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THERMAL EXPANSION

Case of bimettalic strip

$\alpha_1 < \alpha_2$

$\alpha_1 > \alpha_2$

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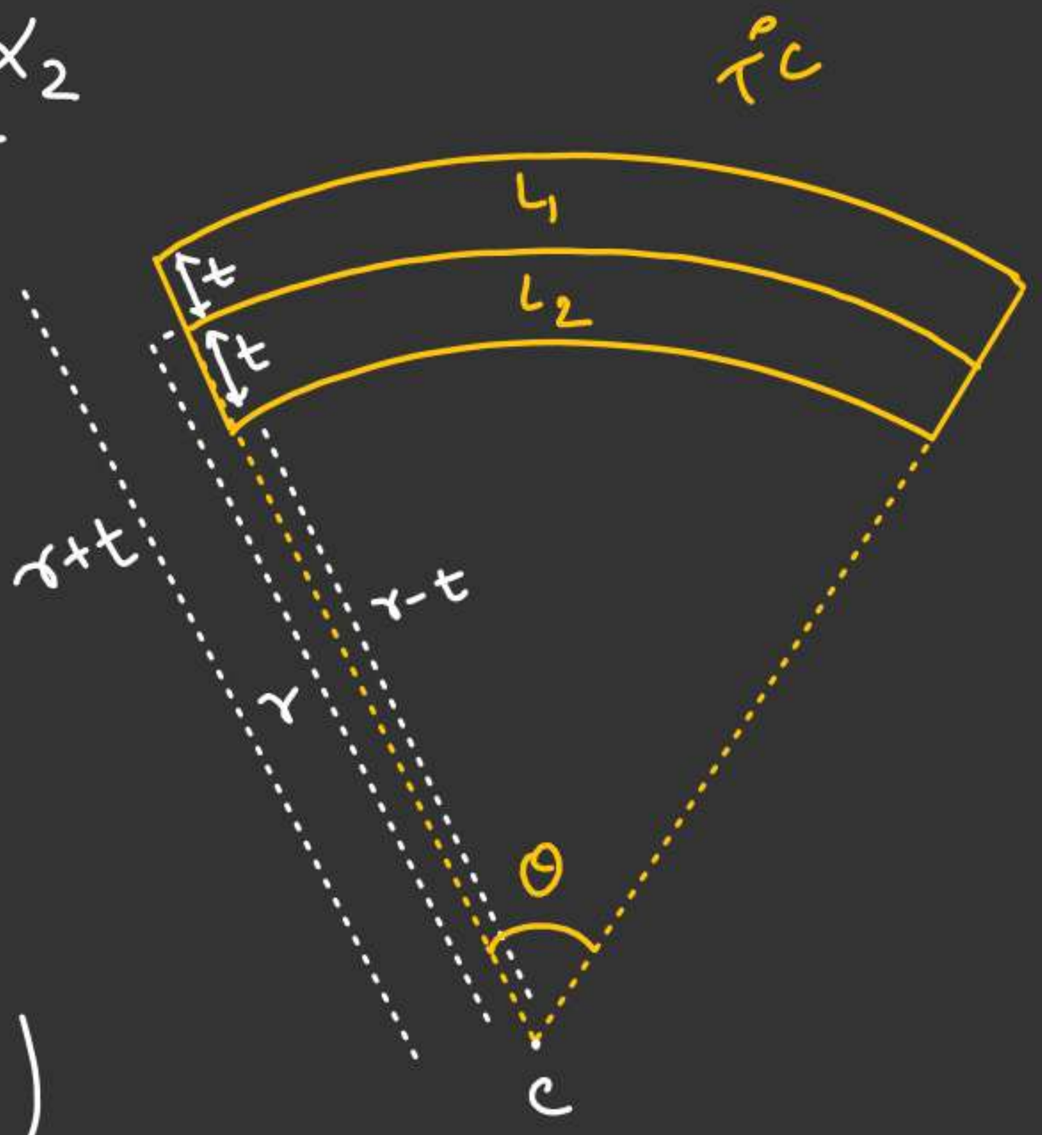
Case of bimettalic strip

