Nishant Jindal

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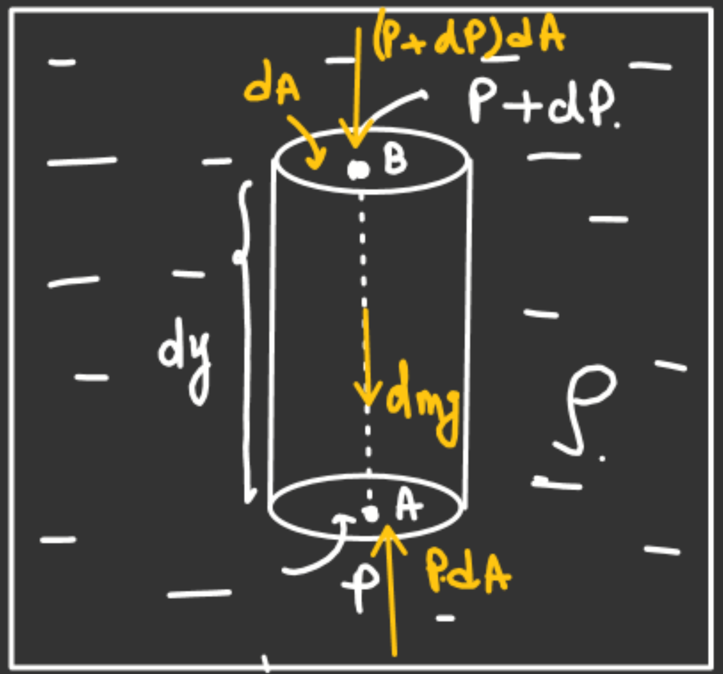
Fluid Static

** Pressure difference



Fluid is static.
force balance in defferential liquid Column

$$(P+dP)dA + dmg = P\,dA$$

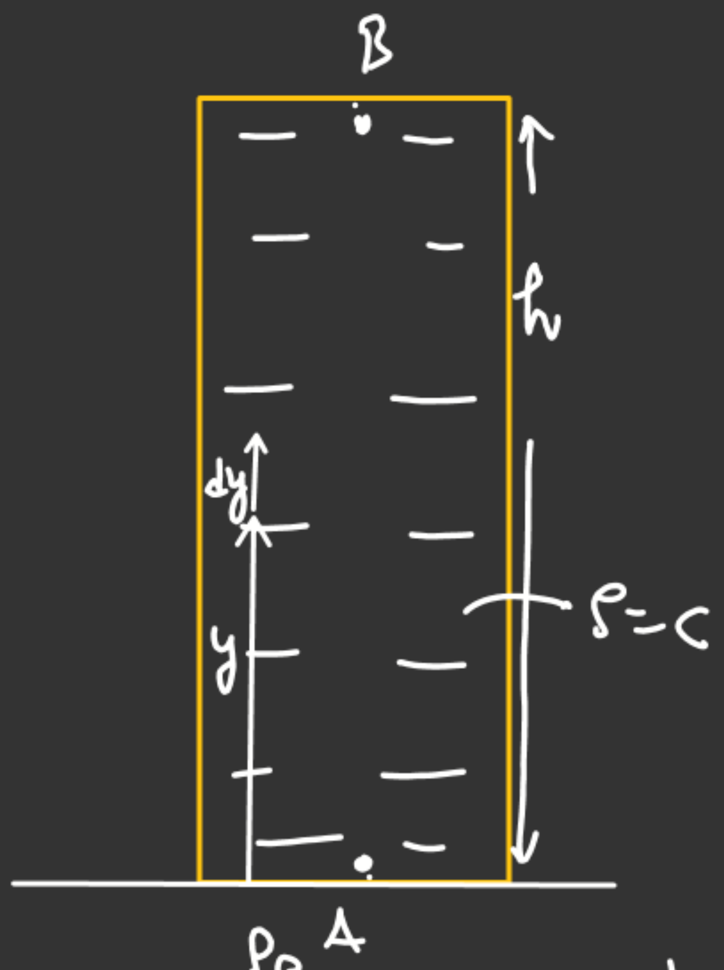
$$dm = (\rho\, dA\, dy)$$

$$\cancel{P dA} + dP.dA + \rho \cancel{dA}.dy = \cancel{P dA}$$

** $$dP = -\rho g\, dy$$

$$\boxed{\frac{dP}{dy} = -\rho g}$$

** $$\boxed{\frac{dp}{dy} = -\rho a_y}$$



$$\int_{P_A}^{P_B} dP = -\rho g \int_0^h dy$$

$$P_B - P_A = -\rho g h$$

$$\boxed{P_A - P_B = \rho g h.}$$

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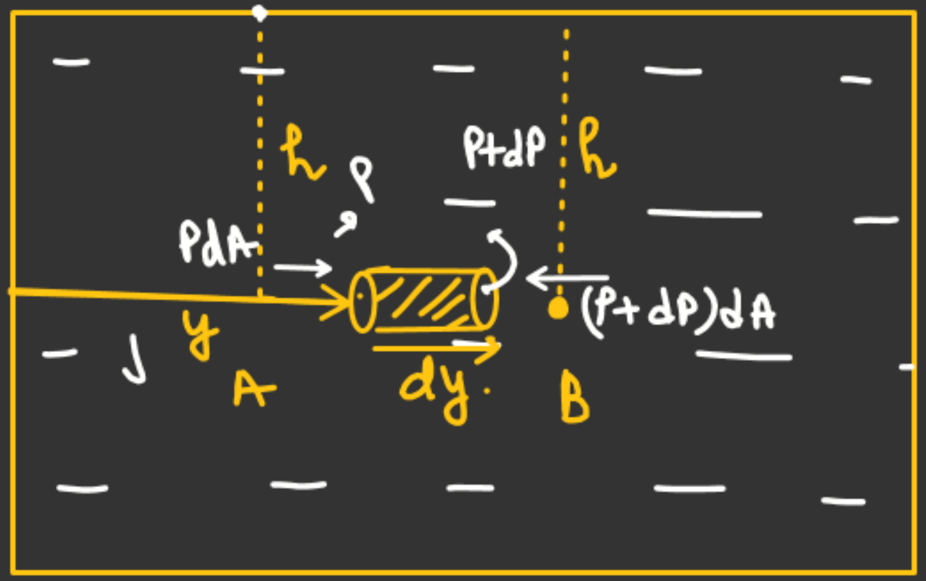
#4 Two point at same horizontal level have same pressure or pressure difference zero.



