Type: Single Date:__________

Objective: Heat, Temperature and Linear Expansion of Solids

Homework: READ 12.1 - 12.4
Do CONCEPT Q. # (5, 7)
Do PROBLEMS (11, 13, 19) Ch. 12 (12/19)

How Heat Effects the Expansion and Contraction of matter

The Kelvin Temperature and Pressure – Absolute Zero

The Super Fridge

AP Physics "B" Date: ________

Mr. Mirro Heat, Temperature and Linear Expansion of Solids

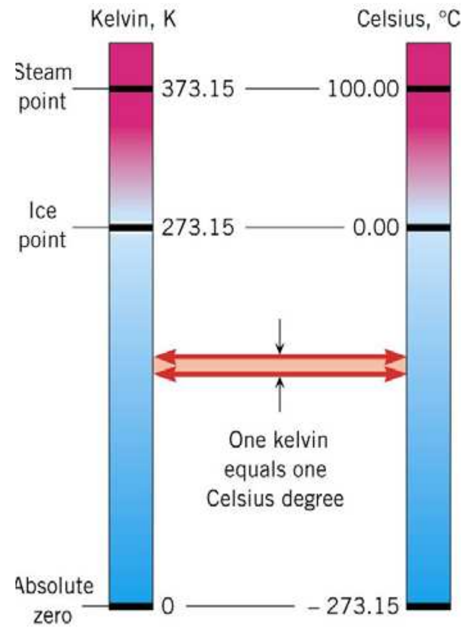
In the United States, ***temperatures*** are often expressed in ***degrees Fahrenheit (°F)***. However, in science and engineering, where **SI units** are commonly used, ***temperature*** is measured in ***degrees Celsius (°C)*** as well as ***absolute temperature*** expressed in ***Kelvins (K)***.

Heat is defined as "**thermal energy**" due to the ***random motion*** of molecules.

Temperature, on the other hand, is a ***measure*** of the ***concentration*** of an object's "**internal**" ***thermal energy***.

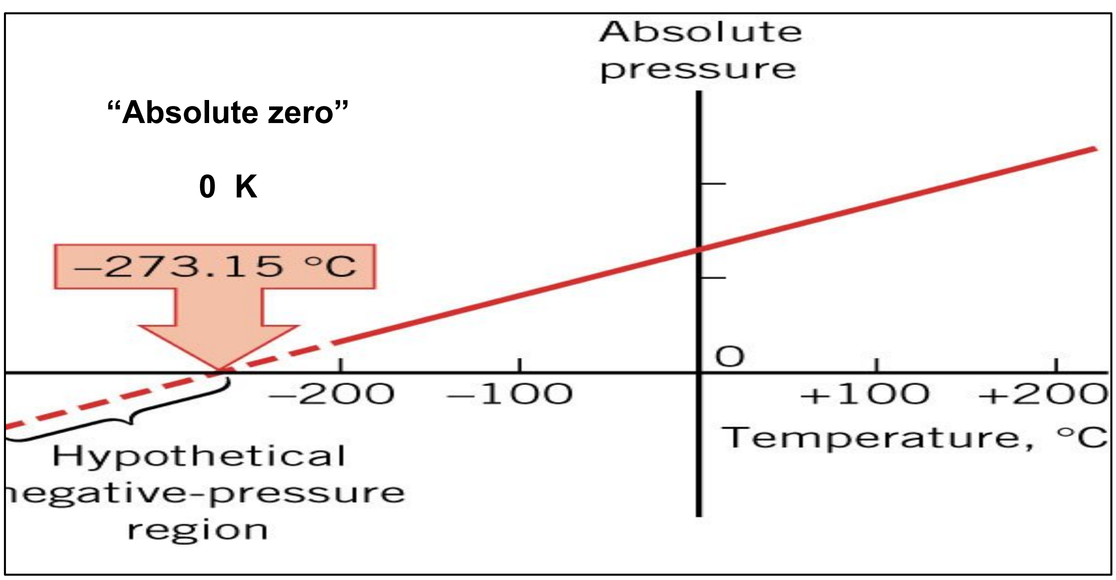
We can convert between the systems as follows:

$°F = \frac{9}{5}\,°C + 32$	Fahrenheit
$°C = \frac{5}{9}\,[°F - 32]$	Celsius
$K = °C + 273$	Kelvin



