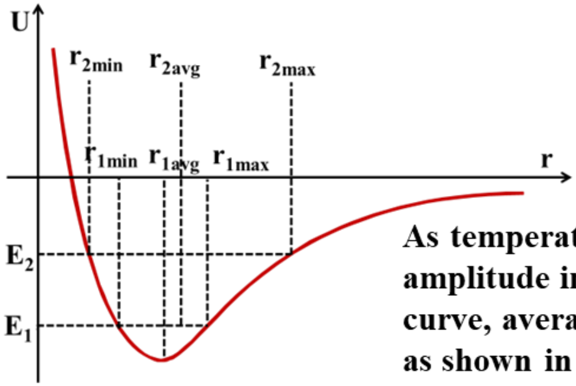
MIND MAP

Thermal Expansion

Potential Energy v/s Distance Curve



$T_2 > T_1$

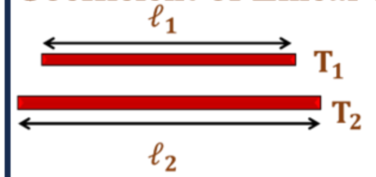
$E_2 > E_1$

$r_{2avg} > r_{1avg}$ (due to asymmetric nature of curve)

As temperature increases, relative vibrational amplitude increases. Due to asymmetric nature of curve, average distance between the atoms increases as shown in the curve.

On increasing temperature, most of the substances expand. This expansion in dimension of body due to increase in temperature is called **Thermal expansion.**

Coefficient of Linear Expansion (α)



$$\frac{\Delta \ell}{\ell_1} = \alpha \Delta T$$

α = Coefficient of linear expansion

$$\ell_2 = \ell_1[1 + \alpha(T_2 - T_1)]$$

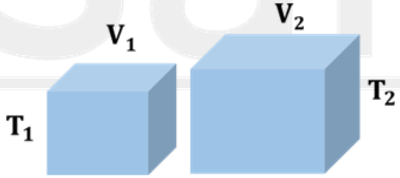
Coefficient of Area Expansion (β)

$$\frac{\Delta A}{A_1} = \beta \Delta T$$

β = Coefficient of Area expansion

$$A_2 = A_1(1 + \beta \Delta T)$$

Coefficient of Volume Expansion (γ)



$$\frac{\Delta V}{V_1} = \gamma \Delta T$$

γ = Coefficient of volume expansion

$$V_2 = V_1(1 + \gamma \Delta T)$$

[Unit of α, β, γ is /°C or °C^{-1} or /K or K^{-1}]

Calculating Fractional Change or Percentage Change

$Z = k A^x B^y$ (k: Constant)

$$\frac{dZ}{Z} = x\frac{dA}{A} + y\frac{dB}{B}$$

For small change

$$\frac{\Delta Z}{Z} \times 100 = x\frac{\Delta A}{A} \times 100 + y\frac{\Delta B}{B} \times 100$$

(%change in Z) = x (%change in A) + y (% change in B)

Time period of a Simple Pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}} \qquad \frac{\Delta T}{T} = \frac{1}{2}\alpha\Delta\theta$$

Time lost or gain in a day

$$= \frac{\Delta T}{T} \times 24 \times 3600$$

When $\theta\uparrow$, $\ell\uparrow$, $T\uparrow$
clock will run slow & time will be lost.

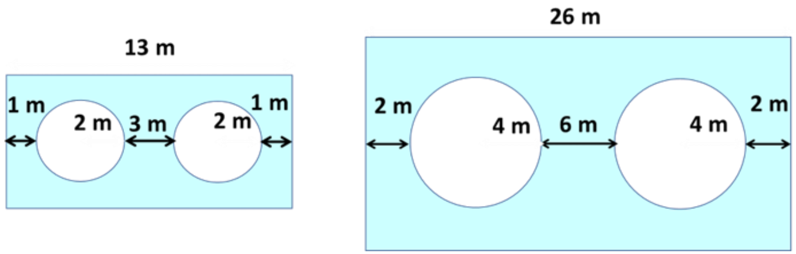
When $\theta\downarrow$, $\ell\downarrow$, $T\downarrow$
clock will run fast & time will be gained.

MIND MAP

Thermal Expansion

Isotropic Expansion

In this expansion, percentage change in linear dimension at any point and in any direction is same for same change in temperature.



This expansion is similar to uniform photographic enlargement.

Relationship between α, β, & γ

For Isotropic Expansion

$\beta = 2\alpha \qquad \gamma = 3\alpha$

The expansion which is not Isotropic is called <u>Anisotropic Expansion</u>.

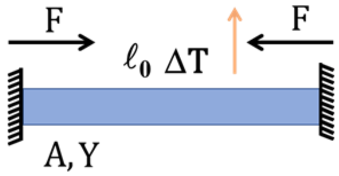
Relationship between α, β, & γ

For Anisotropic Expansion

$A = \ell \times b \qquad V = \ell \times b \times h$

$\beta = \alpha_\ell + \alpha_b \qquad \gamma = \alpha_\ell + \alpha_b + \alpha_h$

Thermal Stress



$$\text{Stress} = \frac{F}{A} = Y\,\alpha\,\Delta T$$

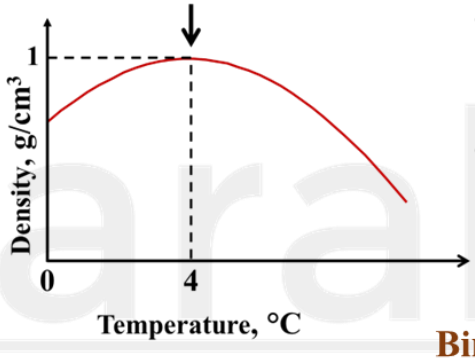
Variation of Density With Temperature

$$\rho = \frac{\text{Mass}}{\text{Volume}}$$

At temperature $T_0 + \Delta T$, $\rho = \dfrac{M}{V_0(1 + \gamma\Delta T)}$

$$\rho = \frac{\rho_0}{1 + \gamma\Delta T} \approx \rho_0(1 - \gamma\Delta T)$$

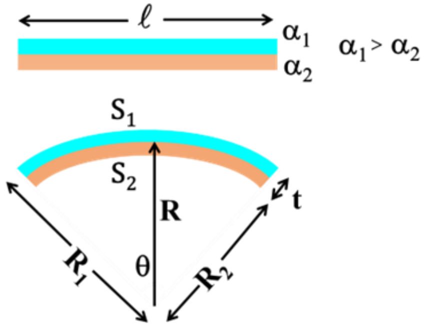
Anomalous Expansion of Water



- If water at 0 °C is heated, it's volume decreases until the temperature reaches 4 °C.
- Above 4 °C water behaves normally and it's volume increases as temperature increases.

Bimetallic Strip

A bimetallic strip is made from two thin strips of metal that have different coefficients of linear expansion.



$$R = \frac{t}{(\alpha_1 - \alpha_2)\Delta T}$$