Thermal Expansion

* Co-efficients of expansion:

1. Linear expansion: α

$$(l_2 - l_1) = \alpha \, l_1 \, (t_2 - t_1).$$

$$\alpha = \frac{\Delta l}{l_1 \, \Delta t} \, /^\circ C = \frac{1}{l} \frac{dl}{dt} \, /^\circ C.$$

2. Superficial expansion: β.

$$(A_2 - A_1) = \beta \, A_1 \, (t_2 - t_1).$$

$$\beta = \frac{\Delta A}{A_1 \, \Delta t} \, /^\circ C. = \frac{1}{A} \frac{dA}{dt} \, /^\circ C.$$

3. Volume expansion: γ.

$$(V_2 - V_1) = \gamma \, V_1 \, (t_2 - t_1).$$

$$\gamma = \frac{\Delta V}{V_1 \, \Delta t} \, /^\circ C = \frac{1}{V} \frac{dV}{dt} \, /^\circ C.$$

* Relation between α, β, γ:

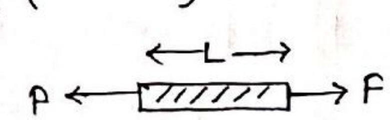
$$2\gamma = 3\beta = 6\alpha$$

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

* Variation of density with temp:

$$\rho_1 = \rho_2 (1 + \gamma \cdot t) \Rightarrow \rho_2 = \rho_1 (1 - \gamma t).$$

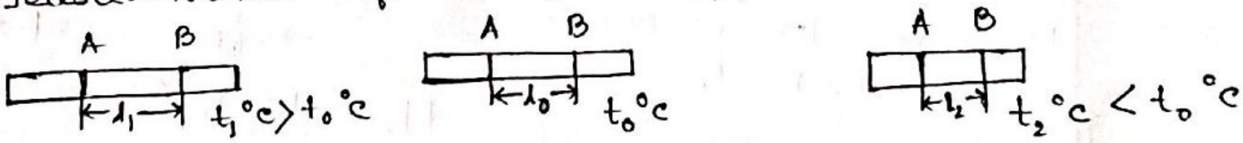
* Thermal Stress: $\frac{F}{A} = Y \alpha t$.



[Y = Young's Modulus].

* Error due to thermal expansion:

1. Measurement of length by a scale.



$$l_1 = l_0 [1 + \alpha (t_1 - t_0)]$$

$$l_0 = l_2 [1 + \alpha (t_0 - t_2)]$$

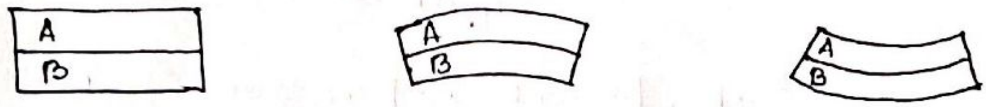
Joyoshish Saha

2. Clock going fast or slow: $T_0 = 2\pi\sqrt{\frac{l_0}{g}}$.

$$T_t = 2\pi\sqrt{\frac{l_0[1+\alpha(t-t_0)]}{g}}$$

* Bucking of bimetallic strips:

$\alpha_A > \alpha_B$ $\quad t_0{}^\circ c \quad t_1{}^\circ c > t_0{}^\circ c \quad t_2{}^\circ c < t_0{}^\circ c$



* Thermal expansion of liquid: Liquid has only coefficient of volume expansion.

- Co-efficients of real & apparent expansion of liquid in a glass flask:

$$\gamma_r = \gamma_a \times \gamma_g .$$

γ_r → real expansion coef.

γ_a → apparent expansion coef.

γ_g → volume expansion coef. of glass.

- Variation of density of liquid with temp.

$$\rho_1 = \rho_2 (1 + \gamma_r t).$$

* Apparent weight of a body immersed in a liquid at different temp.

$$M_2 = M_1 [1 - (\gamma_l - \gamma_s) t].$$

M_2 → app. loss in weight in temp t_2 $\boxed{(m - V_1 \rho_l) = m_1}$

M_1 → app. loss in weight in temp t_1.

$\boxed{m_1' = [m_1 + V_1\rho_l(\gamma_l - \gamma_s)t]}$

γ_l → for liquid

γ_s → for solid.

$M_2 = m - m_1'$

$M_1 = m - m_1$

* Temperature correction in barometer reading:

i) Scale Correction: $H = h(1 + \alpha\theta)$.

$h \rightarrow$ observed height of barometer at $0°C$

$H \rightarrow$ correct height at the temp. $\theta°C$ after scale correction.

ii) Density correction: $\rho_0 = \rho(1 + \gamma\theta)$.

Considering both correction,

$H_0 = h[1 - (\gamma - \alpha)\theta]$.

[$H_0 \rightarrow$ correct height,
$h \rightarrow$ observed height].