$$P\,dA = (P + dP)\,dA$$

$$\boxed{dP = 0}$$

$$P_A = P_{atm} + \rho g h$$

$$P_B = P_{atm} + \rho g h$$

$$(P_A = P_B)$$

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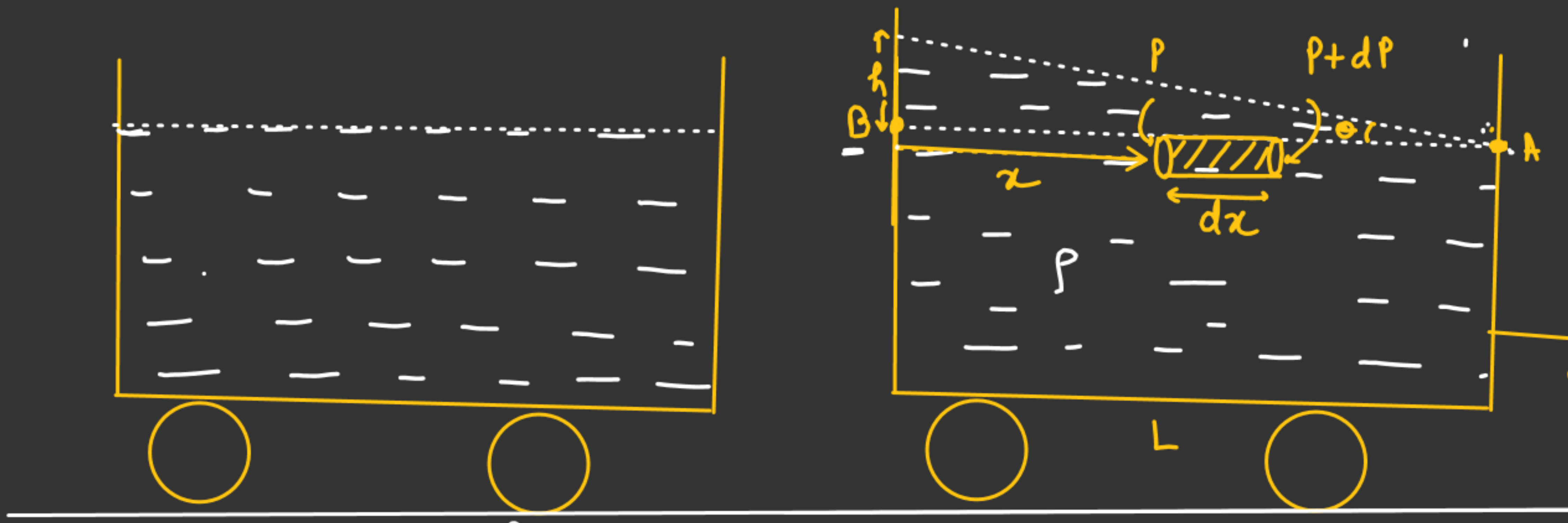
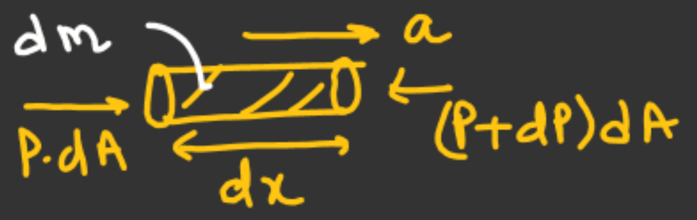
Pressure difference in acclerated frame.



dA = Crossectional Area.



$$PdA - (P+dP)dA = dm\,a$$

$$\cancel{PdA} - \cancel{PdA} - dP\,\cancel{dA} = \rho\, dx\,\cancel{dA}\,a$$

a = c

$$\boxed{-\frac{dP}{dx} = \rho a}$$

$$\boxed{-\frac{dP}{dx} = \rho a_x}$$

$$dm = \rho(dx\,dA)$$

$\Downarrow$

Volume (dV)

