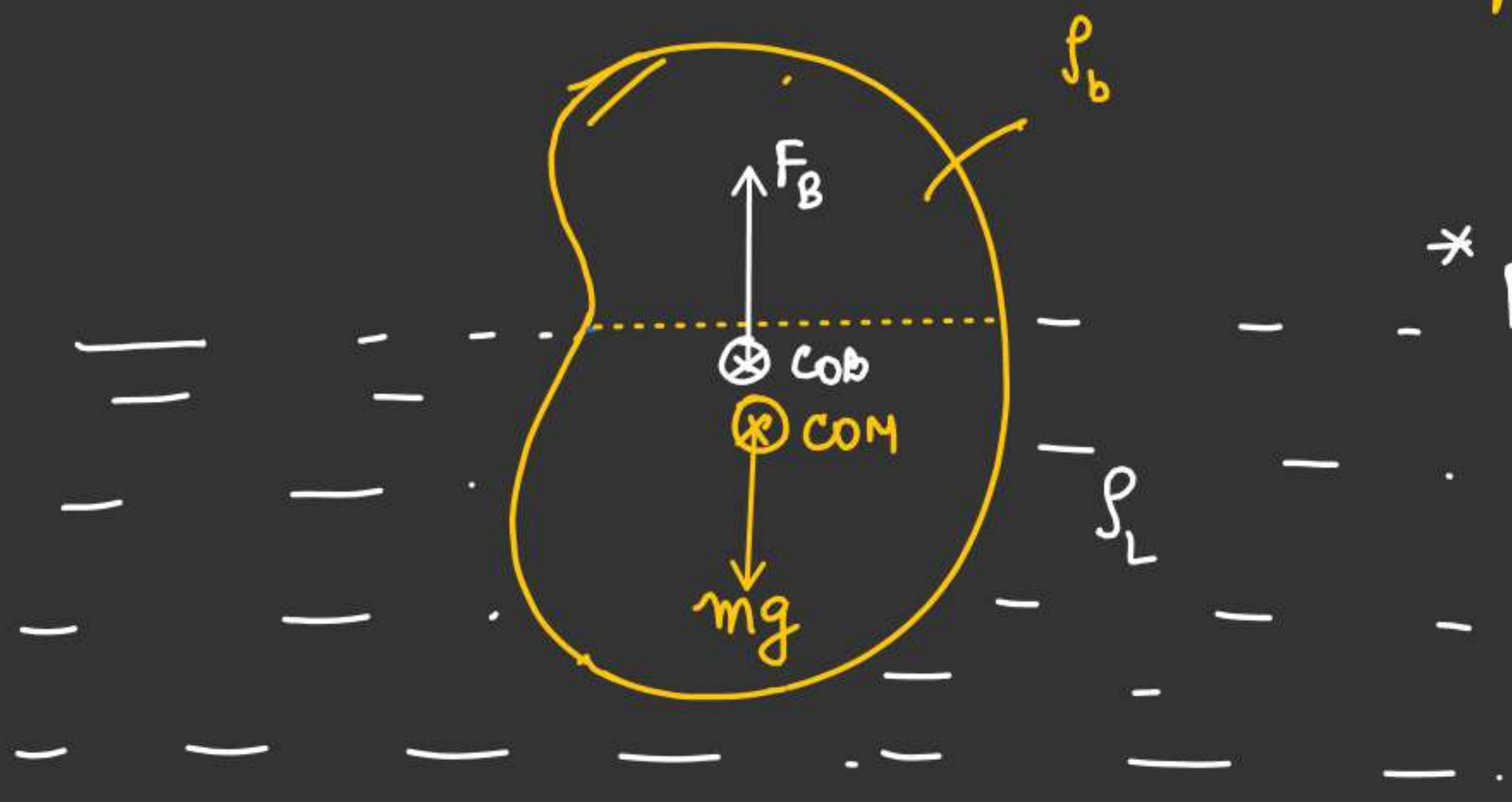
Nishant Jindal

Law of floatation



At Equilibrium

$$F_B = mg$$

* For Rotational Equilibrium
F_B and Mg along the same line.

$$V_s \rho_L g = \rho_b V_b g$$

$$\boxed{\frac{V_s}{V_b} = \frac{\rho_b}{\rho_L}}$$

V_s = Volume of Submerged part of the body

V_b = Volume of body.

