Spring Rate Activity

STEM Lesson for TI-Nspire™ Technology

Objective: Students will investigate rate of change (slope) using spring data from RC cars.

About the Lesson: In NASCAR, the selection of springs (and spring rate) determines the ride height of the car. If a NASCAR racer has 500 lbs down force on the front of the car and 250 lbs/in springs in the car, the front of the car will go down 1.00" (two springs, each carrying half the load) when it is at speed and the aero load is fully developed. Different springs take more or less weight to compress depending on the spring rate; therefore, crew chiefs can predict which spring to use for different chassis setups.

Materials: 3 different size RC springs
Digital Scale
Machinist's scale or a tool to measure small distances
Metal bar or similar stiff light weight beam
Chair
String
2L drink bottle
Water
Student Worksheets

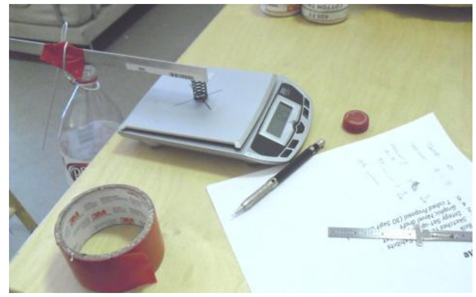
Procedure:

1. Set a digital scale on a table or low countertop. If your length measuring device is in inches, set the units to ounces (oz) or pounds (lbs.). If you measure length in millimeters, set the scale to grams (g).

2. Place one of the springs in the middle of the digital scale.

3. Place one end of a metal bar or similar stiff light weight beam (meter stick) on the spring and the other end on a chair or another table that is the same height as the object in step 1.

4. Tie one end of a piece of string around the neck of a 2L drink bottle and the other end to the beam close to the spring. The bottle should be at lease 0.5" away from the table or countertop.



5. Measure the length of the spring as exact as possible. Record the length.

6. Pour water into the bottle until the spring starts to compress. Measure and record the new length of the spring and the weight from the scale.

7. Pour more water into the bottle until the spring is a little over half compressed. Measure and record the new length and the weight from the scale.

8. Pour more water into the bottle until the spring is completely compressed. Measure and record the compressed length and the weight from the scale.

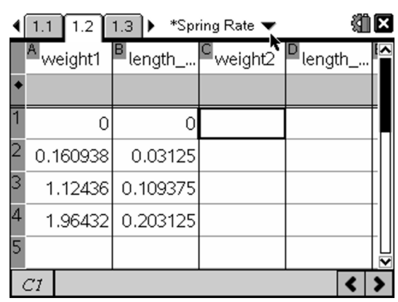
9. Calculate how much the spring length changed between each measurement.

10. Repeat steps 5-8 for 2 more different size springs.

Analysis:

On your handheld, go to My Documents and open the file named *Spring Rate.tns*.

1. Move to page **1.2**. Enter the weight and **change** in length data for spring 1 in the first two columns, spring 2 for the next two columns, and spring 3 in the next two. Start with a weight of 0 and a 0 change in length.



1.1 1.2 1.3 *Spring Rate

	A weight1	B length_...	C weight2	D length_...
◆				
1	0	0		
2	0.160938	0.03125		
3	1.12436	0.109375		
4	1.96432	0.203125		
5				

C1

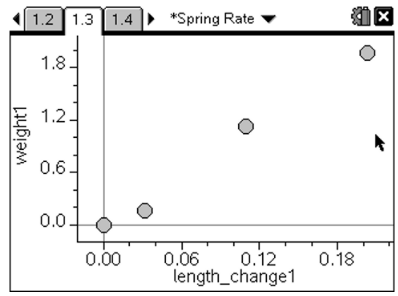
2. Now we need to create a scatter plot for each set of data for weight vs. change in length. Move to page **1.3**.

3. Which variable is the independent variable x?

4. Which variable is the dependent variable y?

5. Move the cursor to the bottom of the screen where it says “click to add variable”. Press x and choose **length_change1**.