$$\int_{P_B}^{P_A} dP = -\rho a \int_0^L dx$$

$$(P_A - P_B) = -\rho a L \Rightarrow P_B - P_A = \rho a L \text{ —(1)}$$

$$P_B = P_{atm} + \rho g h, \quad P_A = P_{atm}$$

$$P_B - P_A = \rho g h \text{ —(2)}$$

$$\rho a L = \rho g h$$

$$\boxed{\frac{a}{g} = \frac{h}{L} = \tan\theta.}$$

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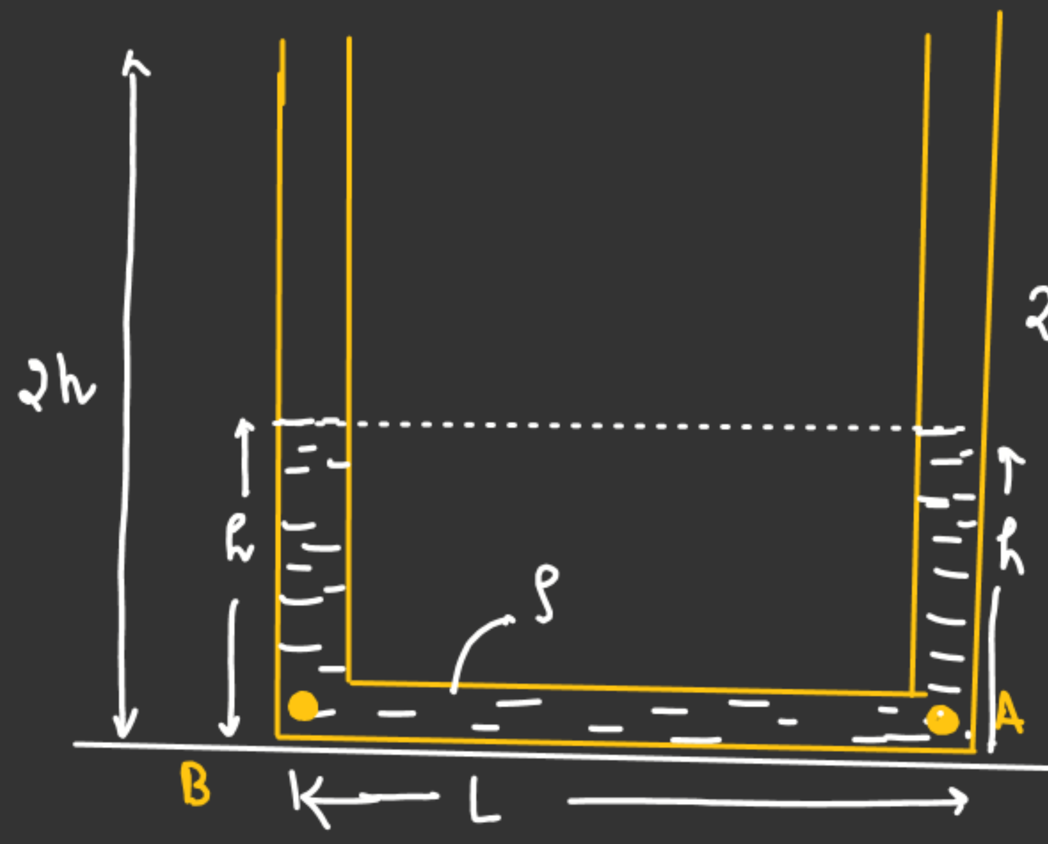
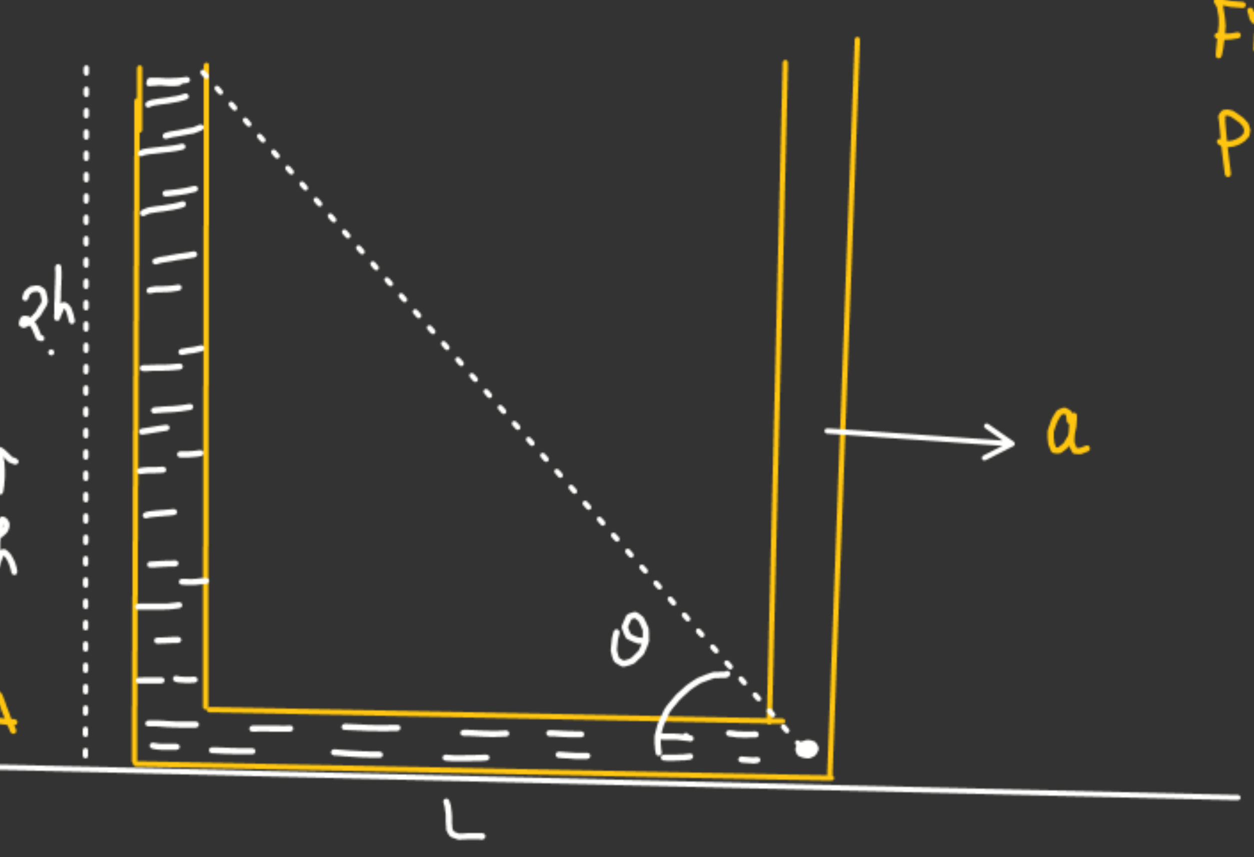
Find a_{min} so that pressure at A become. P_{atm}.