ρ_b = density of body

ρ_l = density of liquid

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$$\frac{V_s}{V_b} = \frac{\rho_b}{\rho_L}$$

Case-1 :-

$V_s < V_b$

$\Rightarrow \rho_b < \rho_L$

$\Rightarrow$ Body partially Submerged float.

Case :- 2

$\rho_b = \rho_L$

$V_s = V_b$

Body fully Submerged & float.

Case-3

$\rho_b > \rho_L$

$\Rightarrow \underline{V_s} > \underline{V_b}$ (Not possible)

$\Rightarrow$ (Body will Sink)

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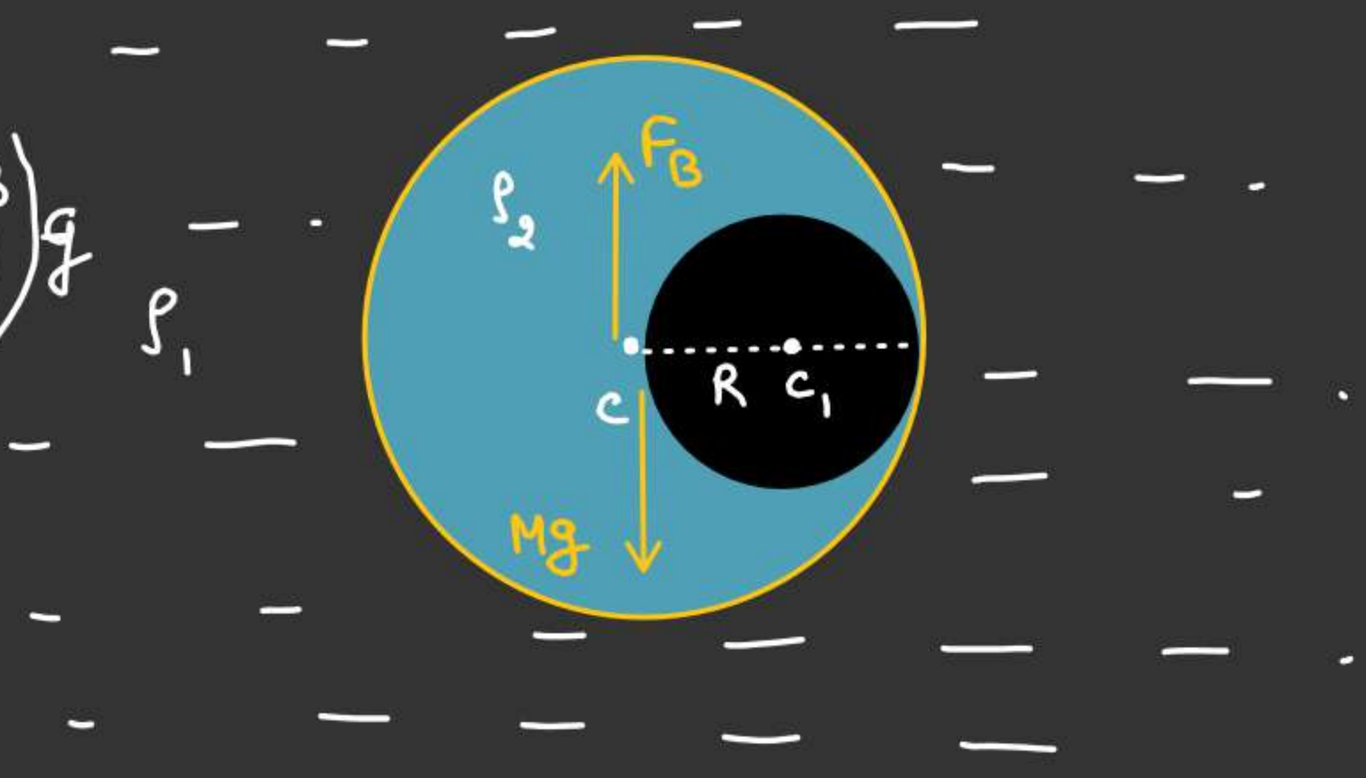
For body to float

