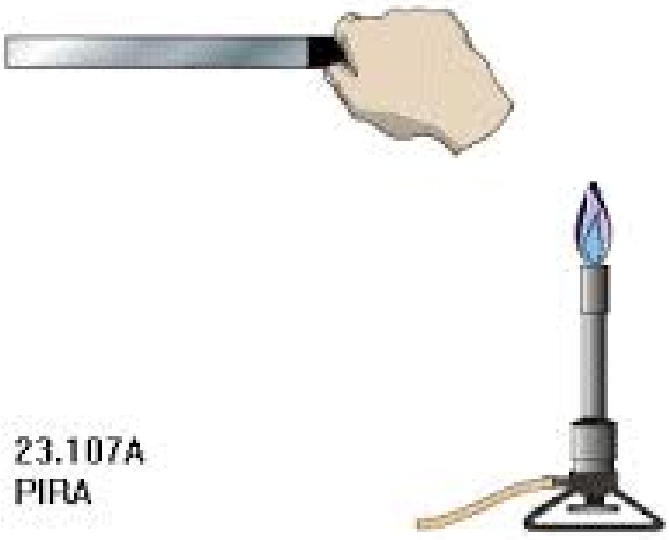
Linear Expansion

What happens when an object is heated?

The particles gain more energy, move faster, and spread out. This causes the whole object to expand.



Solids can expand in a single direction.

Linear expansion (ΔL) depends on:

1. Change in Temperature ΔT
2. Original Length L_o
3. The substance α
   (coefficient of linear expansion)

All of these come together to give us an equation that looks like

$$\Delta L = L_o \alpha \Delta T$$

α

Ex: A 2.0 m long piece of metal expands by 1.5×10^{-3} m when heated from 10.0°C to 51.0°C. What metal is this?

$L_0 = 2.0\,m$

$\Delta L = 1.5\times10^{-3}\,m$

$T_1 = 10.0^\circ C$

$T_2 = 51.0^\circ C$

$\alpha = ?$

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

$$\frac{\Delta L}{L_0(T_2-T_1)} = \frac{L_0\alpha(T_2-T_1)}{L_0(T_2-T_1)}$$

$$\frac{\Delta L}{(L_0(T_2-T_1))} = \alpha$$

$$\frac{1.5\times10^{-3}\,m}{(2.0\,m(51.0^\circ C-10.0^\circ C))} = \alpha$$

$$\frac{1.5\times10^{-3}\,m}{(2.0\,m\times 41.0^\circ C)} = \alpha$$

$$0.00001829\ ^\circ C^{-1} = \alpha$$

$$0.000018\ ^\circ C^{-1}$$

or

$$1.8\times10^{-5}\ ^\circ C^{-1}$$

Ex: A 4.5 m long piece of concrete is poured for a sidewalk when it is 15 °C. The builders left a gap of 1.5 mm along the edge. What is the maximum temperature the sidewalk can take?

$L_0 = 4.5\,m$

$T_1 = 15^\circ C$

$\Delta L = 1.5\,mm = 1.5\times10^{-3}\,m$

$T_2 = ?$

$\alpha = 12\times10^{-6}\ ^\circ C^{-1}$

$$1.5\,mm\left(\frac{1\,m}{10^3\,mm}\right)$$

$$\frac{\Delta L}{L_0\alpha} = \frac{L_0\alpha(T_2-T_1)}{L_0\alpha}$$

$$\frac{\Delta L}{L_0\alpha} + T_1 = T_2 - T_1 + T_1$$

$$\frac{1.5\times10^{-3}\,m}{(4.5\,m\times12\times10^{-6}\,^\circ C^{-1})} + 15^\circ C = T_2$$

$$27.777777^\circ C + 15^\circ C = T_2$$

$$42.777777777^\circ C = T_2$$

$$43^\circ C = T_2$$

Where do we see this type of expansion?

- Doors sticking in the summer
- Power lines sag more in the summer because they longer
- Railway rails have to have gaps in them or they buckle under increased heat
- Bridges have expansion "teeth" to allow them to move slightly as they heat and cool

Thermal expansion

p 362 # 39, 40
p 370 #91, 92,& 93