$P_A = P_{atm} + \rho g h$

$P_B = P_{atm} + \rho g h$

$P_A = P_B$

$\tan\theta = \frac{a}{g} = \frac{2h}{L}$

$a = \left(\frac{2gh}{L}\right)$ (min)

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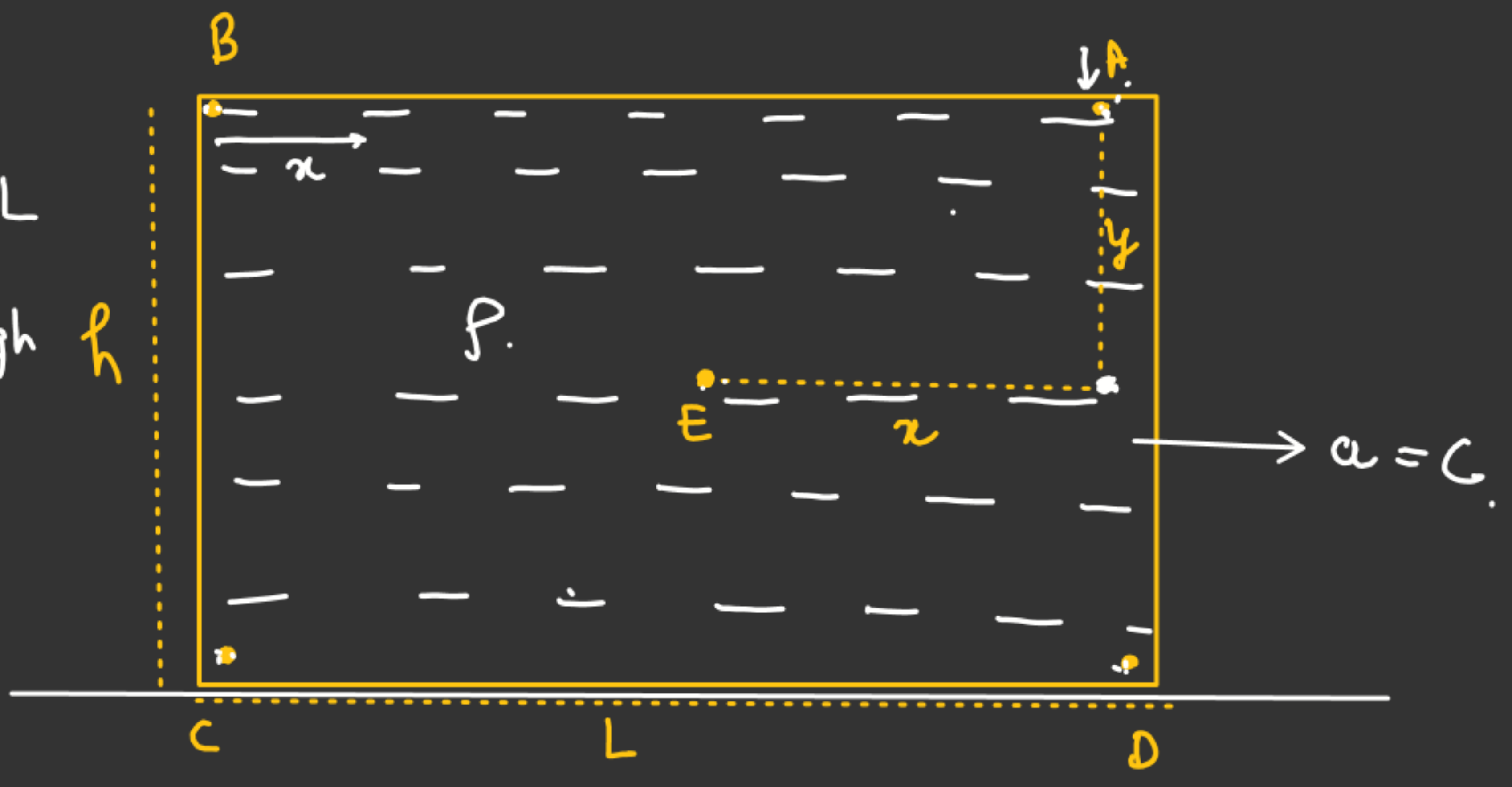
$P_A = P_{atm}$