$$F_B = Mg$$

$$\left(\frac{4}{3}\pi R^3\right)\rho_1 g = \rho_2\left(\frac{4}{3}\pi R^3 - \frac{4}{3}\pi\left(\frac{R}{2}\right)^3\right)g$$

$$\cancel{\frac{4}{3}\pi R^3}\rho_1 \cancel{g} = \cancel{\left(\frac{4}{3}\pi R^3\right)}\rho_2\left(1-\frac{1}{8}\right)\cancel{g}$$

$$\rho_1 = \rho_2\left(7/8\right)$$



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Q4.

$L = 1m.$

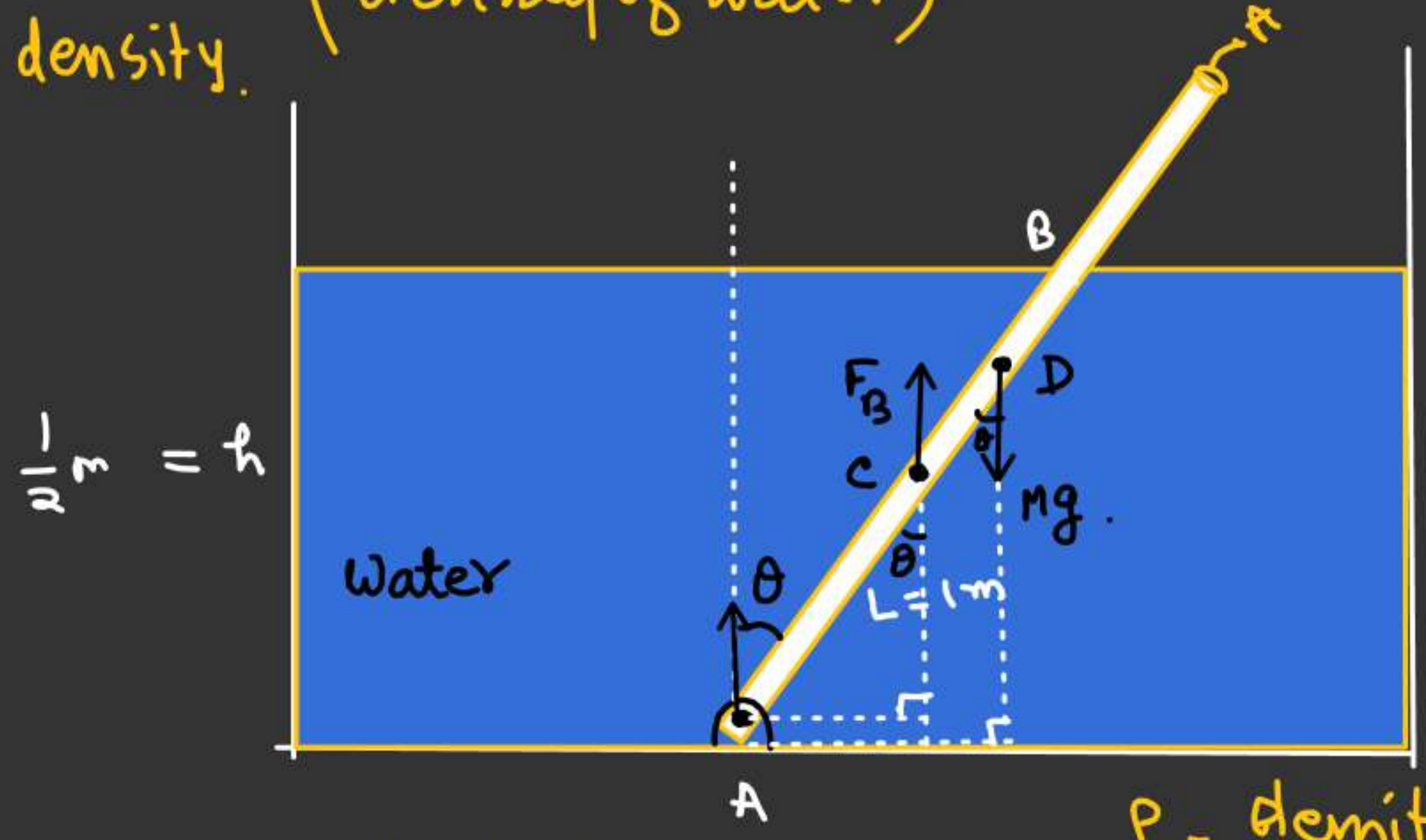
$h = \frac{1}{2}m.$

Specific gravity of the Stick is = 0.5

Find 'θ' if stick is in equilibrium.

Stick has uniform crossectional area.

Specific gravity = $\left(\frac{\text{density of body}}{\text{density of water}}\right)$
or
Relative density.



