**Your brakes failed! What surface will keep you safe?**

**Transportation Roadways and Vertical Curves**

**DESCRIPTION**: You are taking a nice drive in your beautiful car, when suddenly your brakes fail and your car is driving out of control. This activity will allow you to test several different surfaces to see which one would be ideal to safely stop your car.

You will simulate several “test drives” onto different available surfaces and determine which surface provides the best and safest stopping material for your “vehicle”.

**MATERIALS**:

* One (1) toy car (bigger than a matchbox car works best)
* One (1) cardboard ramp approximately 6 inches
* Go! Motion detector
* Laptop with Fathom connection and Logger Lite
* At least 3 different surfaces

**GOALS ALIGNED WITH NC COMMON CORE STANDARDS:**

**Students will interpret functions that arise in applications in terms of the context.**

**F-IF.4** For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.

**F-IF.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

**F-IF.6** Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

**F-IF.9** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

**Students will build a function that models a relationship between two quantities.**

**F-BF.1** Write a function that describes a relationship between two quantities.

**BEFORE YOU BEGIN**:

Watch the “Transportation Roadways and Vertical Curves” Role Model video at scaleupstem.ncsu.edu 🡪 Career Role Models.

Discuss the following questions with your group…

1. What does the slope of the line mean in relation to speed?
2. What effect does the surface of a roadway have on the speed of a vehicle?
3. Of the 3 surfaces you have chosen, which surface do you believe provides the fastest speed? Which surface would provide the slowest speed? Why?

**SETTING UP THE EXPERIMENT**:

1. Connect to the VCL and open Fathom.
2. Open Logger Lite. The program will ask for a USB connection for a measurement device.
3. Connect the Go! Motion detector to your laptop. In Logger Lite, a new table and graph should appear.
4. Set up ramp.
5. Hold the Go! Motion detector at the top of the ramp.
6. Place the car at the top of the ramp.

**CONDUCTING THE EXPERIMENT**:

You will complete several runs onto different surfaces. Using the Go! Motion detector, you will measure the car’s distance traveled over a specific period of time. Using this data, you will be able to determine the car’s speed at different intervals and be able to determine which surface allowed a quicker stopping speed.

**COLLECT THE DATA**:

1. In Logger Lite, click Experiment 🡪 Data Collection
2. Change the Length to 3 seconds. Then click Done.
3. When you are ready, click the green “Collect” button in Logger Lite and release the car down the ramp.
4. If necessary, complete several runs to achieve a solid data collection.
5. Click File 🡪 Export as… 🡪 CSV
6. Save the file to your Desktop as “Test Run” and the surface you used (example: Test Run 1 – Carpet)
7. In Fathom, click File 🡪 Import…
8. Find your file on your Desktop. Double-click it to open.
9. A new collection should appear in Fathom.
10. Repeat steps 3 – 9 for each surface.

**ANALYZE AND INTERPRET THE DATA**:

1. Select the collection and create a table.
2. In your table, create a new attribute named “Velocity”.
3. Right-click on the Velocity attribute and click Edit Formula.
4. Enter the formula (next(Distance) – Distance) / (next(Time) – Time) into the pop-up. Click OK when finished.
5. The table should calculate the velocity of the car at each time interval.
6. Create two graphs. One graph should be Time vs. Distance and the other should be Time vs. Velocity.
7. Repeat steps 1 – 6 for each surface.

Once you complete all your test runs on your surfaces and have uploaded the data, discuss the following questions about the different surfaces’ effect on your car.

1. What do you notice about the Time vs. Distance graphs amongst the different surfaces?
2. What do you notice about the Time vs. Velocity graphs amongst the different surfaces?
3. How do all the Time vs. Distance graphs compare to the Time vs. Velocity graphs? Why are they so different?
4. Your Time vs. Velocity graphs should display a significant change at some point. What is the significant change displayed? What do you think this represents?

The goal of this experiment is to determine which surface provides a safer stopping material for a car. We can make some educated assessments of this goal by analyzing the data further.

1. On your Time vs. Velocity graphs, find the first data point in which the velocity has changed. This should indicate where the car began to slow down due to its surface. For each Time vs. Velocity graph, select all the data points that occurred before this point. Click Edit 🡪 Delete Cases. The unwanted data points should disappear.
2. With the graph selected, click Graph 🡪 Least-Squares Line. A line of best fit should appear on the graph, and a linear equation using Time and Velocity, as variables should also appear below the graph.
3. Repeat steps 1 and 2 for each surface.

**FINAL QUESTIONS**:

Discuss the following questions with your group.

1. What do you notice about the slope of each least-squares line? Which line had the highest slope? Which line has the lowest slope?
2. What does the slope represent in these lines? What does the y-intercept represent?
3. Based on the slopes, which surface would provide a safer stop for a car?
4. What force within each surface produces a different speed?

Submit the following to complete the assignment:

* A Microsoft Word document containing all Time vs. Distance and Time vs. Velocity graphs, labeled appropriately for each surface
* Typed answers to final questions #1 - #4. Please use complete sentences and provide thorough explanations.

**EXTENDED THOUGHTS/QUESTIONS:**

Discuss the following questions with your group.

1. Does this experiment provide a good example for a real vehicle? Why or why not?
2. Is there a way to safely reproduce this experiment using real vehicles? Why or why not?
3. If you were chosen to design a highway, what surface material would you use on the road itself? What surface material would you use as the safety stopping material?
4. Which surfaces (that you didn’t test) would be interesting to try? Why do you think it would provide an interesting test run?