$P_B = P_A + \rho a L = P_{atm} + \rho a L$

$P_C = P_B + \rho g h = P_{atm} + \rho a L + \rho g h$

$P_D = P_{atm} + \rho g h$

$P_E = P_{atm} + \rho g y + \rho a x$



$$-\frac{dP}{dx} = \rho a_x = \rho a$$

$$-\int_{P_B}^{P_A} dP = \rho a \int_0^L dx$$

$$\underline{P_B - P_A = \rho a L}$$

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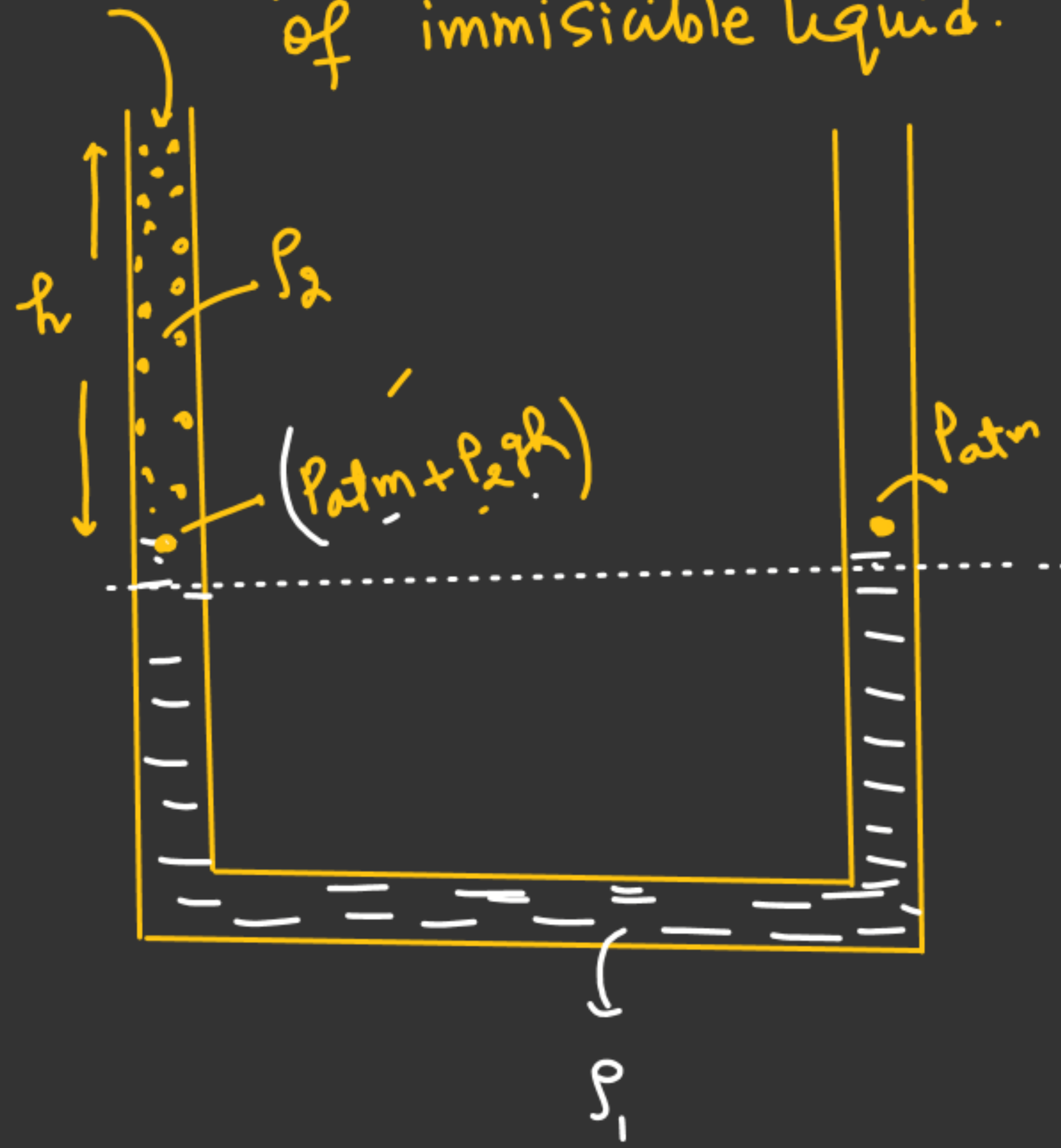
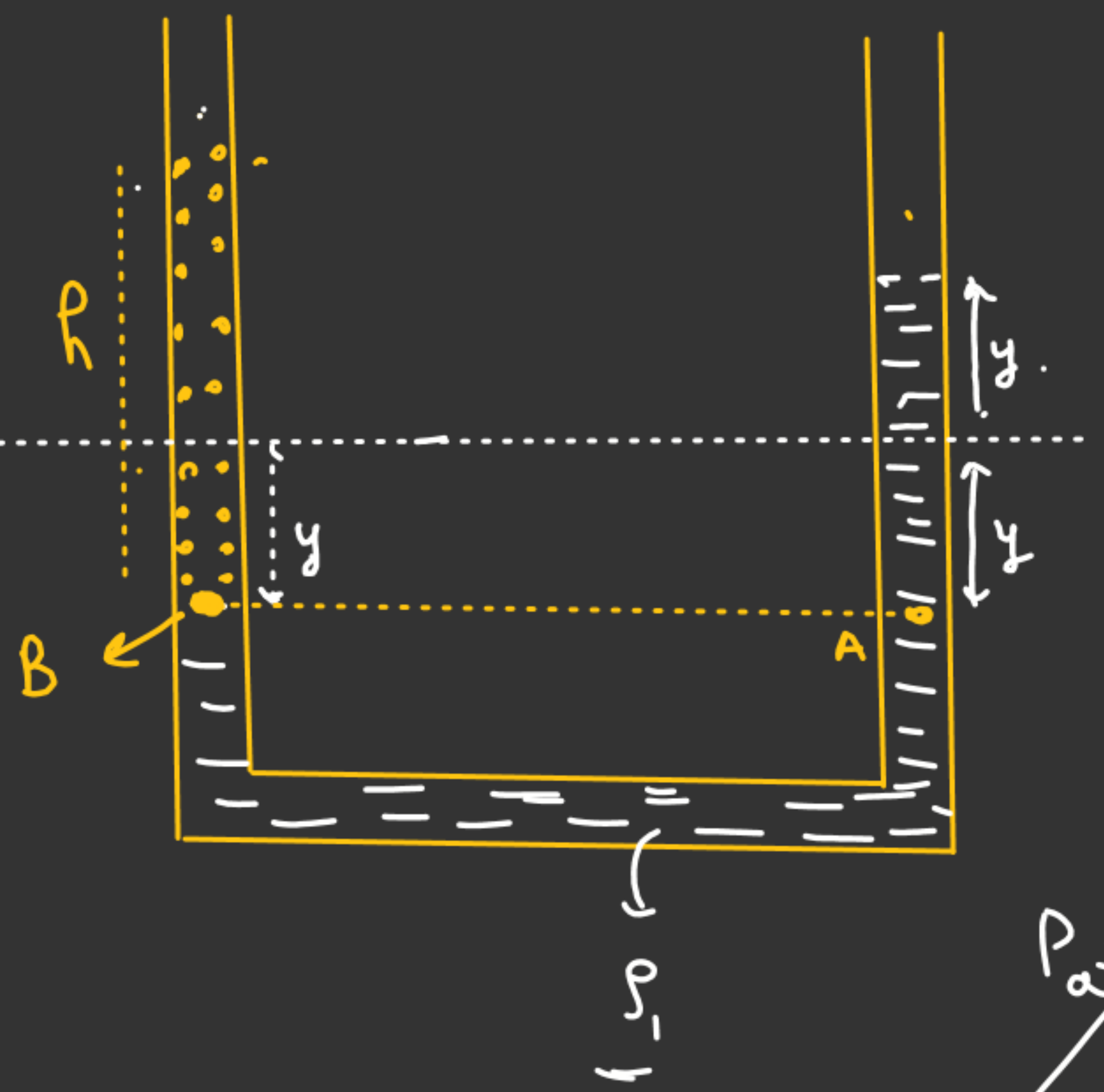
ρ_1 & ρ_2 densities of immisicible liquid.