ρ_s = density of stick

$\cos\theta = \frac{h}{AB}$

$AB = (h\sec\theta)$

$AD = \frac{L}{2}.$

$AC = \frac{AB}{2} = \frac{h}{2}\sec\theta$

$\tau_{F_B} = \tau_{mg}$ (About hinged)

$\Downarrow$

$\left[F_B\left(\frac{h}{\cancel{2}}\sec\theta\right)\right]\cancel{\sin\theta} = mg\frac{L}{\cancel{2}}\cancel{\sin\theta}$

$F_B h\sec\theta = mgL$

$\Downarrow$

$\left[(L_{AB})\cancel{A}\rho_L \cancel{g}\right]h\sec\theta = (\cancel{A}L^2)\rho_s \cancel{g}$

$\Downarrow$

$(h\sec\theta)(h\sec\theta) = L^2\left(\frac{\rho_s}{\rho_L}\right)$ 0.5

$h^2\sec^2\theta = \frac{L^2}{2}$

$\theta = 45°$

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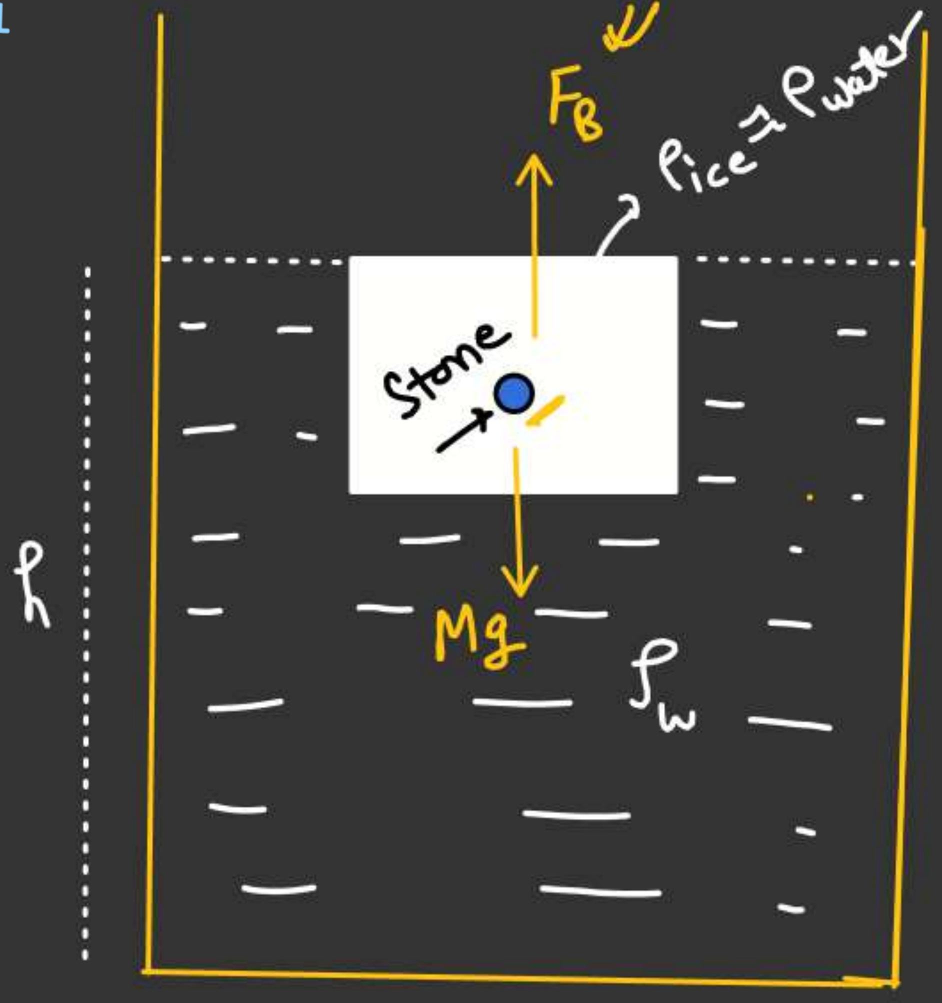

