When engineers design buildings, bridges, machines, motors, submarines, ship, airplanes and antennas, it is important for them to have information about the materials that they are using. Knowing what the mechanical properties of the materials they are using helps them to design and build these structures safely. One mechanical property that engineers are interested in is how much force a material can withstand before it breaks. Each of these types of structures that engineers build has to withstand some forces acting on it. For example, a bridge needs to be able to withstand the weight of cars passing over it. When deciding what building materials to use, it is important to choose ones that are able to hold up under the types of forces that will be present.

The mechanical properties of the materials are determined by tests performed on sample pieces of the material. These tests are conducted in a materials-testing laboratory, which has machines that are able to test the material in different ways (for example by pulling or pushing on two sides). The most common test is called the tension test. During this test, the ends of the material are pulled away from one another. The two ends of the sample are designed to fit into the machine. Below is a picture of a sample.

![Tension Test Sample](image)

A device called an extensometer is attached to the testing machine. Its job is to measure how much longer the sample gets under different amounts of pulling. We measure the amount of pull, or the force in pounds.

The information we get from these tests can be used in many different situations. One example of a use of the data is in what happens to an elevator cable as more people get on the elevator. We can think of the amount of force applied as the combined weight of the elevator and the people or objects on it. Look at the picture of an elevator with a visible cable below. Have you seen elevators like this on construction sites before? Why do you
think information about the amount of stretch of the cable might be important to the designers?

Your teacher will give you data from a test on an aluminum sample to put into the lists on your calculator. List 1 has the force applied measured in pounds. List 2 has the change in the length of the sample measured in inches. Use this data to explore the following problems:

1. Create a graph of Change in Length vs. Force. Sketch your graph below.

2. What sort of relationship do these two quantities have?
3. Write an equation that allows you to find the change in length (L) given the force (F).

   \[ L = \] 

4. Let’s think about the elevator situation again. What would the change in length of the cable be if the elevator itself weighed 2500 lbs. and people who weigh a total of 300 lbs got onto it? If people who weigh a total of 750 lbs. got on?

5. Find the slope and y-intercept of the equation that you found in question 3. What meaning do these quantities have in terms of the test or the elevator situation?

6. Our original aluminum sample was 3 inches long. Create a new list in your calculator that tells you what the total length is. Use this information to fill in the total length column on your table.

7. Create a graph of Total Length vs. Force. Sketch your graph below.

8. What sort of relationship do these two quantities have?
9. How are the graphs from question 1 and 7 similar? How are they different?

10. Write an equation that allows you to find the total length (T) given the force (F).

\[ T = \]

11. Let’s think about the elevator situation again. Suppose a small section of the elevator cable was originally the same length as the sample from the test (3 inches). What would the total length of the cable be if the elevator itself weighed 2500 lbs. and people who weigh a total of 300 lbs got onto it? If people who weigh a total of 750 lbs. got on?

12. Find the slope and y-intercept of the equation from question 10. What meanings do these quantities have in terms of the test or the elevator situation?

13. Compare your formulas from questions 3 and 10. What is the same? What is different? Explain these similarities and differences based on the test or the elevator situation.
14. The width of the aluminum sample is 0.5 inches and the thickness is 0.125 inches. Find the area of a rectangular cross section.

15. Engineers call the intensity of the force applied the stress. They find this by dividing the force by the area of the cross section. Write an equation that allows you to find stress (S) given force (F).

\[ S = \] 

16. What units is stress measured in?

17. Create a new list in your calculator for stress. Use this information to fill in the stress column in your table.

18. Engineers call the percent change in length the strain. They find this by dividing the change in length by the original length. Write an equation that allows you to find strain (E) given force (F).

\[ E = \] 

19. Strain will not have any units associated with it. Why?

20. Create a new list in your calculator for strain. Use this information to complete the strain column in your table.
21. Create a graph of Stress vs. Strain. Sketch your graph below.

22. What sort of relationship do these two quantities have?

23. Write an equation that allows you to find stress (S) given the strain (E).

\[ S = \]

24. What is the slope of your equation? What is the y-intercept?

25. Write a statement about what is happening to the stress as the strain increases.
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