Thermal Expansion

Objectives
- Explain why thermal expansion occurs & give examples.
- Calculate an objects thermal expansion or contraction of new length.
- Explain differences in expansion of water.

Thermal Expansion of Water
As the temp. decreases from 4°C to 0°C, water expands - ice.
The maximum density of water (1.0 g/mL) occurs at 4°C.

Thermal Expansion
- higher temp → higher velocity → requires more space
- low temp → slower velocity → requires less space

Calculating Thermal Expansion
Different materials expand at different amounts with the same temperature rise.

\[ \Delta L = L_0 \times \alpha \times \Delta T \]

\[ \Delta L = \text{change in length} \]
\[ L_0 = \text{original length} \]
\[ \alpha = \text{coefficient of linear expansion} \]
\[ \Delta T = \text{change in temperature} \]

Linear Expansion Coefficients (°C⁻¹)

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>23 x 10⁻⁶</td>
</tr>
<tr>
<td>Brass</td>
<td>19 x 10⁻⁶</td>
</tr>
<tr>
<td>Copper</td>
<td>16 x 10⁻⁶</td>
</tr>
<tr>
<td>Glass</td>
<td>3.2 x 10⁻⁶</td>
</tr>
<tr>
<td>Gold</td>
<td>14 x 10⁻⁶</td>
</tr>
<tr>
<td>Iron (Soft)</td>
<td>12 x 10⁻⁶</td>
</tr>
<tr>
<td>Lead</td>
<td>29 x 10⁻⁶</td>
</tr>
<tr>
<td>Quartz</td>
<td>.40 x 10⁻⁶</td>
</tr>
<tr>
<td>Steel</td>
<td>11 x 10⁻⁶</td>
</tr>
</tbody>
</table>

Thermal Expansion Problem
\[ T_1 = 20 \text{°C} \]
\[ L_0 = 20 \text{ cm} \]
\[ T_2 = 600 \text{°C} \]
\[ \Delta L = \frac{L_0 \cdot \alpha \cdot \Delta T}{L_0} \]
\[ \Delta L = 0.22 \text{ cm} \]
\[ L = 20.22 \text{ cm} \]
Thermal Expansion

Thermal Expansion Problem

The Eiffel Tower, constructed in 1889 by Alexandre Eiffel, is an impressive latticework structure made of steel. If the tower is 301 m high on a 22 °C day, how much does its height decrease when the temperature cools to 0.0 °C?

\[ \Delta L = L_0 \cdot \alpha \cdot \Delta T \]

\[ = 301 \text{ m} \cdot 11 \times 10^{-6} \cdot 22 \text{ °C} \]

\[ \Delta L = 0.07 \text{ m} \]

Thermal Expansion Joints

Bimetallic Strip

Steel
\[ \alpha = 11 \times 10^{-6} \text{ °C}^{-1} \]

Brass
\[ \alpha = 19 \times 10^{-6} \text{ °C}^{-1} \]

(Heat)

Bimetallic Strip

Steel
\[ \alpha = 11 \times 10^{-6} \text{ °C}^{-1} \]

Brass
\[ \alpha = 19 \times 10^{-6} \text{ °C}^{-1} \]

(Cool)

Thermostat

Assignments . . .

- Begin Chapter 21 Homework #16 - 20