At Equilibrium



$P_A = P_B$ (At Equilibrium)

$$\cancel{P_{atm}} + \rho_1 g 2y = \cancel{P_{atm}} + \rho_2 g h.$$

$$\left(y = \frac{\rho_2 h}{2\rho_1} \right) ✓$$

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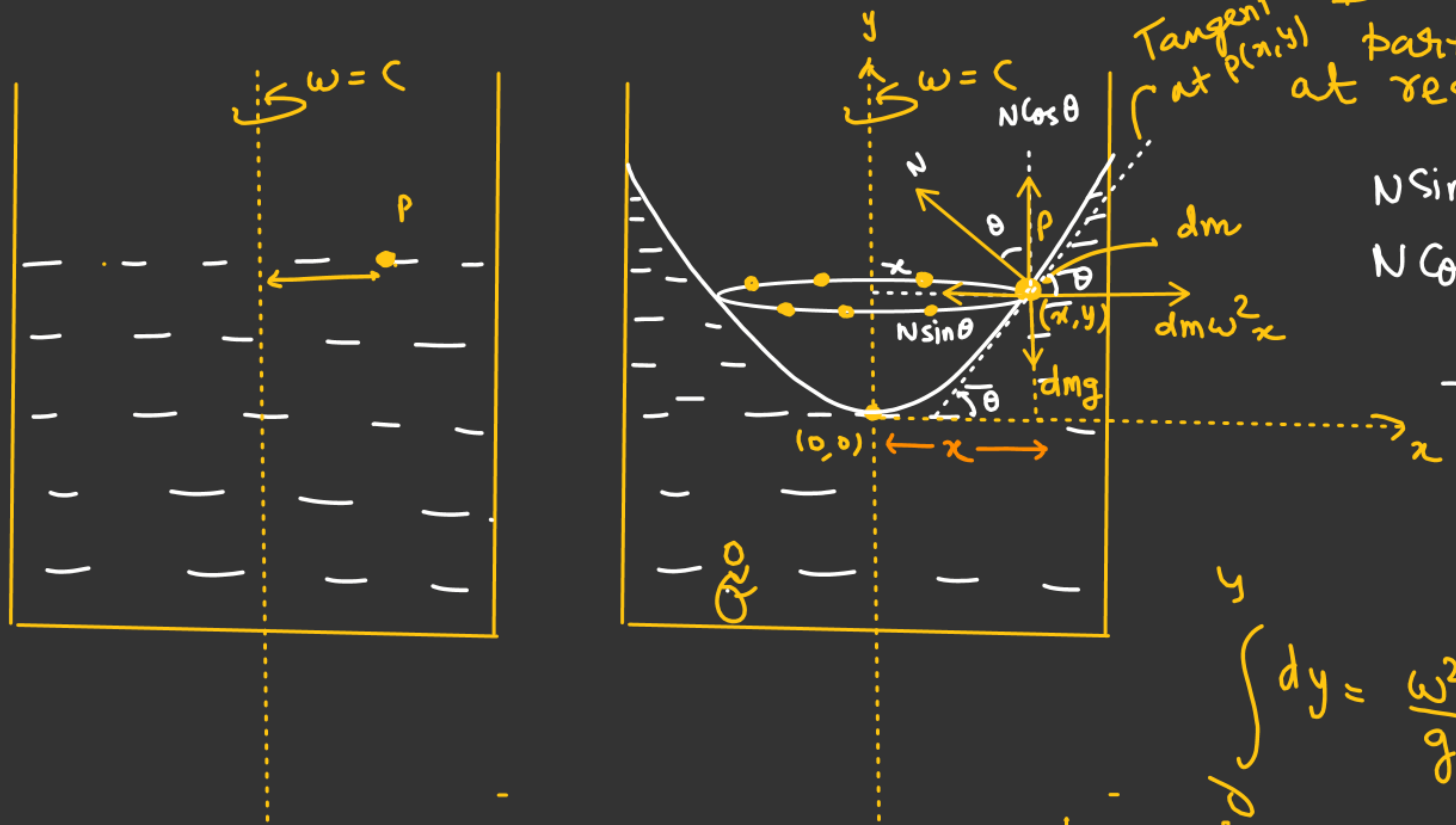
Pressure gradient in rotating frame.



In Rotating frame. particle P of dm mass. at rest.

$$N\sin\theta = dm\omega^2 x.$$

$$N\cos\theta = dm\, g$$

$$\tan\theta = \frac{\omega^2 x}{g}.$$

$$\frac{dy}{dx} = \frac{\omega^2 x}{g}$$

$$\int_0^y dy = \frac{\omega^2}{g}\int_0^x x\,dx$$

$$\boxed{y = \frac{\omega^2 x^2}{2g}}$$

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Pressure gradient in rotating frame.

