

Thermal Expansion On The Cheap

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OK, you want to do thermal expansion, but you don't want to put out \$200+ for one of those fancy thermal expansion setups. Here's a way to get similar results for around \$10

Materials:

2x4, 82 cm long

Popsicle stick

Brass tube, $\frac{1}{4}$ inch diameter

Aluminum tube, $\frac{1}{4}$ inch diameter

Glass tube, $\frac{1}{4}$ inch diameter

Small Funnel

$\frac{1}{4}$ inch latex tubing, 1 meter

Small mass (about 200g)

Hot water

Ice water

Ring Stand

Small Ring

Bucket

2 Thermometers

Caliper or Micrometer

Rubber Bands

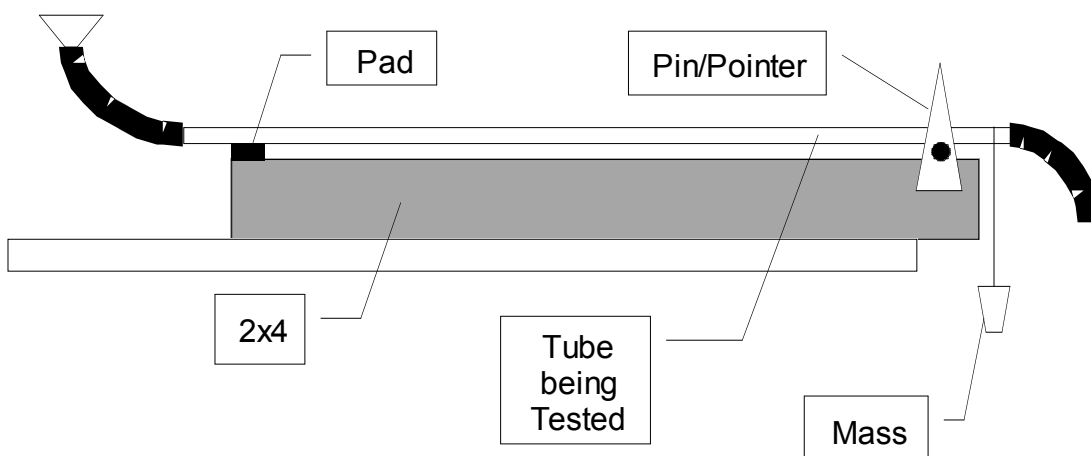
Straight Pin

Index Card

Protractor

Scissors

You can get the metal tubes from a hobby store. The 2x4 can be had from Home Depot. The rest of the stuff can be stolen from any handy Chemistry storeroom



Setup and Operation:

1. Prepare the 2x4 by gluing a small square of Popsicle stick onto one end. This provides a pad by which the tube being tested will be attached to the end of the 2x4. You may also drill a small hole through the 2x4 to provide safe storage for the pointer/pin.

2. Cut a pointer out of the card stock. Push the pin through the center of the pointer and secure with a drop of glue. Measure the diameter of the pin with calipers or micrometer.
3. Place the tube to be tested on the top edge of the 2x4. Secure it on the raised pad with a number of rubber bands.
4. Connect the funnel to the pad end of the tube with latex tubing. Use the ring stand and ring to hold the funnel about 20cm above the level of the tubing.
5. Attach a short length of latex tubing to the other end of the tube to be tested (this deflects water to the bucket placed below)
6. Place the pin/pointer between the tube and the upper surface of the 2x4
7. Hang the weight on the outlet end of the tube (this provides a bit more friction to the pin/pointer to prevent slipping)
8. Pour about 200ml of ice water through the funnel. *This establishes the minimum pointer position.*
9. Align the pointer with the top edge of the 2x4
10. Pour about 200ml of hot water into the funnel. *The pointer will rotate.*
11. Using the protractor, determine the angle through which the pointer turned.
12. Pour about 200ml of ice water into the funnel. *The pointer should return to its original position. If it doesn't something slipped!*
13. Calculate the expansion using the formula:

$$\Delta L = \frac{\pi d \theta}{180}$$

Where ΔL is the change in length in meters, d is the diameter of the pin in meters, and θ is the angle through which the pointer turns in degrees

14. Once you have ΔL , you can calculate the linear coefficient of expansion by using:

$$\alpha = \frac{\Delta L}{L_0(T_H - T_C)}$$

Where α is the coefficient of expansion ΔL is the change in length in meters, L_0 is the distance between the pad and the pin/pointer in meters, T_H is the temperature of the hot water in Celsius, and T_C is the temperature of the cold water in Celsius.

One thing I like about this setup is that it makes the concepts very accessible to the student. You don't have to have sophisticated equipment to determine the coefficient of expansion, just basic stuff that everyone can understand. The cost is low enough that you could build several lab setups and they break down small enough that they can be stored easily.

When you buy the tubing at the hobby store, have them give you the cardboard tubes that the tubing is shipped in. This makes a good storage for the fragile tubes and rubber tubing.

Hope you have fun with this one!