Therefore, water ***freezes*** at **0 °C** [**273 K**] and

boils at **100 °C** **[373 K]**



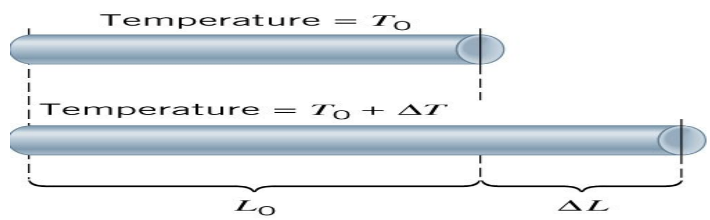
Absolute pressure versus ***temperature*** for a low-density gas at a constant volume.

When a ***substance*** undergoes a ***temperature change***, it ***changes*** in ***size***. For example, when a ***metal lid*** on a jar is too ***tight*** to open….run the lid under ***hot water*** to ***loosen*** the lid.

In other words, let the ***metal expand away*** from the **glass** since both solids ***expand*** at ***different rates***.

- Steel beams that form railroad tracks or bridges expand when they get warmer.
- A balloon filled with air shrinks when placed in a freezer.

The ***change in size*** of a substance due to a ***temperature change*** depends on the "**amount**" of the ***temperature change*** and the ***identity*** of the ***substance***.



The "*identity*" of a ***solid substance*** is known as it ***coefficient of linear expansion*** "**alpha**" (α).

Linear Thermal Expansion of a Solid

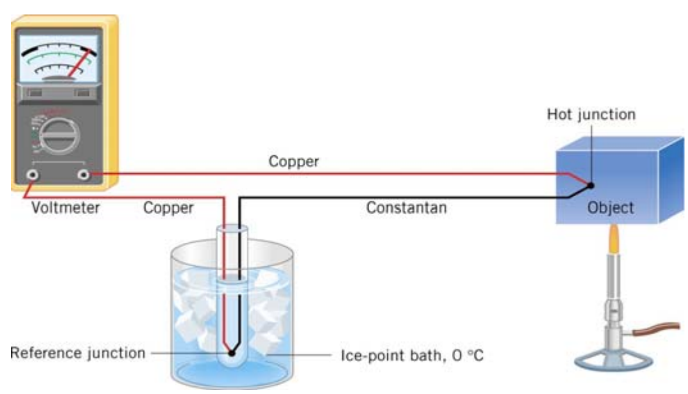
The ***length*** $\mathbf{l_0}$ of an object changes by an amount $\mathbf{\Delta L}$ when its ***temperature*** changes by an amount $\mathbf{\Delta T}$.

$$\Delta L = \alpha L_0 \Delta T$$

where α is the ***coefficient of linear expansion*** having units 1/°C or per degrees Celsius.

All thermometers make use of the change in some physical property with respect to room temperature where $T_{room} \approx 25$ °C. A property that changes with temperature is called a "**thermometric**" property.

A "**thermocouple**" is a thermometer used extensively in scientific laboratories. It consists of thin wires of different metals, welded together at the ends to form form two junctions.



- One junction is the "hot" junction and the other is the "reference" junction.
- When the thermocouple is heated, a voltage is generated based on the difference in temperature between the two junctions.
- With the aid of calibration tables, the temperature of the "hot" junction can be obtained by reading the voltage proportional to temperature.

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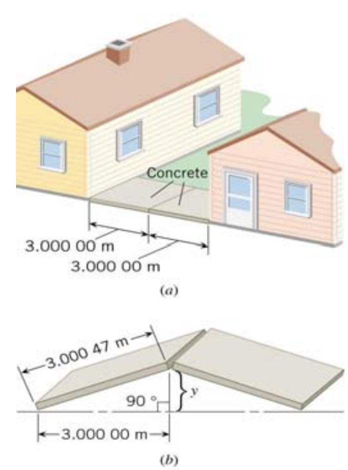
Mr. Mirro Heat, Temperature and Linear Expansion of Solids

Ex 1: A steel beam ($\alpha = 12 \times 10^{-6}$ C^{-1}) used in the construction of a bridge has a length of 30.0 m when the temperature is 15 °C. On a very hot day, when the temperature is 36 °C, how long will the beam be ? [PrinctionReview9.6]