$$P = \underline{P_{atm}} + \rho g y$$

$$\frac{dP}{dx} = 0 + \rho g\left(\frac{dy}{dx}\right)$$

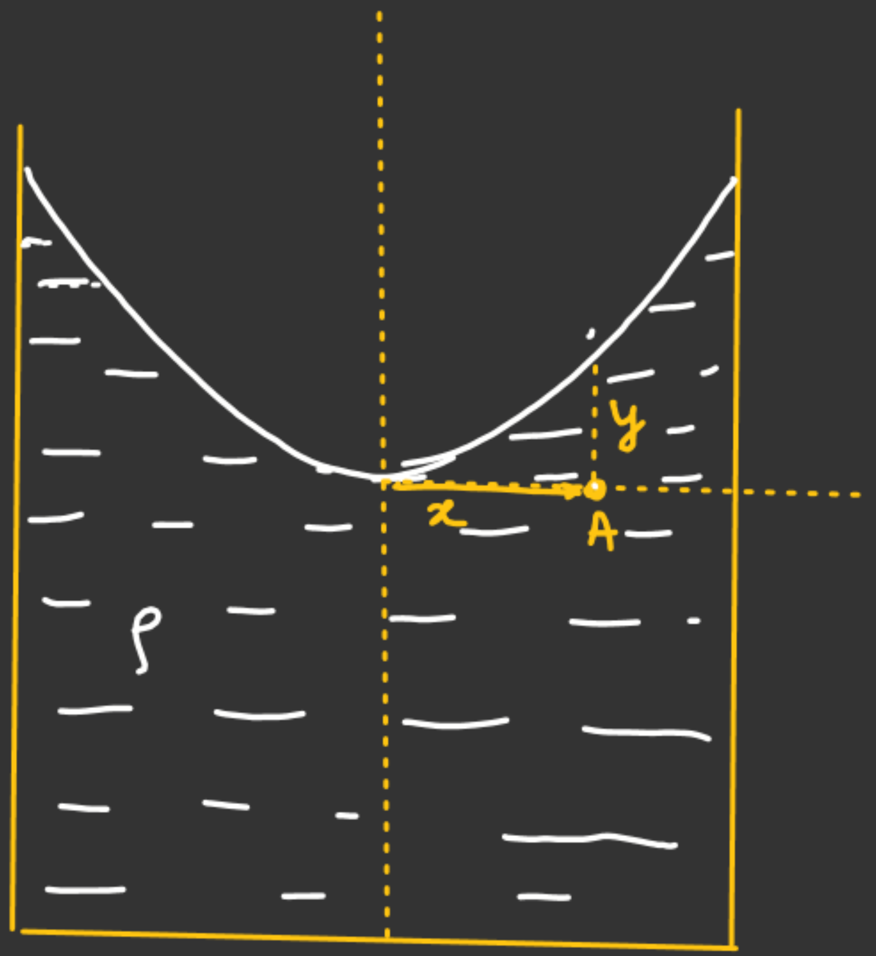
$$\frac{dP}{dx} = \frac{\rho \cancel{g} \omega^2 x}{\cancel{g}}$$