$\alpha_1 > \alpha_2$

r = Mean radius

$\Delta T = (T - T_0)$



$$L_1 = L(1+\alpha_1 \Delta T)$$

$$L_2 = L(1+\alpha_2 \Delta T)$$

$$L_1 = (r+t)\theta$$

$$L_2 = (r-t)\theta$$

$$\frac{L_1}{L_2} = \left(\frac{r+t}{r-t}\right) \Rightarrow \frac{L(1+\alpha_1 \Delta T)}{L(1+\alpha_2 \Delta T)} = \left(\frac{r+t}{r-t}\right)$$

$\Rightarrow$

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$$\frac{(1+\alpha_1 \Delta T)}{(1+\alpha_2 \Delta T)} = \frac{r+t}{r-t}$$

$$\frac{(1+\alpha_1 \Delta T) + (1+\alpha_2 \Delta T)}{(1+\alpha_1 \Delta T) - (1+\alpha_2 \Delta T)} = \frac{(r+t)+(r-t)}{(r+t)-(r-t)}$$

$$\Rightarrow \quad \frac{2+(\alpha_1+\alpha_2)\Delta T}{(\alpha_1-\alpha_2)\Delta T} = \frac{2r}{2t}$$

$$\Rightarrow \quad \boxed{r = \frac{t\left[2+(\alpha_1+\alpha_2)\Delta T\right]}{(\alpha_1-\alpha_2)\Delta T}}$$

$$r = \frac{2t\left[1+\frac{(\alpha_1+\alpha_2)\Delta T}{2}\right]}{(\alpha_1-\alpha_2)\Delta T}$$

$$1 \gg (\alpha_1+\alpha_2)\Delta T$$

$$\boxed{r = \frac{2t}{(\alpha_1-\alpha_2)\Delta T}}$$

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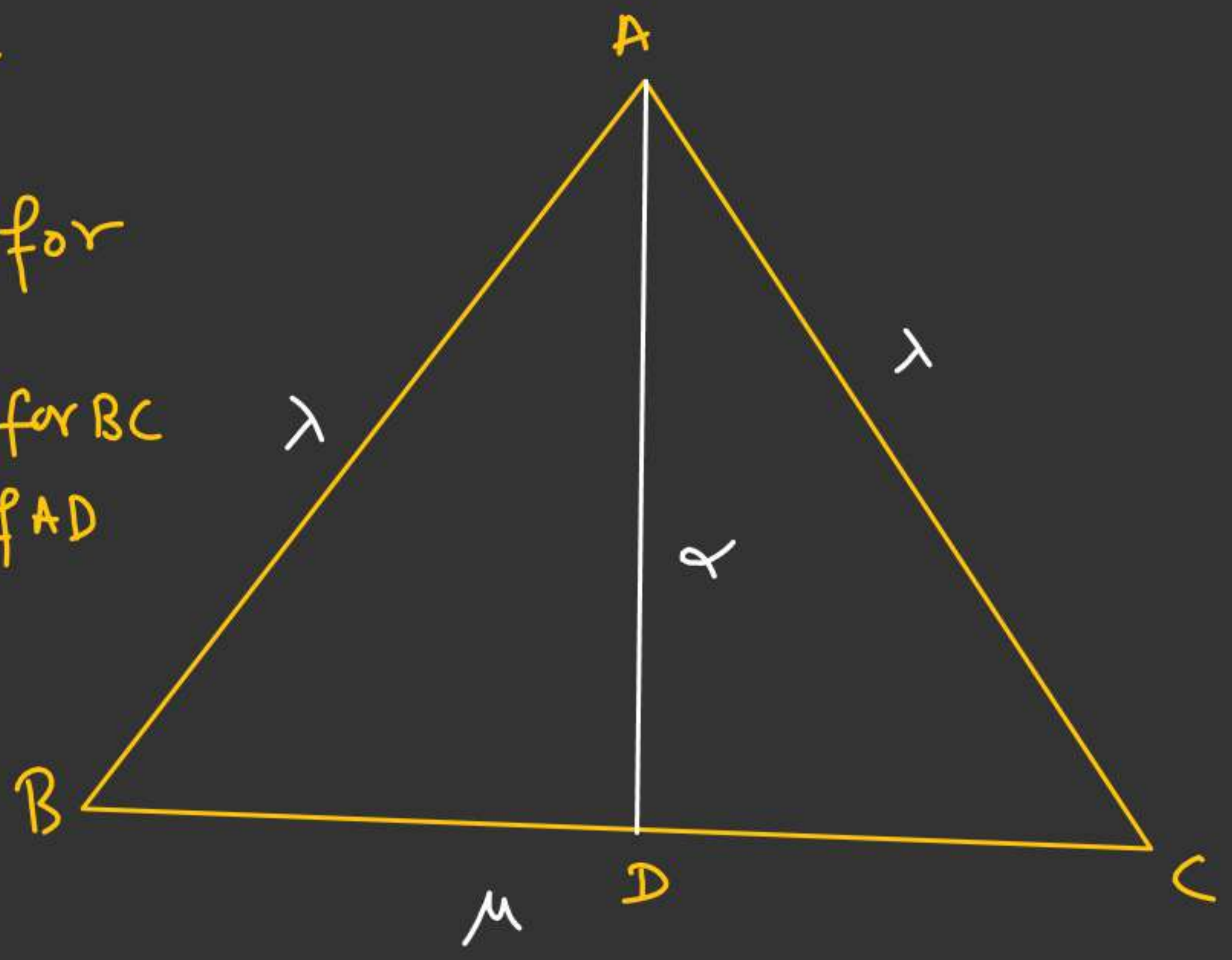
ABC equilaterial triangle form by 3-rods AB, BC & CA