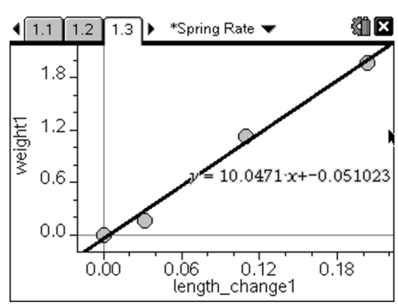
6. Move the cursor to the middle of the left side of the screen until a rectangle appears. Press x and choose **weight1**.



The rate at which something is changing is comparing how fast or how slow one unit is changing compared to another unit. For example if snow is falling at a rate of 0.25 in. per hr., then it means every hour their will be another 0.25 in on the ground in addition to what is already there. After 4 hours their will be 1.00 in on the ground. Once the data is on a graph, we can easily calculate the rate of change of collected data using the formula $(y_2-y_1)/(x_2-x_1)$ where the variables are the coordinates of the data points.

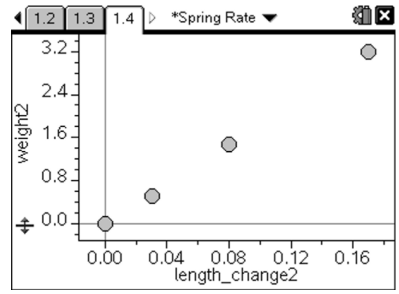
7. For the data for spring 1, at what rate is the length changing compared to the weight? Use the first collected data point instead of (0,0) for better results.

8. Press b **>> Analyze >> Regression >> Show Linear(mx+b)**



9. Which number in the equation on the screen is closest to your answer in **Question 7**?

10. Now we need to create a scatter plot for the other 2 springs. Move to page **1.4**.

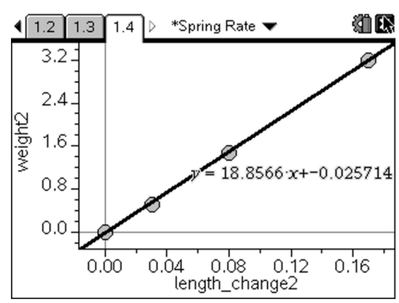


11. Move the cursor to the bottom of the screen where it says “click to add variable”. Press x and choose **length_change2**.

12. Move the cursor to the middle of the left side of the screen until a rectangle appears. Press x and choose **weight2**.

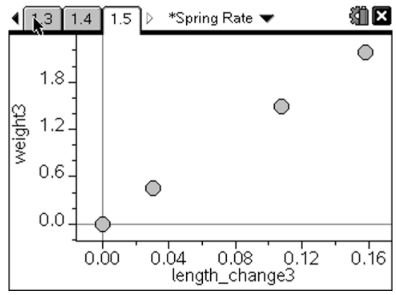
13. Using the data for spring 2, find the rate at which the length changes compared to weight.

14. Press b **>> Analyze >> Regression >> Show Linear(mx+b)**



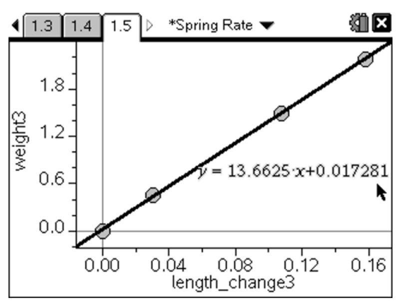
15. Which number in the equation on the screen is closest to your answer in **Question 13**?

