Name _____ Date _____ Period_____

Do Materials Get Tired- Do Rubber Bands Get Longer During Use?

Background:

Materials such as *metals* (aluminum, iron, copper, etc.), *ceramics* (silicon carbide, porcelain) or *polymers* (milk jugs made of polyethylene) are tested by scientists and engineers to reveal certain mechanical properties such as the maximum stress a material can withstand before it fails**.** Some materials will slowly deform when a constant force or displacement is applied to them. This time-dependent and permanent deformation is called *creep*.

If you have ever noticed that chewing gum gradually sags when it is stuck to something or watched a plastic grocery bag gradually tear apart when it is carrying too much weight, you have observed creep!

Today you will be testing the creep behavior of rubber bands!

Strain, ε, is defined as the change in length of a material divided by the original length.

$$\varepsilon = \frac{l_f - l_i}{l_i}$$

l_f = final length of the specimen
l_i = initial length of the specimen

For instance, after a rubber band has been stretched, if the length returns to its original value, the strain is *elastic*. However, if the length of the rubber band is permanently changed, the strain is *plastic*. Both types of strain can occur in rubber bands.

Equipment:

- Two sizes of rubber bands
  - Two rubber bands that are exactly the same size (length and width)
  - Two rubber bands that are different in size (length and/or width)
- A hook or nail attached to a wall (i.e. a coat hook or wall tack)
- A set of weights or objects of known weight
  - Two objects/weights of the same weight
  - Two objects/weights of different weight
- A metric ruler

Hypotheses

Read through the "Procedure" section to get an understanding of the experiment and then create the following hypotheses.

a. State a hypothesis comparing what will happen to the two same sized rubber bands that have different weights.

---

b. State a hypothesis comparing what will happen to the different size rubber bands for the same weight.

---

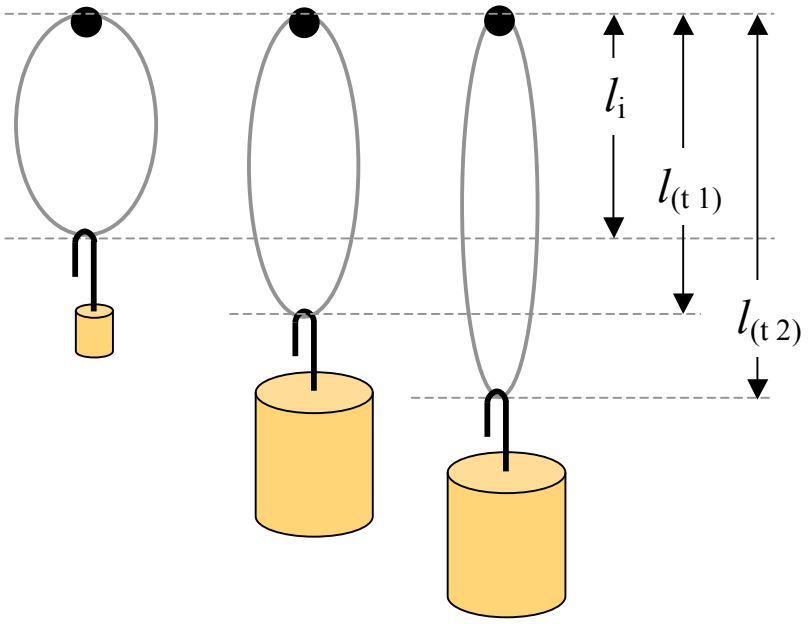
c. State a hypothesis that describes the relationship of the creep of the rubber band with time.

Procedure

Note: During the actual experiment, record all observations (i.e., changes in surface finish, color, etc.)

1. Hang a rubber band from the hook with a light weight attached to the end in order to extent the rubber band without stretching it. Measure the total length (l_i), note the time, and record them in Table A.
2. Hang a known weight on the end of the rubber band and measure the new length. Record the length ($l_{t\,1}$) in Table A.
3. Allow the weight to remain hanging from the rubber band for 24 hours. Measure the total length ($l_{t\,2}$). Record the new length and time in Table A. (Option: If possible, make several measurements of time and length throughout the day: call these measurements ($l_{t\,3}$), ($l_{t\,4}$) and ($l_{t\,5}$).
4. Remove the weight and replace it with the initial light weight. Measure the length to which the rubber band returns (l_f).
5. Repeat steps 1 – 4 for two different scenarios:
    a. Scenario 1: Two rubber bands with the same size (length and width) and different weights.
    b. Scenario 2: Two rubber bands with a different size (length and/or width) and the same weights.
6. Extension: Repeat steps 1 – 4 for any additional scenarios that you wish to explore.