λ is the coff^n of linear expansion for AB and AC

μ be the coff^n of linear expansion for BC

α be the coff^n of linear expansion of AD

Find α So that the frame will not deformed if heated from $T_0°C$ to $T°C$



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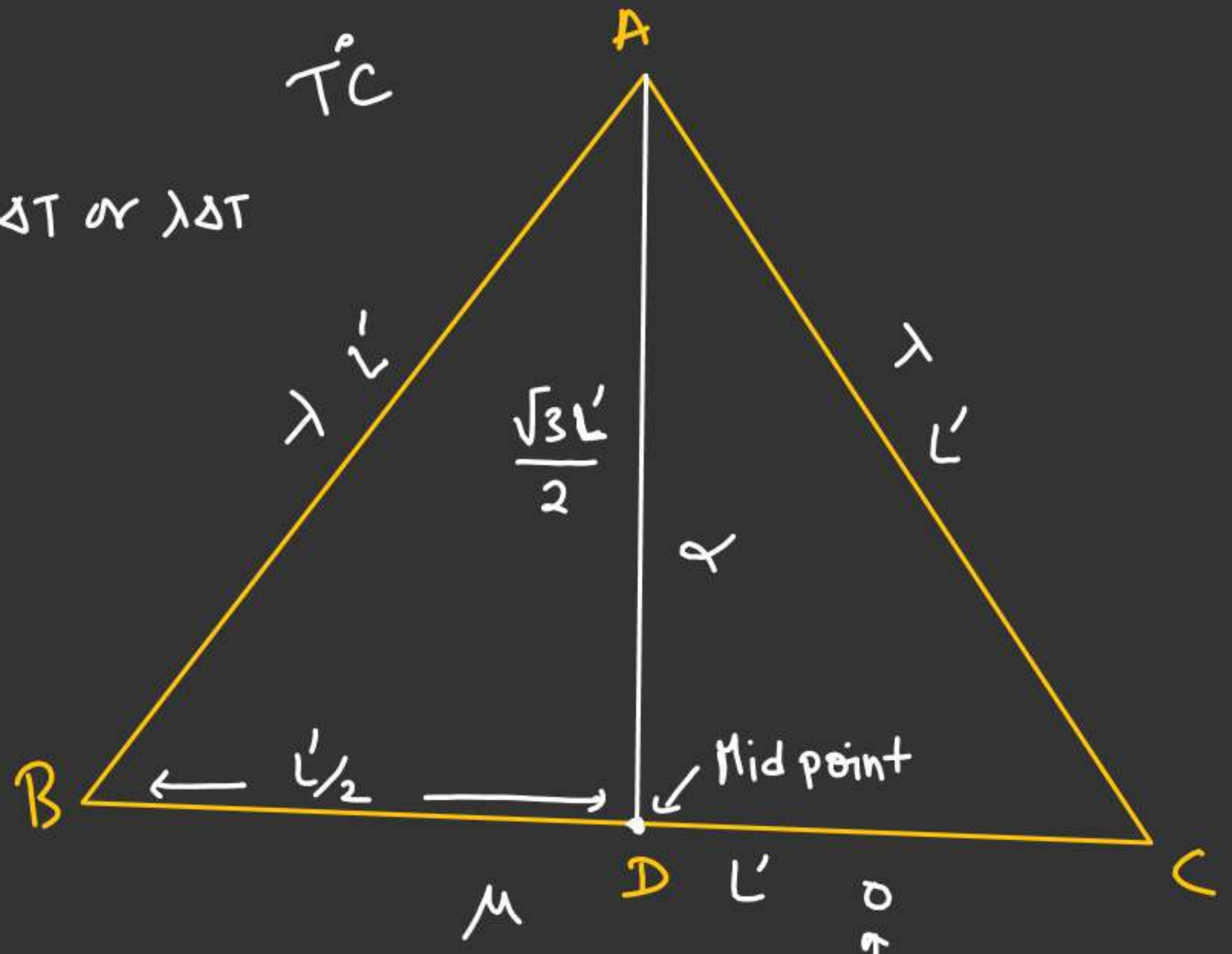

