Summary of the Thermal Expansion Experiment

This document summarises the Thermal Expansion experiment. The full description is at
http://www.upscale.utoronto.ca/IYearLab/Intros/ThermalExpans/ThermalExpans.html

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Introduction

We have a rod, which at a reference temperature $\mathbf{T_0}$ has a length $\mathbf{L_0}$. As the temperature **T** of the rod increases, so does the length **L**.

Call the change in temperature:

$$\Delta T \equiv T - T_0$$

and the corresponding change in length:

$$\Delta L \equiv L - L_0$$

Then:

$$\Delta L \simeq \alpha\, L_0\, \Delta T$$

where α is the *coefficient of thermal expansion*. We will treat α is a constant for a given material.

Data Collection and Analysis

You are supplied two tubes, one of aluminum and one of copper. You will determine the coefficient of thermal expansion for aluminum and copper. For each tube:

- Determine the reference length $\mathbf{L_0}$ at a reference temperature $\mathbf{T_0}$. The length is from the fixed position of the tube to the line inscribed on the tab. Be sure you know which part of the tube is fixed.
- Flow water at various temperatures through the tube. Wait for the tube to achieve thermal equilibrium with the water.
- For each temperature, use the traveling microscope to determine the change in length from the reference length
- To determine α either:
  - Fit ΔL versus ΔT to a straight line.
  - Fit ΔL versus $L_0\, \Delta T$ to a straight line.
- Compare your values of α with the accepted values for different metals.

Preparatory Questions

These questions should be answered and turned in to your Demonstrator *before* beginning the experiment. They *replace* the questions in the Guide Sheet for the experiment: if you are using this web-document as the introduction to the experiment you should answer these questions and not the ones in the Guide Sheet.

Note:

These questions are intended to guide you in your preparation for the experiment. They do not have any "tricks."

1. What are the units of α?
2. Usually when temperatures are written as **T** they refer to values in *Kelvin*; temperatures written as the lower case letter **t** usually refer to the value in *Celsius*. Above we have used **T** for temperature, while the thermometers you will use measure in Celsius. Does it make any difference? Why?
3. Values of α are typically on the order of $\mathbf{10^{-5}}$ in SI units. Imagine a rod with exactly this value of α that has a length of exactly one meter when its temperature is $20^{o}C$.
    1. If its temperature changes from $20^{o}C$ to $80^{o}C$ what is its change in length?
    2. What is the *percentage* change in its length?
4. A rod made of the same material as in Question 3 has a length of exactly 100 meters when its temperature is $20^{o}C$.
    1. What is the percentage change in its length if its temperature changes from $20^{o}C$ to $80^{o}C$?
    2. How does your answer compare to your answer to the second part of Question 3?
    3. Why did your answer to Question 4.2 come out as it did?
5. You will measure the temperature of the water when it enters the tube and again when it leaves the tube, using two thermometers. Particularly at temperatures much above room temperature, at equilibrium the two values may not be the same: the temperature of the water exiting the tube may be less than the water entering it.
    1. What is an explanation of why this is occurring?
    2. What is a reasonable value for the temperature of the rod in this case?
    3. If the difference in temperatures measured by the thermometers is greater than the reading errors of the thermometers, what is a reasonable value of the error in the measurement of the temperature of the rod?