

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.

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

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:

1. Two sizes of rubber bands
2. A hook or nail attached to a wall (i.e. a coat hook or wall tack)
3. A set of mass objects of known mass
4. A metric ruler

Hypotheses

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

a. State a hypothesis comparing what will happen to the rubber band for the different weights.

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

c. State a hypothesis on the creep of the rubber band with time.

Procedure

1. During the experiment, record all observations (i.e., changes in surface finish, color, etc.) in Table C.
2. 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 (see l_i in Figure 1).**
3. Measure the total length (l_i) in cm of the rubber band. Record the mass of the weight, the length of the rubber band (l_i), and the time in Table A.
4. Hang a larger known weight on the end of the rubber band and measure the new length (l_{t1}). Record the mass of the new weight, the new length (l_{t1}) of the rubber band and the time in Table A.
5. Allow the weight to remain hanging from the rubber band for 24 hours. After the 24 hours has elapsed, measure the length (l_{t2}) of the rubber band. Record the this length of the rubber band (l_{t2}) and time in Table A. (Note: If possible, make several measurements of time and length throughout the day.)
6. Remove the weight and replace it with the initial light weight. Measure the final length to which the rubber band returns (l_f) and record it in Table A.
7. Repeat steps 1 – 6 using a different sized rubber band and record the data in TABLE B.

Figure 1: Experimental setup of a rubber bands hanging with weights

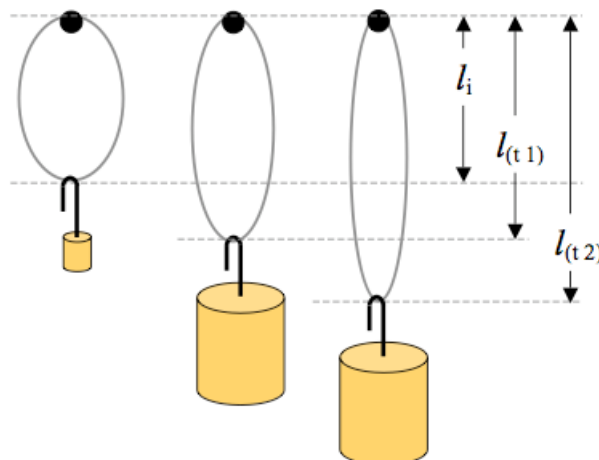


TABLE A (rubber band 1)

Type of Rubber Band	
Mass of initial light weight	
Length of rubber band (l_i) (with initial light weight at initial time)	
Initial time	
Mass of larger weight	
Length of rubber band (l_{t1}) (with larger weight)	
Time	
Length of rubber band (l_{t2}) (with larger weight at end time)	
End Time	
Final Length of rubber band (l_f)	

TABLE B (rubber band 2)

Type of Rubber Band	
Mass of initial light weight	
Length of rubber band (l_i) (with initial light weight at initial time)	
Initial time	
Mass of larger weight	
Length of rubber band (l_{t1}) (with larger weight)	
Time	
Length of rubber band (l_{t2}) (with larger weight at end time)	
End Time	
Final Length of rubber band (l_f)	

TABLE C

Type of Rubber Band	Weight	Observation

8. Using the given equation, calculate the strain applied to each rubber band tested.
SHOW YOUR WORK and CIRCLE YOUR ANSWER!

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

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

Rubber Band 1:

Rubber Band 2:

9. Run the experiment again using the same rubber bands, but increase the amount of weight added. Record these results in Table D, Table E, and Table F.

TABLE D (rubber band 3)

Type of Rubber Band	
Mass of initial light weight	
Length of rubber band (l_i) (with initial light weight at initial time)	
Initial time	
Mass of larger weight	
Length of rubber band (l_{t1}) (with larger weight)	
Time	
Length of rubber band (l_{t2}) (with larger weight at end time)	
End Time	
Final Length of rubber band (l_f)	

TABLE E (rubber band 4)

Type of Rubber Band	
Mass of initial light weight	
Length of rubber band (l_i) (with initial light weight at initial time)	
Initial time	
Mass of larger weight	
Length of rubber band (l_{t1}) (with larger weight)	
Time	
Length of rubber band (l_{t2}) (with larger weight at end time)	
End Time	
Final Length of rubber band (l_f)	