$$\boxed{\frac{dP}{dx} = \rho\omega^2 x}$$

$$\boxed{y = \frac{\omega^2 x^2}{2g}}$$

$$\frac{dy}{dx} = \frac{\omega^2}{2g} \times 2x$$

$$\frac{dy}{dx} = \left(\frac{\omega^2 x}{g}\right)$$



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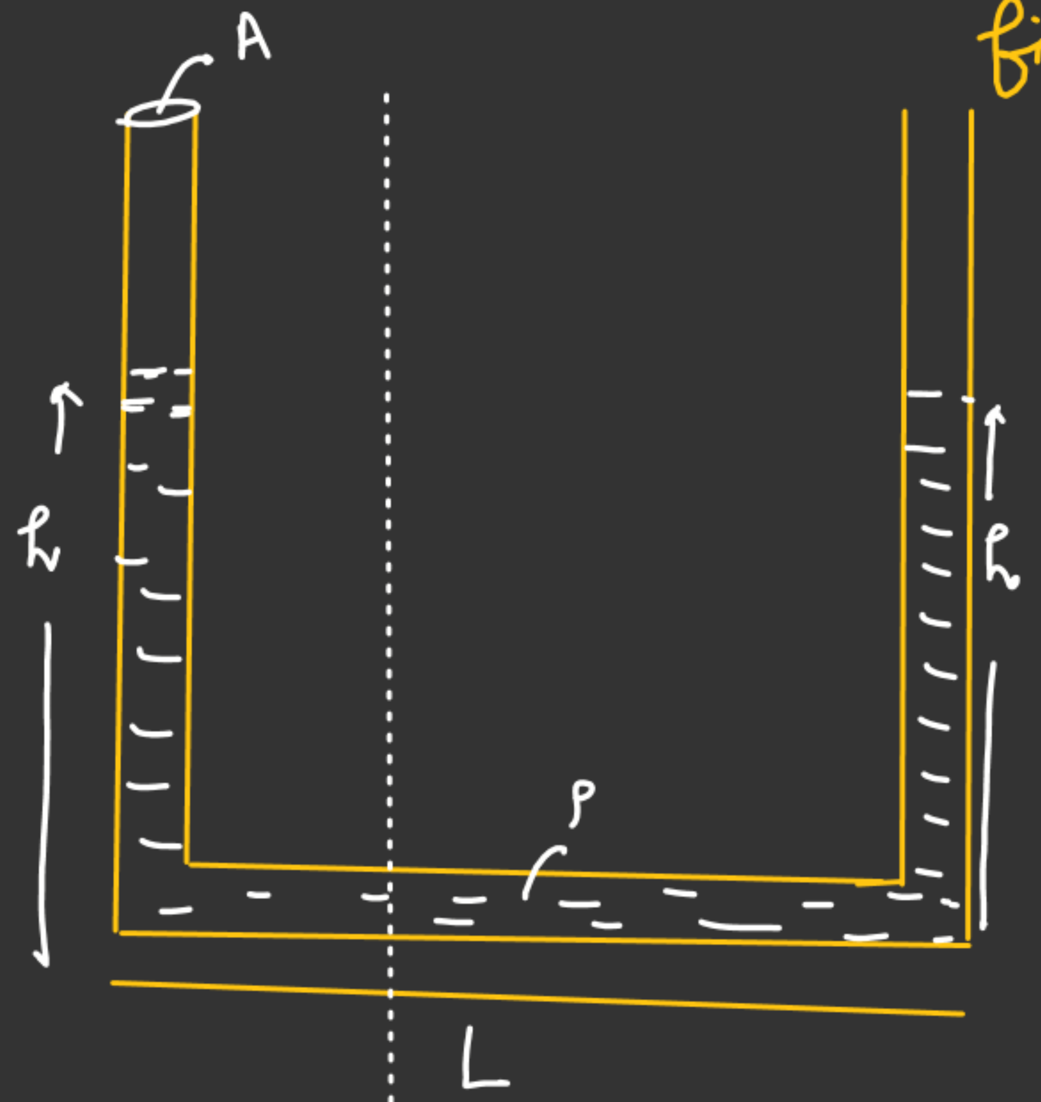
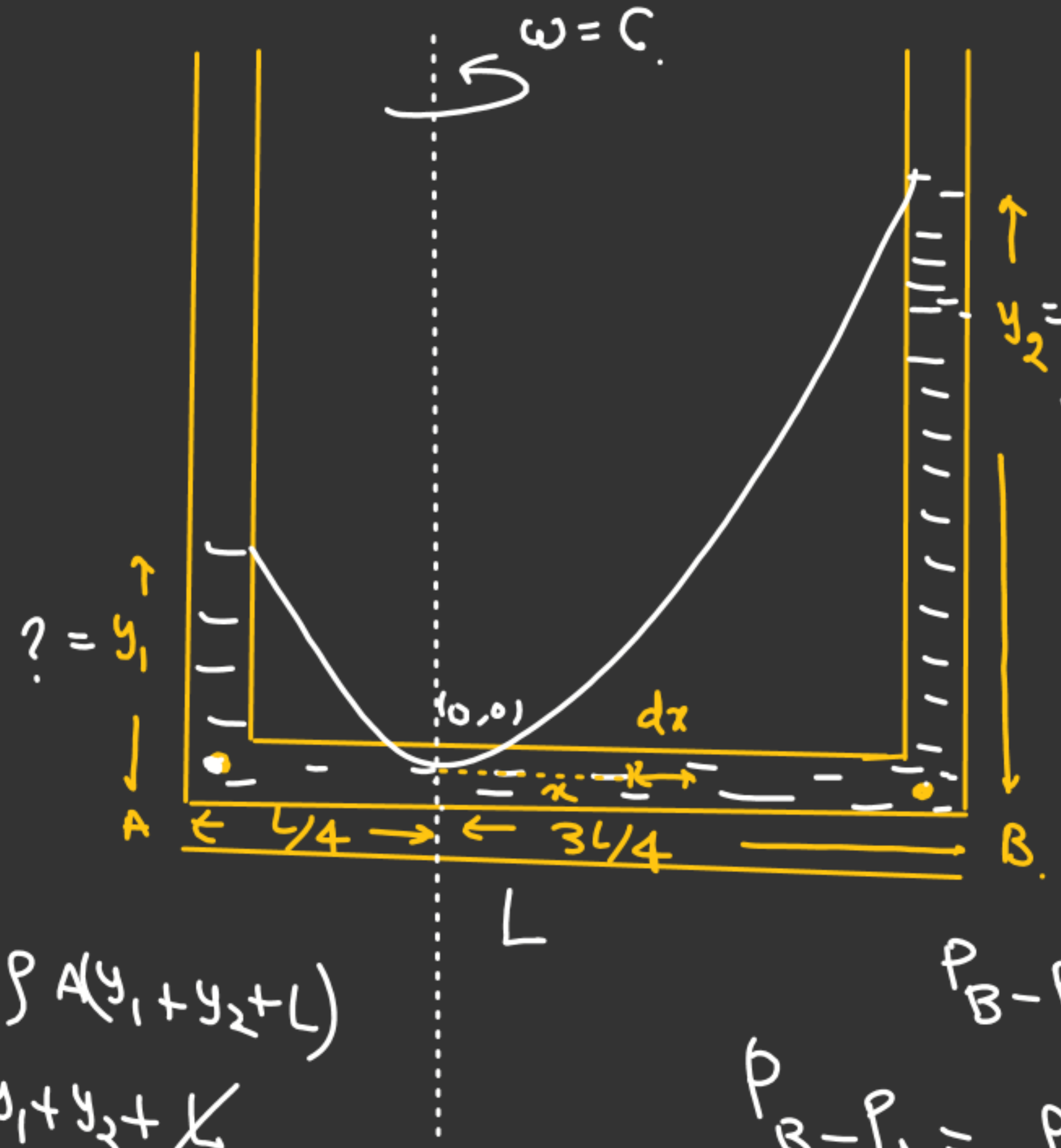
After vessel start rotating with constant ω find height of the liquid in both the limb.





$$2h = y_1 + y_2 \quad — (1)$$

$$(2h+L)A\rho = \rho A(y_1+y_2+L)$$

$$2h+\cancel{L} = y_1+y_2+\cancel{L}$$

Let, dP be the pressure difference

$$\frac{dP}{dx} = \rho\omega^2 x$$

$$\int_{P_A}^{P_B} dP = \rho\omega^2 \int_{-L/4}^{3L/4} x\,dx$$

$$P_B - P_A = \frac{\rho\omega^2}{2}\left[x^2\right]_{-\frac{L}{4}}^{\frac{3L}{4}}$$

$$P_B - P_A = \frac{\rho\omega^2}{2}\left[\frac{9L^2}{16} - \frac{L^2}{16}\right]$$

$$P_B - P_A = \frac{\rho\omega^2}{2}\left[\frac{L^2}{2}\right]$$

$$P_B - P_A = \left(\frac{\rho\omega^2 L^2}{4}\right)$$

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$$2h = y_1 + y_2 \quad \text{—} \quad (1)$$

$$P_B - P_A = \frac{\rho \omega^2 L^2}{4}$$

$$P_B = P_{atm} + \rho g y_2$$

$$P_A = P_{atm} + \rho g y_1$$

$$\cancel{\rho} g (y_2 - y_1) = \frac{\cancel{\rho} \omega^2 L^2}{4}$$

$$y_2 - y_1 = \frac{\omega^2 L^2}{4g} \quad \text{—} \quad (2)$$

$(1) + (2)$

$$2y_2 = \left(2h + \frac{\omega^2 L^2}{4g}\right)$$

$$y_2 = h + \frac{\omega^2 L^2}{8g} \quad ✓$$

$$y_1 = 2h - \left(h + \frac{\omega^2 L^2}{8g}\right)$$

$$y_1 = \left(h - \frac{\omega^2 L^2}{8g}\right) \quad ✓$$

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