Ex 2: A cylinder of diameter 1.0 cm at 30 °C is to be slid into a hole in a steel plate ($\alpha = 12 \times 10^{-6}$ C^{-1}). The hole has a diameter of 0.99970 cm at 30 °C. To what temperature must the plate be heated ? [Schaums15.2]

Ex 3: Solid aluminum pipe ($\alpha = 23 \times 10^{-6}$ C^{-1}) is used in the construction of a section of fence. By what fraction $\Delta L/L_0$ does the length of the pipe increase when the temperature changes from 0 °C on a cold winter day to 40 °C on a hot summer day ? [CutnellP12.13sim]

Ex 4: A concrete sidewalk ($\alpha = 12 \times 10^{-6}$ C^{-1}) is constructed between two buildings on a day when the temperature is 25 °C. The sidewalk consists of two slabs, each three meters in length and of negligible thickness. As the temperature rises to 38 °C, the slabs expand, but no space is provided for thermal expansion. The buildings do not move, so the slabs buckle upward. Determine the vertical distance y in part (b) of the drawing. [Cutnell12.3]



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Mr. Mirro

Heat, Temperature and Linear Expansion of Solids

Ex 1: A steel beam ($\alpha = 12 \times 10^{-6}\ C^{-1}$) used in the construction of a bridge has a length of 30.0 m when the temperature is 15 °C. On a very hot day, when the temperature is 36 °C, how long will the beam be ? [PrinctionReview9.6]

$\Delta L = \alpha L_0 \Delta T = (12\times10^{-6})(30)(36-15) = 7.6\times10^{-3}$ m

$\therefore L' = L_0 + \Delta L = 30 + .0076 =$ **30.0076 m**

Ex 2: A cylinder of diameter 1.0 cm at 30 °C is to be slid into a hole in a steel plate ($\alpha = 12 \times 10^{-6}\ C^{-1}$). The hole has a diameter of 0.99970 cm at 30 °C. To what temperature must the plate be heated ? [Schaums15.2]

$\Delta L = L_1 - L_2$

$\Delta L = 1.000$ cm $- .99970$ cm

$\Delta L = .00030$ cm

So $\Delta L = \alpha L_0 \Delta T$

$\Delta T = \frac{\Delta L}{\alpha L_0} = \frac{.0003}{(12\times10^{-6})(1)}$

$\Delta T = 25\ °C$

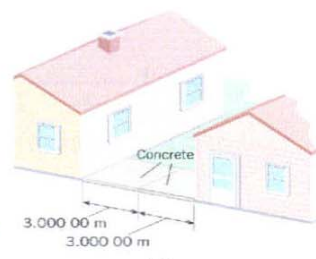
$\therefore T_{new} = 30 + 25 =$ **55 °C**

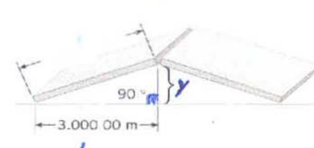
Ex 3: Solid aluminum pipe ($\alpha = 23 \times 10^{-6}\ C^{-1}$) is used in the construction of a section of fence. By what fraction $\Delta L/L_0$ does the length of the pipe increase when the temperature changes from 0 °C on a cold winter day to 40 °C on a hot summer day ? [CutnellP12.13sim]

$\Delta L = \alpha L_0 \Delta T$

So $\frac{\Delta L}{L_0} = \alpha \Delta T = (23\times10^{-6})(40) =$ **9.2×10^{-4}**

Ex 4: A concrete sidewalk ($\alpha = 12 \times 10^{-6}\ C^{-1}$) is constructed between two buildings on a day when the temperature is 25 °C. The sidewalk consists of two slabs, each three meters in length and of negligible thickness. As the temperature rises to 38 °C, the slabs expand, but no space is provided for thermal expansion. The buildings do not move, so the slabs buckle upward. Determine the vertical distance y in part (b) of the drawing. [Cutnell12.3]





$\Delta L = \alpha L_0 \Delta T$

$\Delta L = (12\times10^{-6})(3)(38-25) = .00047$ m

$L' = L_0 + \Delta L = 3.00$ m $+ .00047$ m $= 3.00047$ m

$y = \sqrt{L'^2 - L_0^2} = \sqrt{(3.00047)^2 - (3.000)^2}$

$y = .053$ m