For AB

$$L' = L(1+\lambda\Delta T) \qquad 1 \gg \alpha\Delta T \text{ or } \mu\Delta T \text{ or } \lambda\Delta T$$

For BD.

$$\frac{L'}{2} = \frac{L}{2}(1+\mu\Delta T) \qquad 1 \gg \alpha\Delta T$$

For AD

$$\frac{\sqrt{3}L'}{2} = \frac{\sqrt{3}L}{2}(1+\alpha\Delta T)$$

$$L'^2 = \left(\frac{L'}{2}\right)^2 + \left(\frac{\sqrt{3}L'}{2}\right)^2$$

$$\cancel{L^2}(1+\lambda\Delta T)^2 = \frac{\cancel{L^2}}{4}(1+\mu\Delta T)^2 + \frac{3\cancel{L^2}}{4}(1+\alpha\Delta T)^2$$

$$(1+\lambda\Delta T)^2 = \frac{1}{4}(1+\mu\Delta T)^2 + \frac{3}{4}(1+\alpha\Delta T)^2$$

$$1+\underbrace{\lambda^2\Delta T^2}_{0} + 2\lambda\Delta T = \frac{1}{4}(1+\underbrace{\mu^2\Delta T^2}_{0} + 2\mu\Delta T) + \frac{3}{4}(1+\underbrace{\alpha^2\Delta T^2}_{0} + 2\alpha\Delta T)$$

$$\cancel{1} + 2\lambda\Delta T = \cancel{1} + \frac{\mu}{2}\Delta T + \frac{3}{2}\alpha\Delta T$$

$$2\lambda - \frac{\mu}{2} = \frac{3}{2}\alpha \Rightarrow \alpha = \frac{4\lambda}{3} - \frac{1}{3}\mu$$

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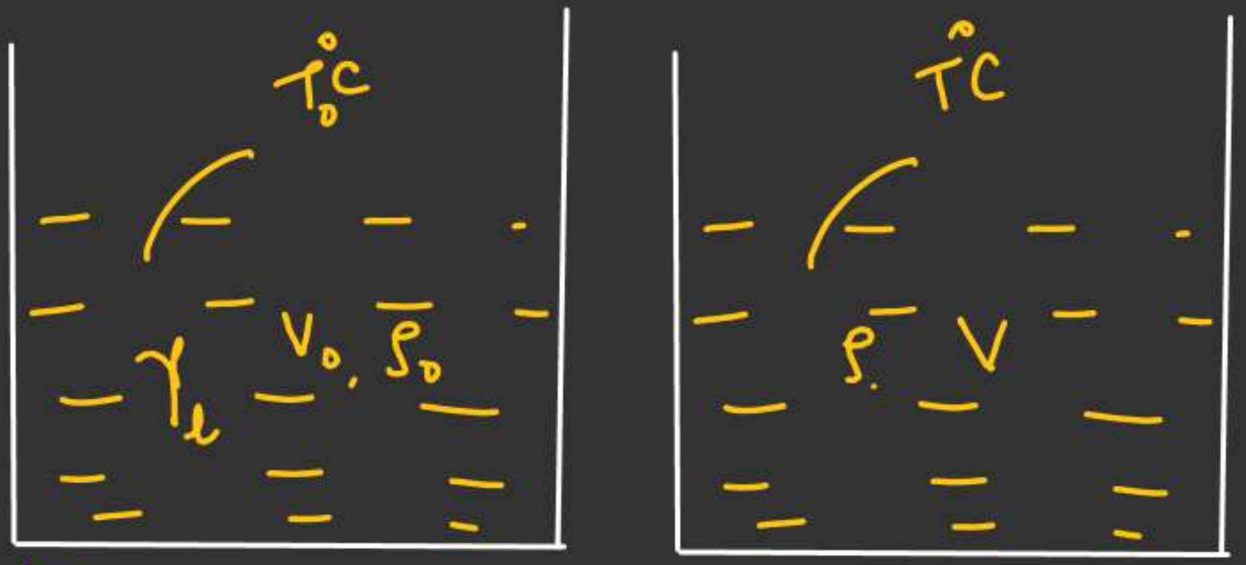
Thermal Expansion in liquid.

