Survey of Physics

Lab 11: Linear Expansion of Metal

Name:_____

partner name(s):_____

Theory:

As a solid is heated, it expands in all directions, so we could consider volume, area, or linear expansion. If the solid is a long tube or rod, the expansion in length will be the most noticeable. Only linear expansion will be considered in this lab.

Factors that affect the amount of linear expansion of a solid are the temperature change ΔT, the original length of the material L_0, and the nature of the material itself. To express this mathematically, we define a quantity a called the coefficient of linear thermal expansion, or just the coefficient of expansion. Then the amount of linear expansion of a material (its change in length ΔL) may be expressed as:

change in length = coefficient of expansion x original length x temperature change

Using symbols, this becomes: $\Delta L = \alpha L_0 \Delta T$

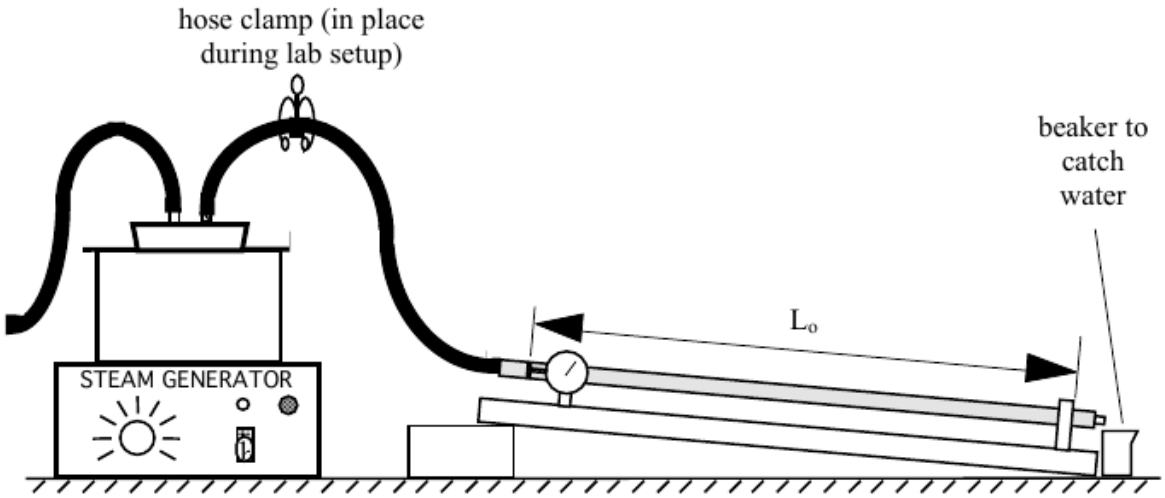

Figure 1

In this lab, you will determine the coefficient of expansion for copper, steel (iron), and aluminum. A diagram of the lab setup is shown in Figure 1. Steam will be passed through each tube, raising its temperature and causing it to expand. A dial gauge will measure the change in tube length. As the tube expands, the gauge indicator rotates, showing ΔL in hundredths of mm.

1. Fill the steam generator half-full of deionized water and begin heating.

2. Assemble the linear expansion apparatus as shown in Figure 1. Measure and record the original (low) temperature of the tube using a thermocouple probe. Record your value in Table 1.

3. Measure the lengths of the tube at low temperature and record in Table 1. **Note:** while the entire length of the tube will expand, the dial gauge only records the expansion of the part of the tube between the pin supports and the end of the dial gauge. Use this length for L_0, as shown in Figure 1.

4. Carefully set the dial gauge by rotating the face of the dial so the starting indicator position is zero.

5. Begin passing steam through the tube. Be sure steam, not water, is coming out the far end of the tube. Watch the dial gauge, and record the expansion when the indicator stops moving. **CAUTION:** Steam can burn!

6. After the full expansion ΔL has been measured, **carefully** use the thermocouple probe to find the tube temperature while steam is still going through the tube. Record this as the high temperature and record in Table 1.

Table 1 – Data

Material	L_0 (mm)	T_{low} (°C)	T_{high} (°C)	ΔL (mm)
Aluminum				
Copper				
Steel				

7. Repeat steps 3 through 6 with the other tubes. **CAUTION:** Tubes will be hot after expansion! Do not touch them with bare hands.

8. Use your measurements to calculate the temperature change ΔT of the tube and your experimental value for the coefficient of expansion α. Record your results in Table 2. **Show your work in the space below:**

Table 2 – Calculations

Material	ΔT (°C)	$\alpha = \dfrac{\Delta L}{L_0 \Delta T}$
Aluminum		
Copper		
Steel		

9. Look up and record the accepted value for α in Table 3. Calculate the percent error between your calculated value for α and the accepted value, and record in Table 3. **Show your work in the space below:**

Table 3 – Comparison

Material	α (accepted)	% error
Aluminum		
Copper		
Steel		