Experimental setup of a rubber bands hanging with weights:



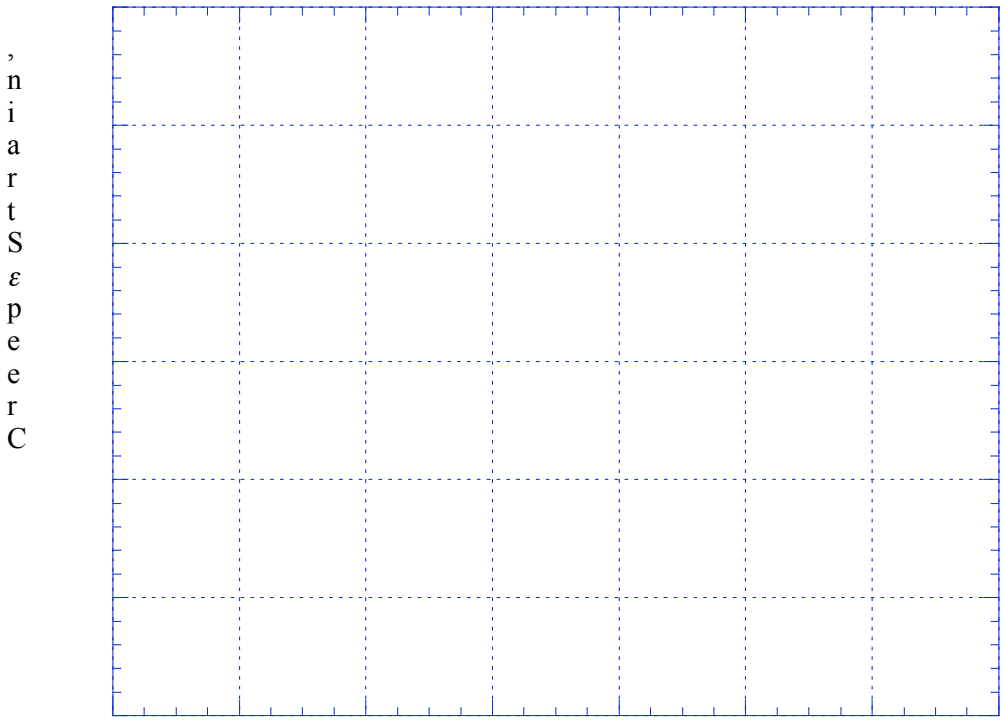
7. Look at the rubber band during and after the experiment. Write down any observations in Table B.
8. Plot your results on the graph shown below.

TABLE A

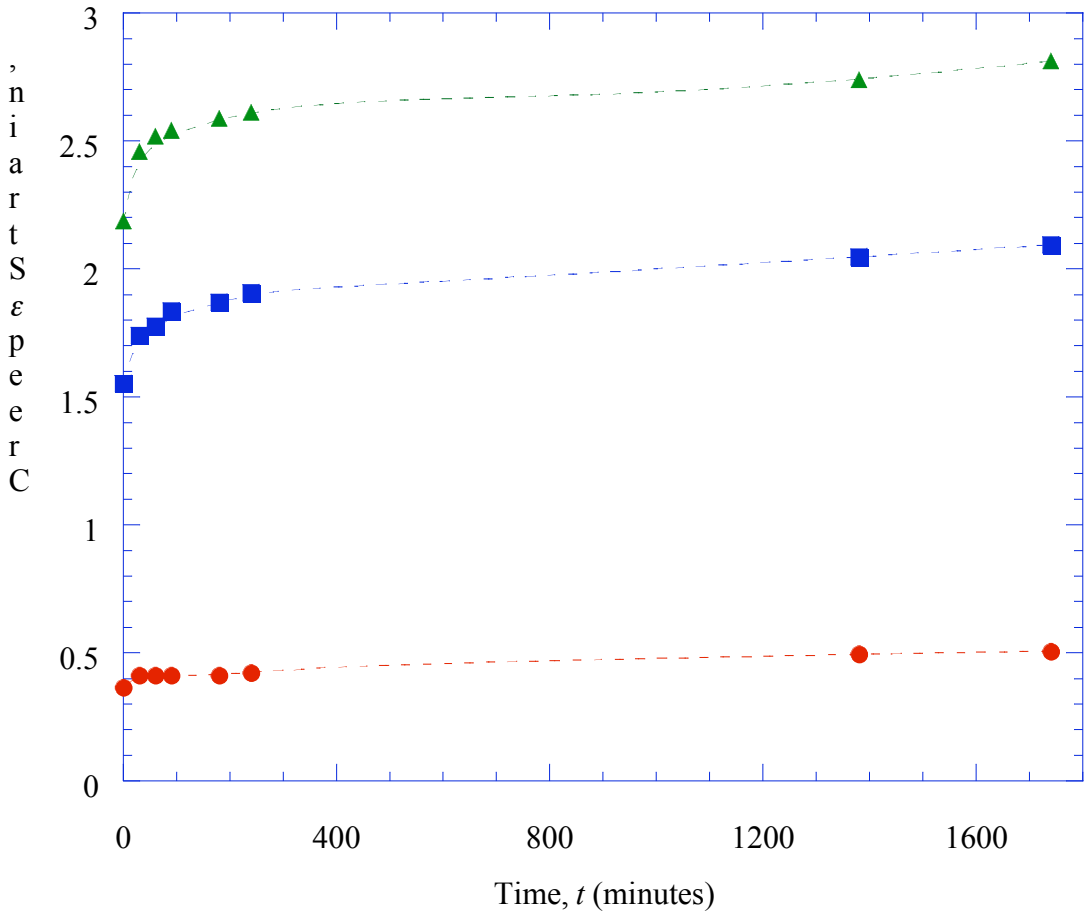
Type of Rubber Band	Time	Weight	Length of Rubber Band
			$l_i =$
			$(l_{t\ 1}) =$
			$(l_{t\ 2}) =$
			$(l_{t\ 3}) =$
			$(l_{t\ 4}) =$
			$(l_{t\ 5}) =$
			$(l_f) =$