Case when only expansion of liquid not vessel

$\rho = \frac{m}{V}$

$\left(\rho \propto \frac{1}{V}\right)$

$m = C$



$\rho_0 \rightarrow$ Density of liquid at $T_0^\circ C$

$\rho \rightarrow$ Density of liquid at $T^\circ C$

$V = V_0(1 + \gamma_l \Delta T)$

$$\frac{\rho}{\rho_0} = \frac{V_0}{V}$$

$$\frac{\rho}{\rho_0} = \frac{V_0}{V_0(1 + \gamma_l \Delta T)}$$

$$\boxed{\rho = \frac{\rho_0}{(1 + \gamma_l \Delta T)}}$$

$1 >> \gamma_l \Delta T$

$\rho = \rho_0(1 + \gamma_l \Delta T)^{-1}$

$$\boxed{\rho = \rho_0(1 - \gamma_l \Delta T)}$$ ✓

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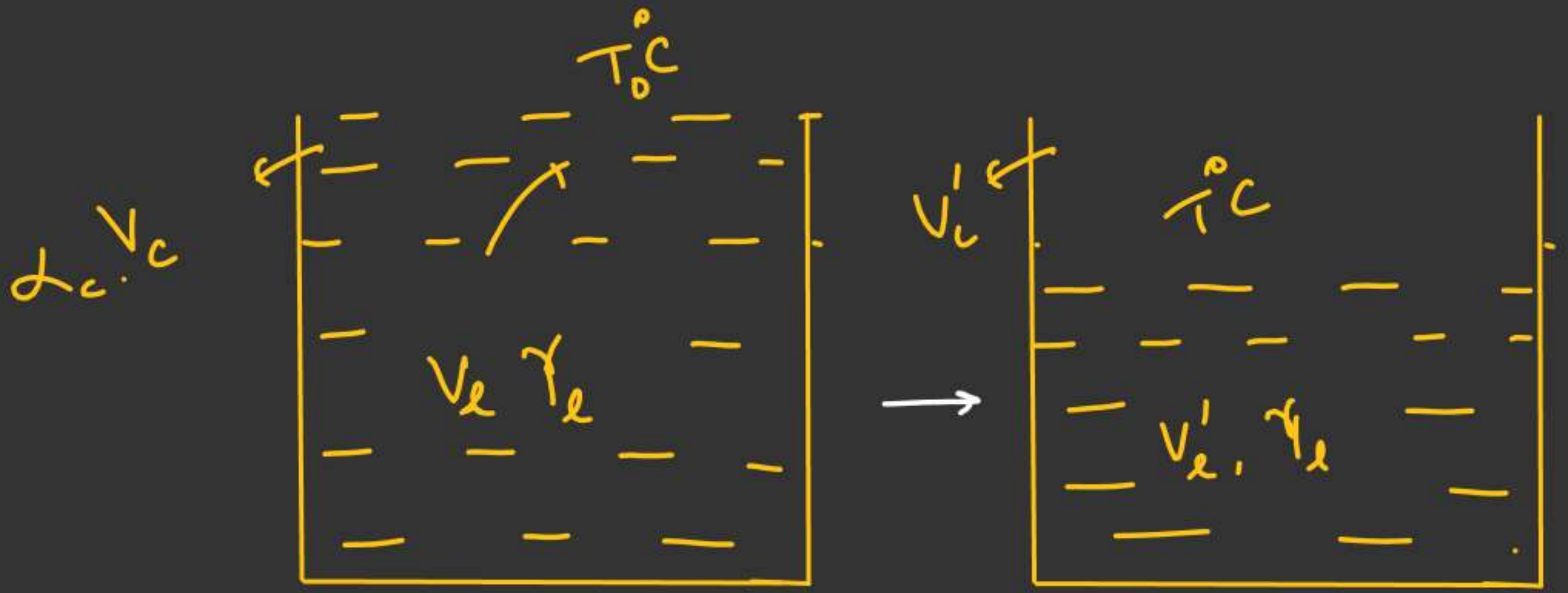
At $T°C$