When ice cube melt, level of water ??

$$M = (m_{ice} + m_{stone})$$

$$F_B = Mg.$$

$$\underline{V}\,\rho_w \cancel{g} = (m_{ice} + m_{stone})\cancel{g}$$

$$V_i = \left[\frac{m_{ice}}{\rho_w} + \frac{m_{stone}}{\rho_w}\right]$$

$V =$ Volume of ice cube.

$V_i \rightarrow$ liquid displaced.

$$\rho_{stone} > \rho_w$$

$$V_f < V_i$$

$\Rightarrow$ Level of liquid decrease.

After Melting of ice Cube

Volume of water due to melting of ice $= \dfrac{m_{ice}}{\rho_{water}}$

Volume of water displaced when Stone sink $= \dfrac{m_{stone}}{\rho_{stone}}$

$$\underline{\underline{V_f}} = \left(\frac{m_{ice}}{\rho_{water}} + \frac{m_{stone}}{\rho_{stone}}\right)$$

$\Downarrow$

Final Volume of liquid displaced

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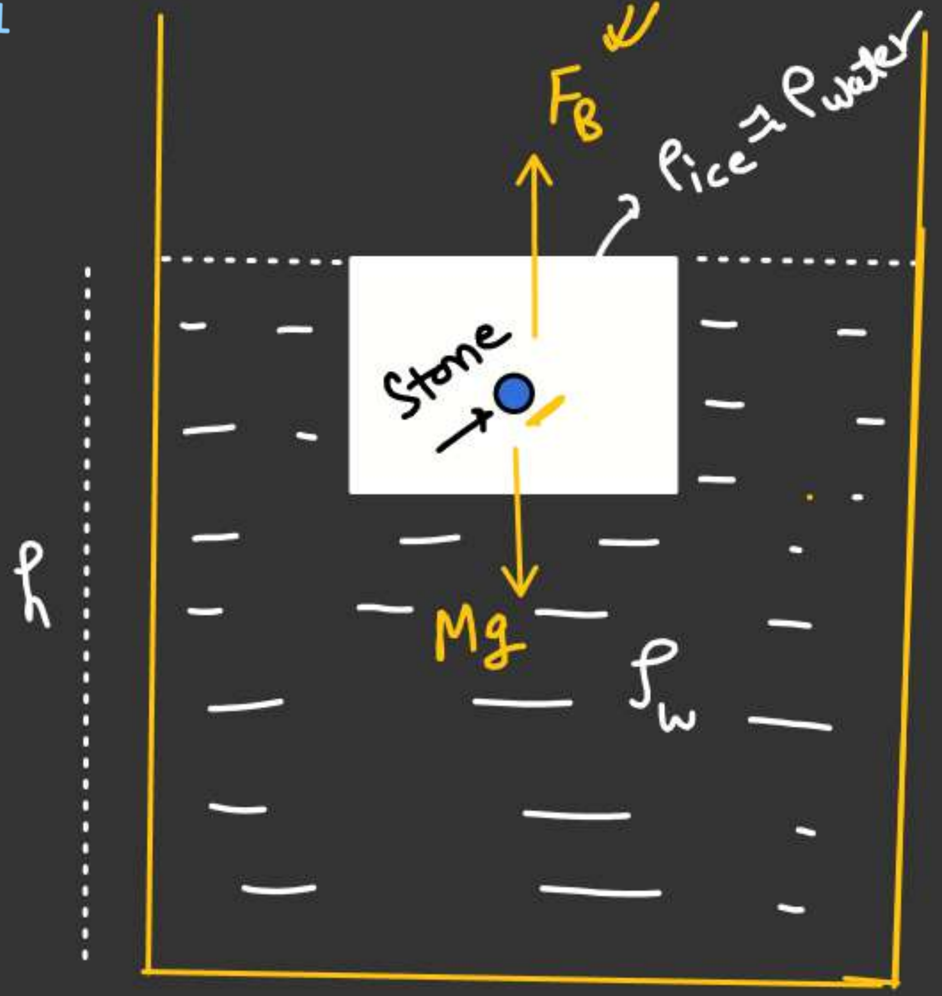