TABLE F

Type of Rubber Band	Weight	Observation

10. Again, calculate the creep for the second set of rubber bands. **SHOW YOUR WORK and CIRCLE YOUR ANSWER!**

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

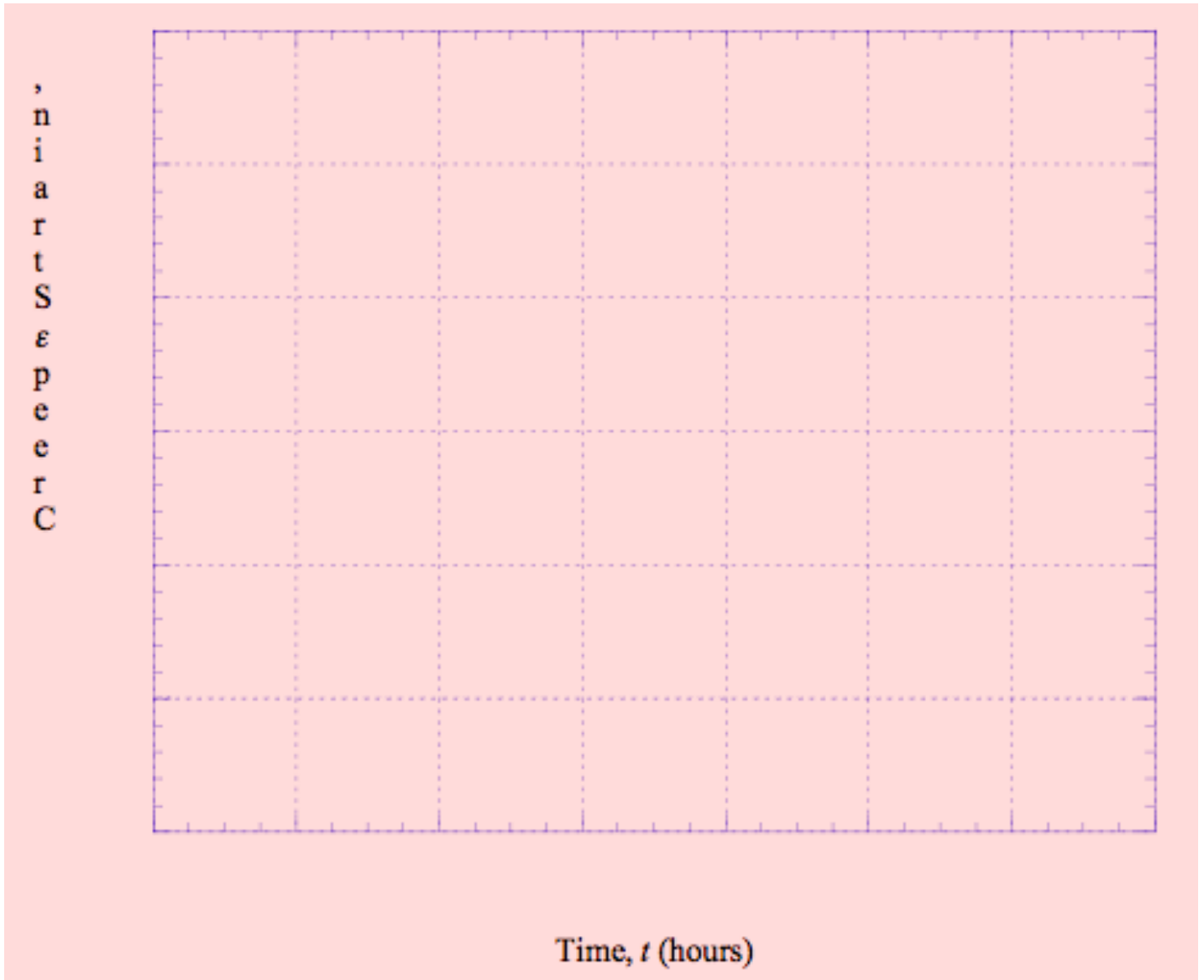
l_f = final length of the specimen
 l_i = initial length of the specimen

Rubber band 3:

Rubber band 4:

11. Plot your creep for each rubber band on the graph below and connect your data points with a smooth curve.

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



Analysis Questions

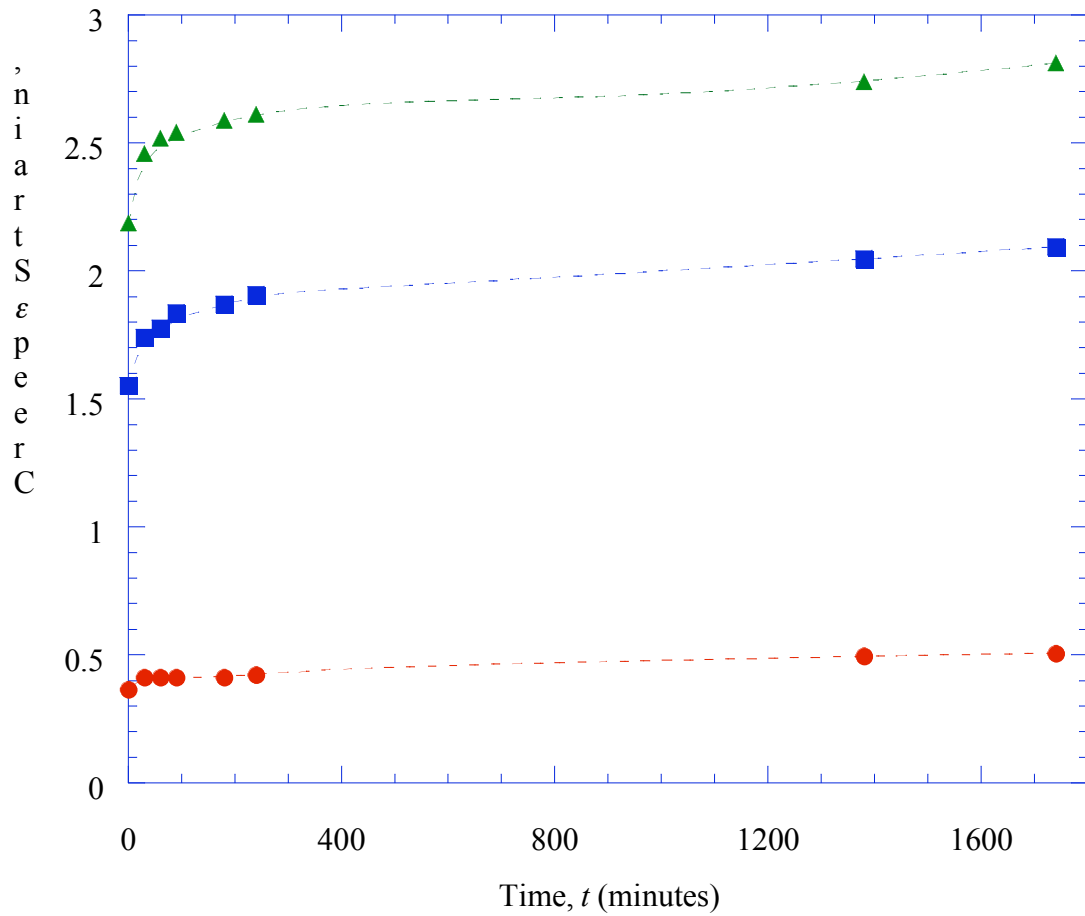
1. Which type of rubber band had the largest creep?

2. Which type of weight caused the most creep?

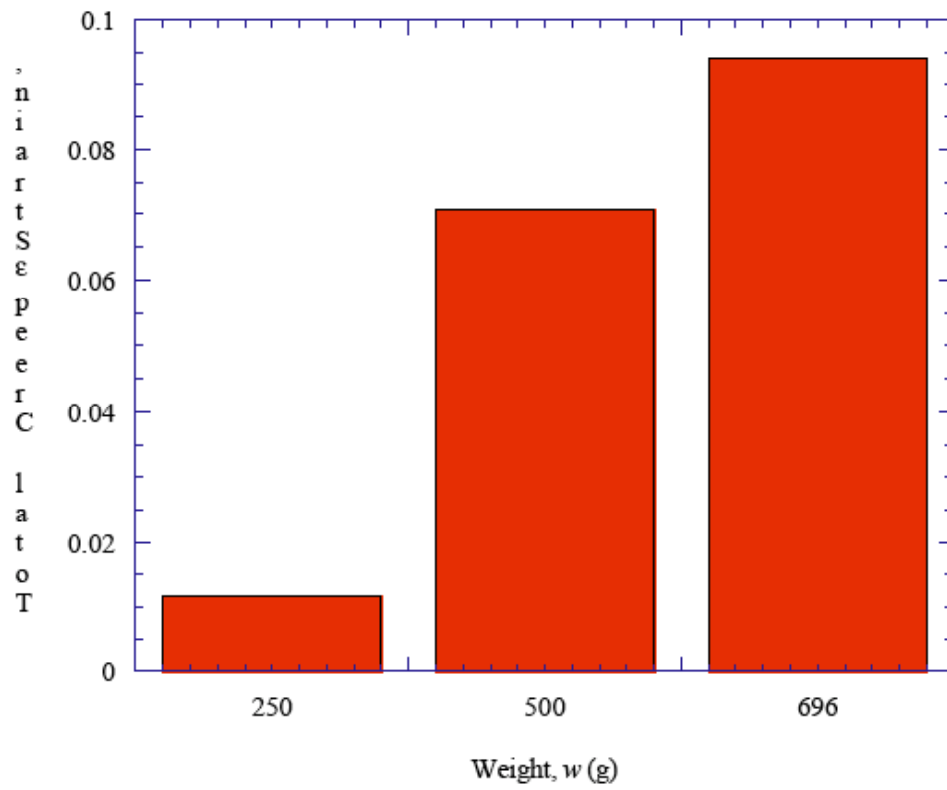
3. Based on your lab results, were ALL of your hypotheses correct?

4. List some sources of error in your experiment.

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



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.