At $T_0°C$

✓ V_ℓ = Volume of liquid

✓ V_c = Volume of container

At $T°C$

V_ℓ' = Volume of liquid

V_c' = Volume of Vessel

For liquid

$$V_\ell' = V_\ell(1+\gamma_\ell \Delta T)$$

$$V_c' = V_c(1+\gamma_c \Delta T)$$

$$\gamma_c = 3\alpha_c \qquad (\gamma = 3\alpha)$$

$$V_c' = V_c(1+3\alpha_c \Delta T)$$

$$(V_\ell = V_c = V_0)$$

$$\Delta V_\ell = V_\ell' - V_c'$$

$$= V_\ell(1+\gamma_\ell \Delta T) - V_c(1+3\alpha_c \Delta T)$$

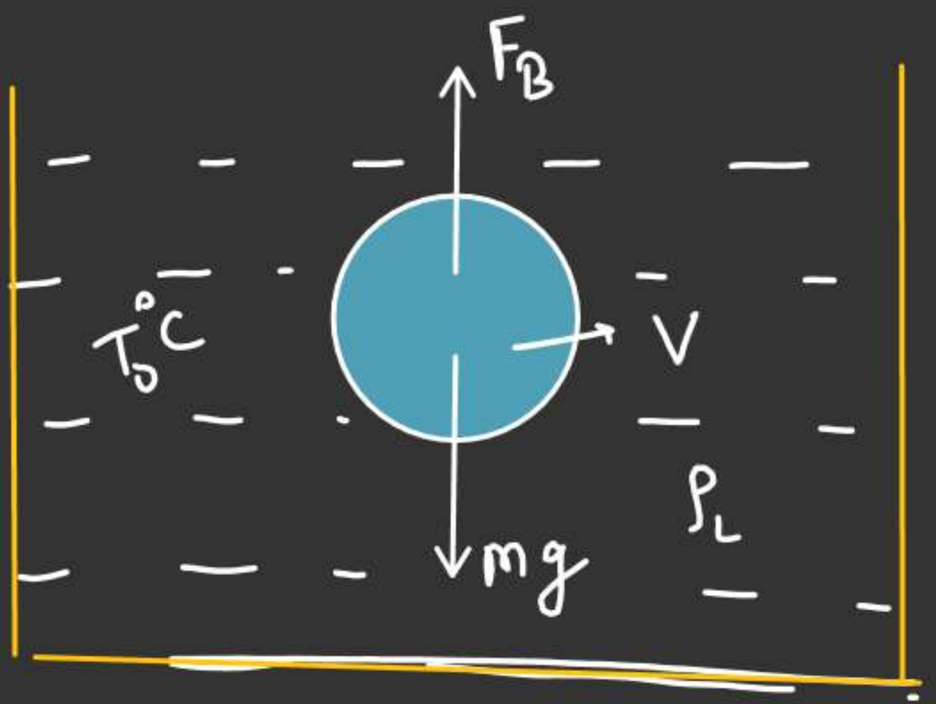
$$\boxed{\Delta V_\ell = V_0(\gamma_\ell - 3\alpha_c)\Delta T}$$

