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# string and sticky tape experiments

Section Editor: R. D. Edge  
University of South Carolina  
Columbia, South Carolina 29208

## A soda-straw thermometer

It is difficult for students to understand the concept of temperature without a thermometer. Here is a simple experiment requiring only sticky tape, a soda straw, and a little water, which demonstrates Charles' law as well as giving the temperature.

Fold the end of a straw over two or three times as shown, and fasten it with sticky tape (Fig. 1).

Fill the open end of the straw with about 5 cm of water (it may be easier to put the water in first, before sealing the other end). If you place the closed end in your mouth, you can see that the expanding hot air forces the water out. Remove the straw from the mouth, and notice how the air moves the water back up the tube (to its original position) as it cools. Now squirt cold water from the drinking fountain over the straw, or place it in a cold drink. The water will move way back.

The thermometer may be used quantitatively by marking the position of the water meniscus (with a pen) on the side away from the open end, first at room temperature, then for the ice cold water, for your mouth, and for very hot (preferably boiling) water. You can calibrate your thermometer on the basis of Charles' law, which states that the volume of air, or length of the air column, is proportional to its absolute temperature (temperature in  $^{\circ}\text{C} + 273$ ).

$$\frac{V_1}{V_2} = \frac{T_1 + 273}{T_2 + 273} = \frac{L_1}{L_2}$$

where  $V_1$  is the volume and  $L_1$  the length of the air column of temperature  $T_1^{\circ}\text{C}$ , and  $V_2$  and  $L_2$  the corresponding values at  $T_2^{\circ}\text{C}$ . Figure 2 shows typical measurements. The length of air at room temperature in this example  $T_2$  is 12.4 cm, for boiling water it is 16 cm, and for ice water 11.5 cm, and for body temperature  $T_B$  it is 13.2 cm.

$$\frac{\text{Temp } ^{\circ}\text{A}}{\text{Length of air}} = \frac{373}{16} = \frac{273}{11.5} = 23.5 = \frac{T_r}{12.4} = \frac{T_B}{13.2}$$

This gives room temperature as  $291^{\circ}\text{A}$  or  $18^{\circ}\text{C}$ , and body temperature as  $310^{\circ}\text{A}$  or  $37^{\circ}\text{C}$ . You can mark a linear scale (from 0 to 100) on the side of the thermometer if you can obtain the fixed points at  $0^{\circ}\text{C}$  and  $100^{\circ}\text{C}$  as described.

It is difficult to place the whole length of the straw in the mouth or cup. Unfold a paper clip, and drop it in the straw as shown in Fig. 3. The paper clip, within the straw, may then be bent to reduce the overall length.

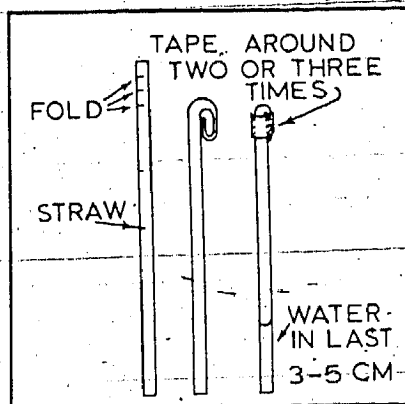


Fig. 1.

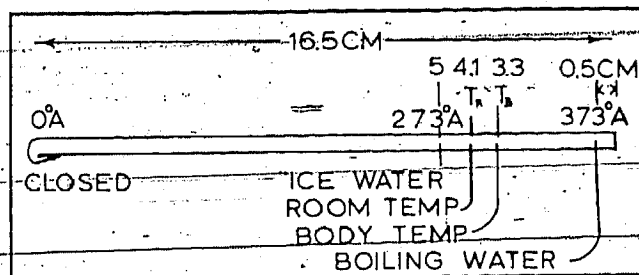


Fig. 2.

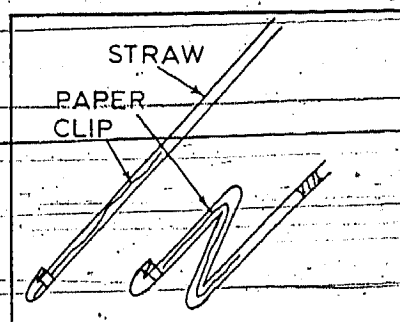


Fig. 3.