Experiment 4
Coefficient of Linear Expansion

Introduction

We've seen in lecture that increasing the temperature of a gas increases the average kinetic energy of the gas molecules, and that in turn means that the gas molecules are moving at a higher average speed. The molecules in a solid are not free to move around at random; they tend to oscillate about their average positions. Increasing the temperature of a solid leads to an increase in the amplitude of the motion about the "position" of the molecules, and this causes the solid to take up more space. In this experiment, we will study the change in length of several rods of different materials as they change in temperature.

Theory

It is observed experimentally that the change in length of an object is proportional to the original length and to the change in temperature. The constant of proportionality α is called the coefficient of linear expansion.

$$\Delta L = \alpha L_0 \Delta T \tag{1}$$

describes this expansion. Here, L_0 is typically the length of the object at temperature 0^oC, though that point is completely arbitraty. We will use L_0 being the length at room temperature, and the slight difference should not be important.

Apparatus

You'll need the linear expansion apparatus, a meter stick, a boiler and hot plate, a power supply and several unknown samples.

Procedure

1) Fill the boiler 1/3 to 1/2 full of water, attach a length of hose to the steam outlet, put on the lid and start heating it on the hot plate.

2) Attach the power supply to base.

3) Measure the length of one of the rods with the meter stick. Insert the rod into the heating jacket and attach to the linear expansion base. Be certain that the fixed end of the rod is at the proper level to hit the stop; shim if necessary. Insert the thermometer. Adjust the vernier end of the linear expansion apparatus until there is electrical contact at both ends of the rod. Turn on the power supply, and slowly adjust the voltage until the bulb lights. Do not use more than 5 Volts.

4) Back the vernier away from the rod. Move the vernier towards the rod slowly, and stop as soon as the light bulb lights. Record the vernier reading. Repeat 3 times. Record the temperature.

5) Back the vernier away from the rod 3 full turns. Each full turn is equal to 1 millimeter. Connect the boiler to the jacket, and wait until the temperature equalizes. Record the temperature. Move the vernier towards the rod, and stop as soon as the lightbulb lights. Record the vernier reading. Keep track of the number of turns beyond the cold length that you used. Repeat this measurement 3 times. The difference in vernier reading hot *vs.* cold tells you the change in length in millimeters of the rod.

Substance	α $(10^{-6}/C^o)$
Aluminum	23
Brass	19
Copper	17
Iron	12
Lead	29
Steel	11

Table 1: Coefficient of linear expansion.

6) Remove the steam connection from the jacket and disassemble when cool to handle. Cool the jacket in cold running water.

7) Choose another unknown and repeat setps 3) through 6).

You now have enough experimental information to extract the coefficient of linear expansion α. Do so for all the unknown samples you used, and compare with the table below.