Activity Overview

Make a real-world connection between the gradient on a highway sign with the slope of a line. Use transformations of y=x to determine the slope of the "road" (hypotenuse of a triangle) on a highway sign. This is an excellent use of background images on the Graph Screen on a TI-84plusC.

Materials

- TI-84 Plus C Graphing Calculator
- Photo of highway warning sign saved as Background Image (for TI-84plusC)
- Metric Ruler

Middle school students may or may not be familiar with the slope-intercept form ($y = mx + b$) of linear equations. This activity has students "build" a linear equation which (ideally) will have them discover the effect of *m* and *b* on the graph of a line.

Before starting this activity, if using the TI-84plusC, load the background image of the highway warning sign onto each handheld unit. (See Getting Started with TI-Connect and Let's Talk in the Appendix for instructions on loading Background Images). It does not matter which image number is used for storing. The provided image is stored as image3, but this can be changed using TI-Connect software.

1. How steep is a 7% grade? (note: most people will answer this by saying the steepness, or slope, is 7%). Steer the discussion to help students understand that by converting the percent to a fraction, then the slope definition of rise/run, or 7/100 will be more obvious.

2. The truck pictured on the warning sign sits on the hypotenuse of a right triangle. Do you think the slope of the hypotenuse is actually 7%? If not, then estimate the slope.

3-5 On the TI-84plusC, estimating can be done visually by graphing linear equations until the graph appears to be parallel to the hypotenuse of the triangle on the warning sign.

NOTE:If using a TI-84plus (non-color), you should have 2 lines, but not the background image. The activity still can be completed, but now you're working to match the photograph at the beginning of the Student Activity.

6. Have students confirm their estimates by actually measuring the legs of the right triangle in the warning sign in the photograph at the start of their worksheet. Use millimeters, then convert the resulting ratio (rise/run) to a percent. NOTE: All students should do this, regardless of which model of calculator they are using.

7. Their line might appear parallel, but it's difficult to confirm. It would be easier to tell if the line could be shifted vertically so it actually coincides with the "road" in the warning sign. Ask students how to change the equation so it can be raised upwards. Have them use trial and error to determine the amount of the shift.

   There may be slight variations in their equations. This is expected due to the thickness of the lines and the resolution of the screen. The graph of the equation seen in the screenshot in the student activity has the equation $y = .41x + 1.2$

8-9 While most middle school students have not yet studied trigonometry, this is a good opportunity to look ahead and discuss how trigonometry, the study of ratios of sides of right triangles, can help us convert slope (as percents or fractions) into an angle of elevation measured in degrees. The TI-84plus and TI-84plusC have built in Trig functions. The tangent function calculates the ratio of the side opposite the angle of elevation to the side adjacent to the angle (rise/run). So, since we have the rise/run, we use the inverse tangent to find the measure of the angle of elevation.
Part 8 of the student activity asks the student to estimate the number of degrees of each slope. Part 9 has the students calculate each angle measure using the Inverse Tangent function on their TI-84.

10 Lead students to interpret this mathematical answer for the driver on the highway. About every 100 feet the driver moves along the road, the elevation drops 7 feet. To be more precise, the 100 feet is a horizontal change. Using the Pythagorean Theorem: $7^2 + 100^2 = 10049$. $\sqrt{10049} \approx 100.25$ feet, so for every 100.25 feet of travel, the elevation drops 7 feet. For estimating distances and elevation changes, 100 feet is close enough.

   The sign says the hill is 3 miles long. 3 miles is 15840 feet. $15840ft \times \frac{7ft}{100ft} = 1109ft$.

   So, the hill drops about 1100 feet in elevation from top to bottom.

Extension

Find photographs on the Internet and/or take your own photographs that include straight lines and load onto the TI-84plusC as background images. Even better, have students take photographs. When loaded as background images, use transformations of linear functions to find equations in $y = mx + b$ form. Student motivation is increased when the images have meaning to them. Assign tasks such as finding out how steep the roof of their house or school might be (carpenters call this pitch), or how steep is a wheelchair ramp. Encourage creativity!!