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$$F_B = Mg$$

$$V \rho_w \cancel{g} = (m_{ice} + m_{stone}) \cancel{g}$$

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$\Downarrow$

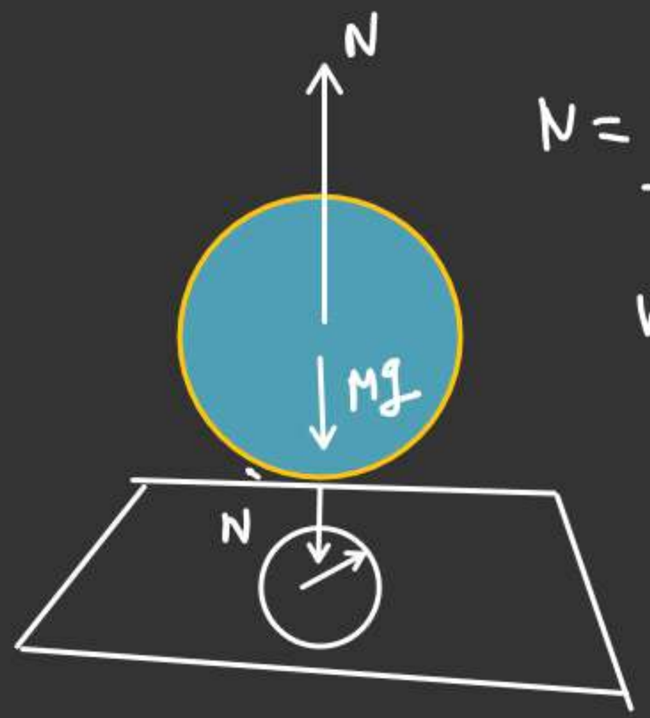
Final Volume of liquid displaced

$$\rho_{stone} > \rho_w$$

$$V_f < V_i$$

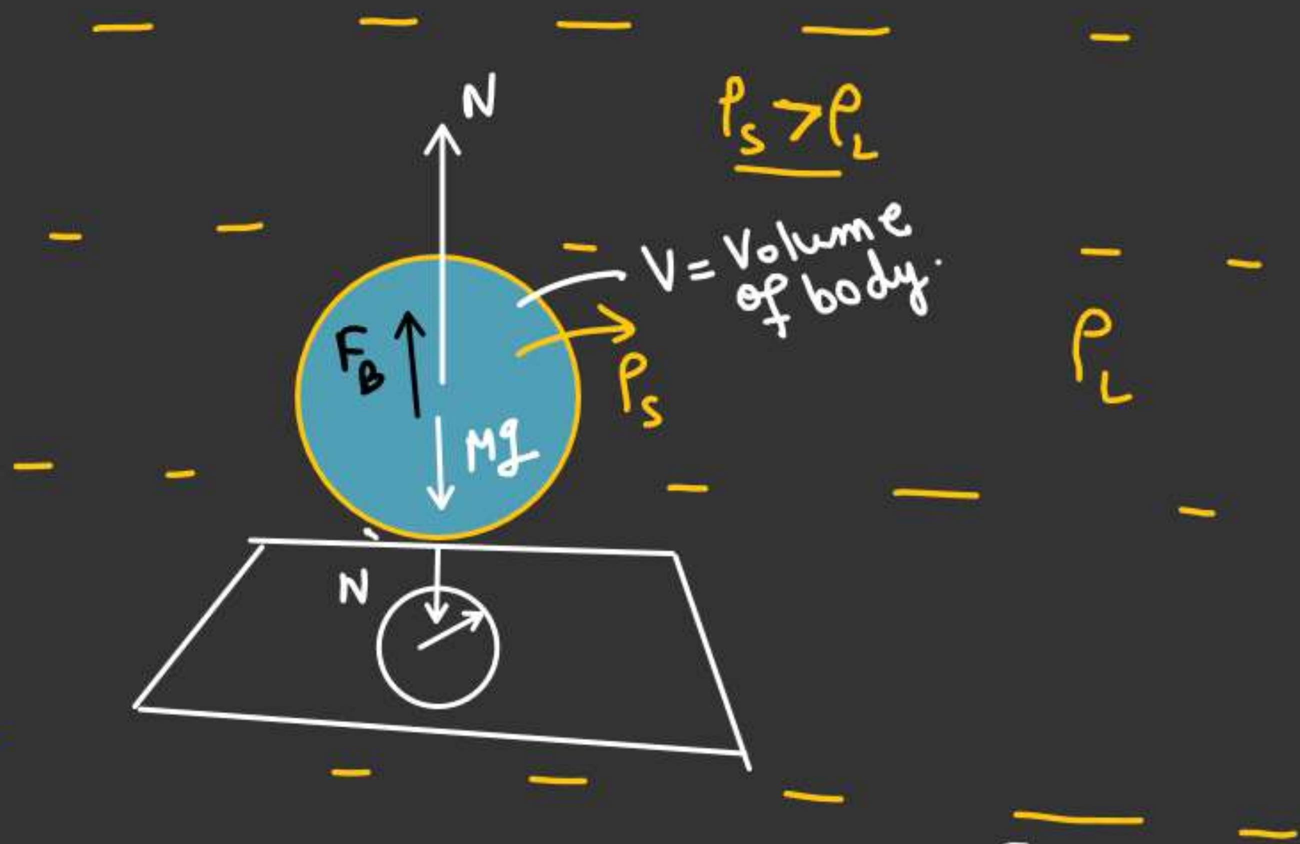
$\Rightarrow$ Level of liquid decrease.

Concept of Apparent weight



$N = \underline{Mg}$

Real weight



$$\boxed{W_{app} = W_{real}\left(1 - \frac{\rho_L}{\rho_s}\right)}$$

$$F_B + N = Mg$$

$$N = Mg - F_B$$

$$\underline{N} = \underline{\underline{Mg}}\left(1 - \frac{F_B}{Mg}\right)$$

$$W_{app} = W_{real}\left(1 - \frac{\rho_L}{\rho_s}\right)$$

$F_B = V \rho_L g$

$M = V \rho_s$

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Note :-

[In acclerated frame while writing F_B take g_{eff}]

T_0 be the tension in the string when elivator at rest.

Find $T = ?$ when elivator acclerating with constant acc leration $a \cdot m/s^2$

At Equilibrium when $a=0$

$$F_B = T_0 + mg$$

$$T_0 = (F_B - mg)$$

$$m = V\rho_s$$

$$T_0 = mg\left(\frac{F_B}{mg} - 1\right)$$

$$T_0 = mg\left(\frac{\rho_L}{\rho_s} - 1\right)$$

At Equilibrium when elivater acclerating upward.