16. Move to page **1.5**. Create a scatter plot for the data for spring 3.



17. Using the data for spring 3, find the rate at which the length changes compared to weight.

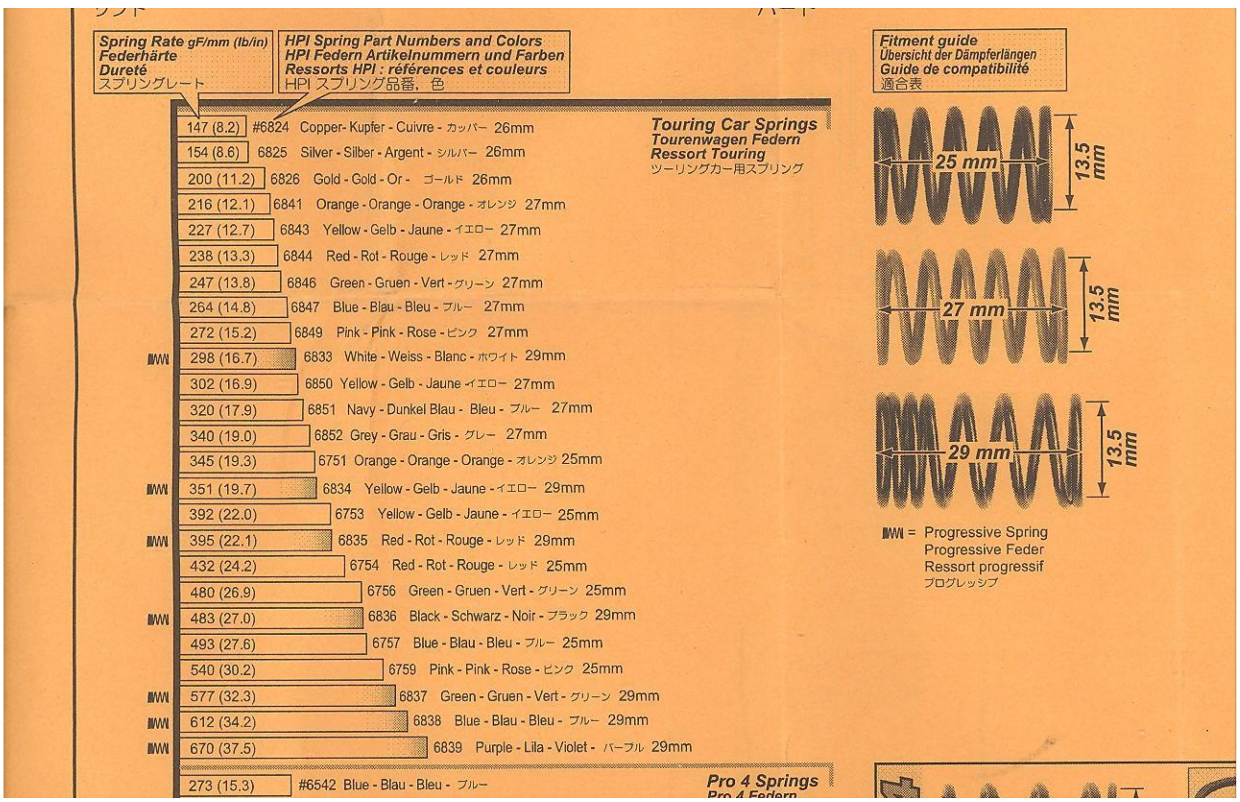
18. Press b **>> Analyze >> Regression >> Show Linear(mx+b)**



19. Which number in the equation on the screen is closest to your answer in **Question 17**?

20. Make a conjecture about writing an equation given the rate of change.

When we model data with a graph, the rate of change is called the **slope** of the line through the data points. The equation of that line is another way to model data. These models allow us to calculate other data points and make predictions. Spring manufacturers use the slope to rate the spring. Below is an example of a manufacturers spring chart.



The first column is the rate for each spring. The first number is in grams per millimeter and the number in parentheses is in pounds per inch.

21. Round your answer from **Question 7** to the tenths place. Which spring from the chart has the closest rating to your rating?

22. Round you answer from **Question 13** to the tenths place. Which spring from the chart has the closest rating to your rating?

23. Round you answer from **Question 17** to the tenths place. Which spring from the chart has the closest rating to your rating?

24. Which spring is the stiffest?

25. Which line was the steepest?

26. How does the slope of the line compare to the spring stiffness?

27. If you were the crew chief, which spring would you recommend in this situation? Your car's weight will never change more than 13 lbs., and you don't want the body to move more than 1 in.

EXTENSION

28. Write an equation modeling the compression of a spring with the rating of 34.2 lbs/in.

29. Use your equation to predict how much weight it will take to compress the spring 0.75 in.

30. Use your equation to predict how far the spring will compress with a weight of 15 lbs.