TABLE B

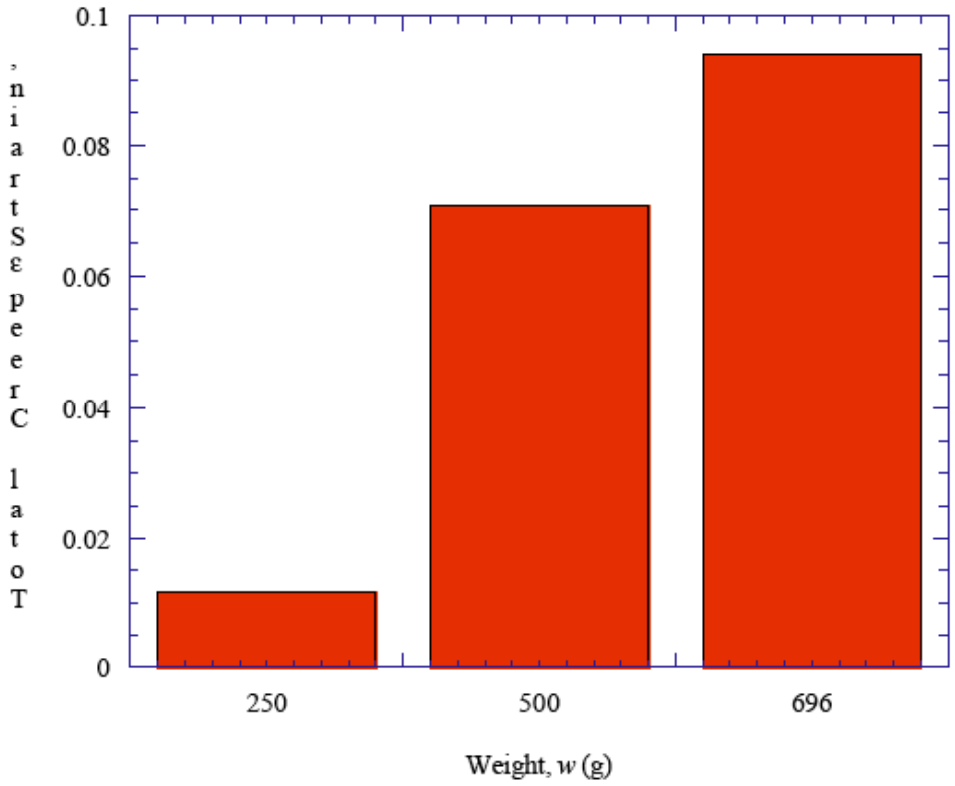
Type of Rubber Band	Weight	Observation



Plot of creep strain versus time for the rubber bands stretched by varying weights.



Example data plot of creep strain versus time for the rubber bands stretched by varying weights. The red circles indicate 250g, the blue squares indicate 500g, and the green triangles indicate 696g over a 24 hour period. (Note: the dashed lines are not *curve fits.)*



Bar graph indicating the total creep strain versus weight for rubber bands after 24 hours.

Analysis Questions

1. By using the equation below, calculate the strain applied to the rubber bands by the hanging weights. Use the table below for your calculations.

$$\varepsilon = \frac{l_f - l_i}{l_i}$$

Table	Rubber band	l_f	l_i	Strain =
Table A				
Table B	Same length			
Table B	Same length			
Table B	Different length and/or width			
Table B	Different length and or width			

2. Compare the amount of creep strain accumulated for each weight and rubber band type. Which rubber band accumulated the greatest amount of creep? The least amount of creep?

_____

_____

3. Why do you think that some rubber bands accumulated different amounts of creep?

_____

_____

4. In every experiment, there are sources of human error. These can include measuring inaccurately or writing down data incorrectly. What are some sources of human error that you had during the lab?

_____

_____

5. Excluding the errors above, what changes would you make to the experiment in order to yield more accurate results? Explain your reasoning.

_____

_____

_____