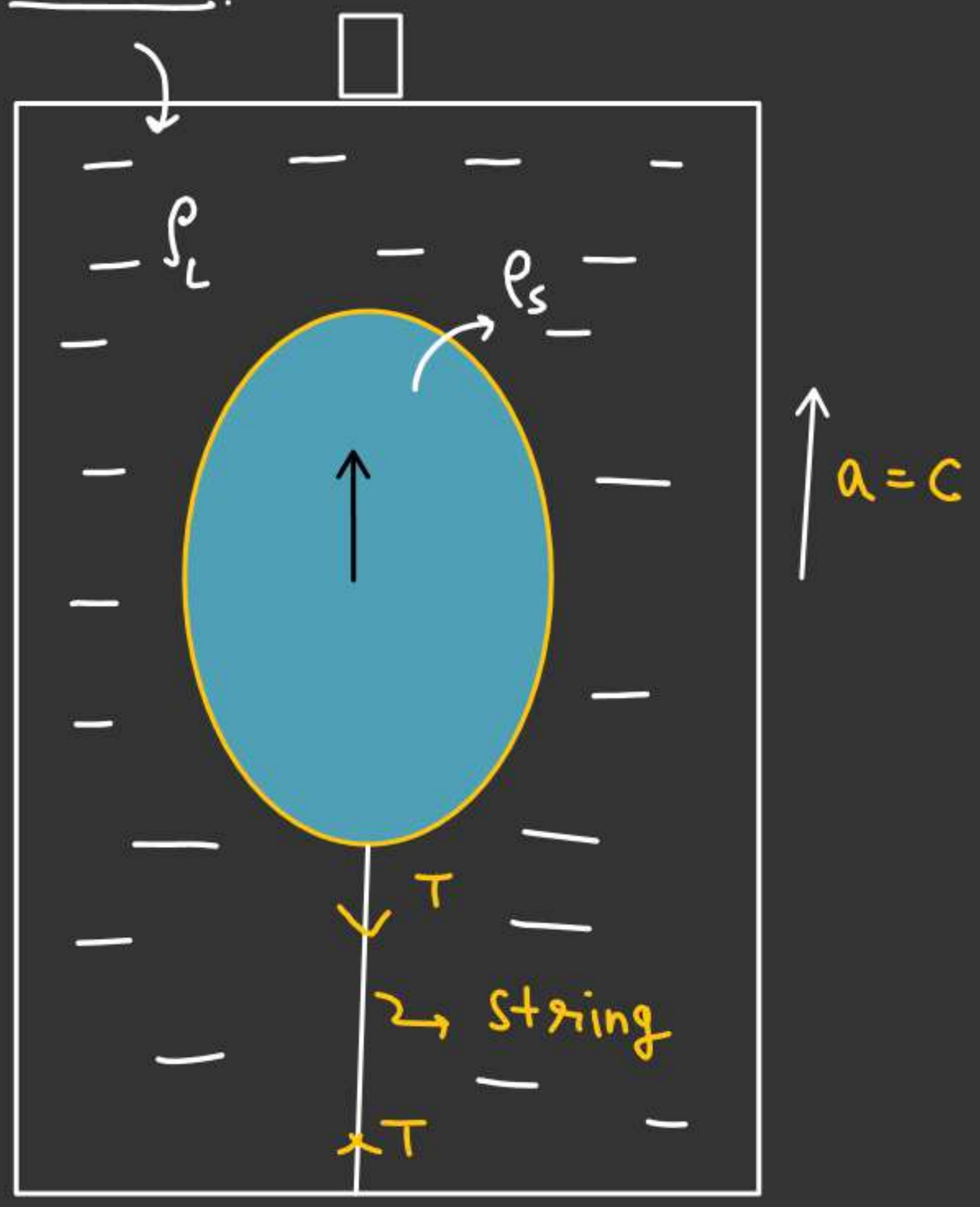
$$F_B' = m(g+a) + T$$

$$V\rho_L(g+a) - V\rho_s(g+a) = T$$

$$T = V(g+a)\rho_s\left(\frac{\rho_L}{\rho_s} - 1\right)$$

$$T = m(g+a)\left(\frac{\rho_L}{\rho_s} - 1\right) \quad 2$$

$\rho_s < \rho_L$



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$$T_0 = mg\left(\frac{\rho_L}{\rho_S} - 1\right)$$

$$T = m(g+a)\left(\frac{\rho_L}{\rho_S} - 1\right)$$

$$\frac{T}{T_0} = \frac{g+a}{g}$$

$$\boxed{T = T_0\left(1 + \frac{a}{g}\right)}$$