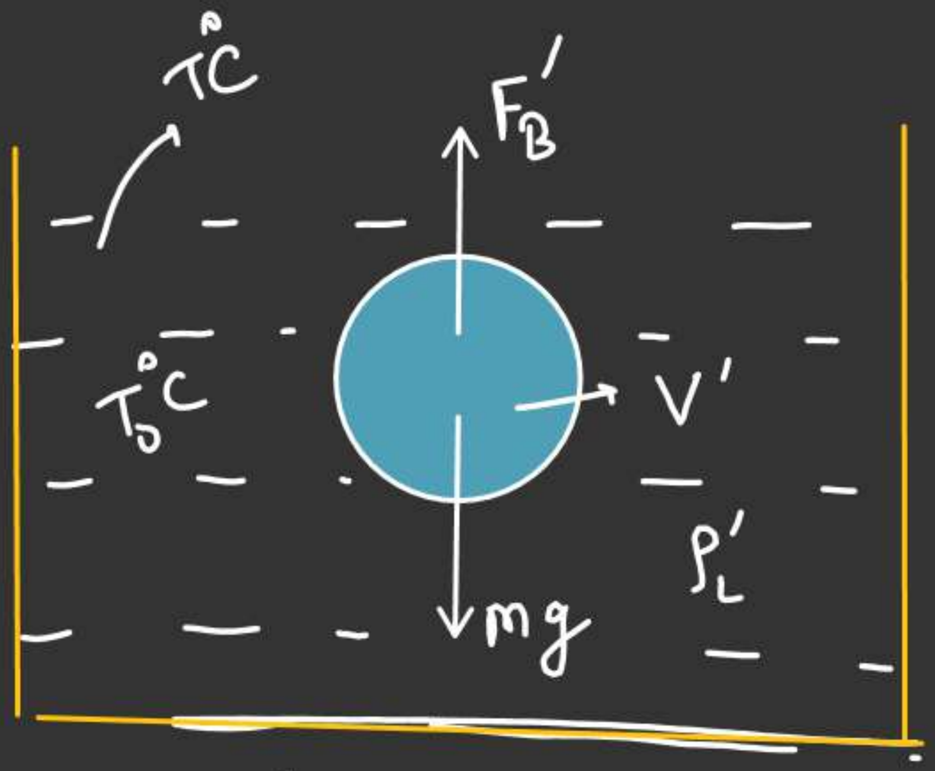
$\gamma_\ell > 3\alpha_c \Rightarrow$ level of liquid increase

$\gamma_\ell < 3\alpha_c \Rightarrow$ level of liquid decrease

Effect of Temperature on the Apparent weight of the body fully submerged

No Expansion of vessel





F_B = Weight of displaced liquid

$= V_\ell \rho_\ell g$

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$V_\ell = V_s$

V_s = Volume of submerged part of body

$$W_{app} = (mg - F_B)$$

$$W_{app} = mg - V\rho_L g$$

$$W'_{app} = mg - F_B' = mg - V'\rho_L' g$$

$$W'_{app} - W_{app} = V\rho_L g - V'\rho_L' g$$

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$$W'_{app} - W_{app} = V\rho_L g - V'\rho'_L g$$

$$V' = V(1+\gamma_s \Delta T)$$

$$\rho'_L = \frac{\rho_L}{(1+\gamma_l \Delta T)} = \rho_L(1-\gamma_l \Delta T)$$

$$\Delta W_{app} = V\rho_L g - \left[V(1+\gamma_s\Delta T)\rho_L(1-\gamma_l\Delta T)g\right]$$

$$\Delta W_{app} = V\rho_L g - V\rho_L g\left[(1+\gamma_s\Delta T)(1-\gamma_l\Delta T)\right]$$

$$= V\rho_L g - V\rho_L g\left[1-\gamma_l\Delta T+\gamma_s\Delta T-\underbrace{\gamma_s\gamma_l\Delta T^2}_{0}\right.$$

$$= V\rho_L g\left[1-(1+(\gamma_s-\gamma_l)\Delta T\right]$$

$$\boxed{\Delta W_{app} = V\rho_L g[\gamma_l-\gamma_s]\Delta T}$$

① $\Delta W_{app} > 0$

$\Rightarrow \gamma_l > \gamma_s$

② $\Delta W_{app} < 0 \Rightarrow (W_{app})_f < (W_{app})_i$

$\Rightarrow \gamma_s > \gamma_l$

③ if $\gamma_s = \gamma_l$

$3\alpha_s = \gamma_l$

No Change in apparent weight.

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SCALE ERROR

$$\boxed{l_a = l_0\left(1+\alpha(T-T_0)\right]}$$

l_a = Acutual length

l_0 = Obsered or Measured length

T_0 = Temperature at which Scale gives correct reading

T = Temperature at which Observation is made