions with the group created by their pairs. You may need to remind students that the VPI is not on the curve. You may also need to remind students about the unit difference of being in stations and grades and slope and feet. Point them back to the Desmos Activity as a reminder of the terminology needed to complete the activity.

Task 2: To determine if any changes need to be made to the second highway that would decrease the number of accidents claimed due to the driver's claims of not being able to see an object in the road.

Complete on the second day. What is not completed in class can be completed as a homework assignment.

Have students split back up into pairs to discuss the preliminary discussion questions for task 2. After about 20 minutes have them reconvene with their group to discuss their responses. Once they are confident in their answers for these questions, they can begin answering the task 2 questions. You may need to remind them that units should be in feet and x units are usually provided in stations. Sight distance is given in feet as that is a total distance. You also may need to remind them that the grade is the actual percent, not the slope value in the formula for sight distance.

Discuss: Students will share their results and compare what they arrived at compared to other groups. Groups can explain their process they used at arriving at their result. You could have groups trade their answers and have groups compare their results with the results of the paper they are reviewing. Again, time is a factor in

how you handle the discussion part of the activity. Do at least have each group explain to some degree how they arrived at some part of their results.

Exit Ticket: Write a paragraph (at least 5 sentences) describing how one of the tasks relates to a mathematical topic. Discuss some other factors that could contribute to designing a "sag" or "crest" curve other than the ones provided in this activity.

Two example assessments for testing:

1. Derive a curve elevation function for the following scenario: You have a 500 foot vertical curve with a VPI station at 15+22.00 and elevation 102.86 provided the beginning grade is -4.2% and ending grade is 1.4%.
2. Using AASHTO's recommended value for driver's eye height of 3.5 feet, determine the sight distance with a 6 inch object for a 650 foot vertical curve with a start grade of 3.0% and an end grade of -2.0% .

Student Activity Sheet

Student Activity Sheet Final.docx

Answer Key

Student Activity Sheet Answer Key.docx