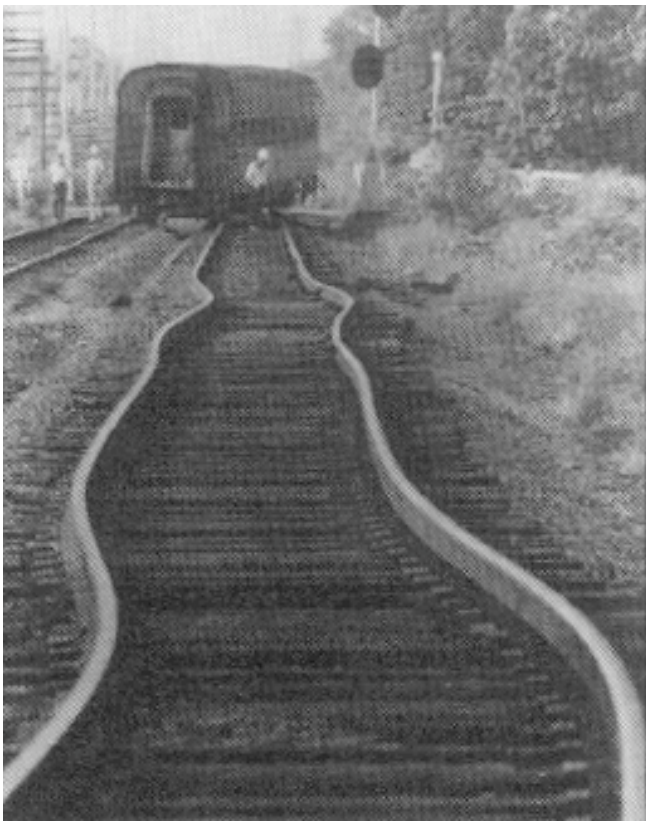
LAB 10: THERMAL EXPANSION



The Objectives

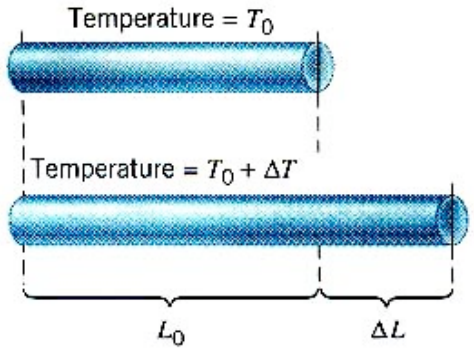
You are certainly aware that heat causes many materials to expand. You may notice that railroad tracks are not one long, solid piece, but many pieces. A gap must be left between adjacent pieces, to allow for thermal expansion. You will also see expansion gaps on bridges. If you have ever installed wood flooring, you will also remember that it is important to leave an expansion space all the way around the perimeter of the room (shame if that floor was to buckle on a hot day!).

How much an object expands depends on several parameters: what the object is made of, how big it was originally, and how much its temperature has been increased. The greater the original length, the more an object will expand. The greater the increase in temperature, the greater the expansion. But not all materials of the same size will expand by the same amount when increased by the same temperature. The coefficient of thermal expansion depends on the type of material: the greater the coefficient, the greater the expansion for a given length of material and given temperature increase.

What is the coefficient of thermal expansion for brass?
What is the coefficient for iron?

Our specific objectives include:

- Observe the linear expansion of several metallic samples
- Determine the coefficients of thermal expansion for two metallic samples
- Compare the coefficients for different types of metallic samples
- Examine experimental equipment and techniques for sources of error
- Perform error analysis to determine the accuracy of the results



The Procedure

- Use the calipers to measure the diameter of each rod. Measure in several places along the rod, and use the average value for calculations.
- Each rod is etched with a circumferential groove. Measure the length from the groove to the end of the rod. You must measure and record each rod separately. The lengths are not uniform.
- Because the actual increase in length ΔL is too small to measure directly, an indirect method will be used. It is not difficult, but can be fussy. Details will be provided in class.
- You should measure and record the expansion of two brass rods and two iron rods. If you need a "do over," you must get a fresh, cold (room temperature) rod. Do not try to re-use a warm rod.

The Data

Keep the data for each rod organized separately:

ROD	DIAMETER (cm)			AVERAGE DIAMETER (cm)	LENGTH L_O (cm)	INITIAL TEMPERATURE T_O (°C)	FINAL TEMPERATURE T_F (°C)	EXPANSION ANGLE (°)
BRASS								
BRASS								
IRON								
IRON								

The Reduction

1. Convert the expansion angle θ into the linear expansion (in cm) for each rod:

$$\Delta L = \left(\frac{\theta}{360°}\right)(\pi d)$$

   where *d* is the average diameter of the rod.
2. Use the expansion equation to determine the coefficient α for each rod:

$$\Delta L = \alpha L_o \left(T_f - T_o\right)$$

3. Average the values for the brass rods, then average the iron rods.

The Analysis

4. Compare your experimental values to the accepted values by calculating your percent error:

$$\alpha_{brass} = 1.92 \times 10^{-5} \text{ / °C}$$

$$\alpha_{iron} = 1.14 \times 10^{-5} \text{ / °C}$$

5. Examine your experimental methods for sources of random error. List these potential sources and the impact they might have on your experimental results. Is testing two rods sufficient for an accurate determination of the expansion coefficient? If you combine your results with the other lab groups, will the overall class average improve?
6. Do you have any reason to suspect that your results may be systematically compromised? Compare your results with other lab groups, and determine whether a pattern emerges. If you detect a systematic effect, return to your procedure and try to determine how it might have occurred.

The Conclusions

Comment on any outstanding data (good or bad), suggest methods for improving your experimental results.