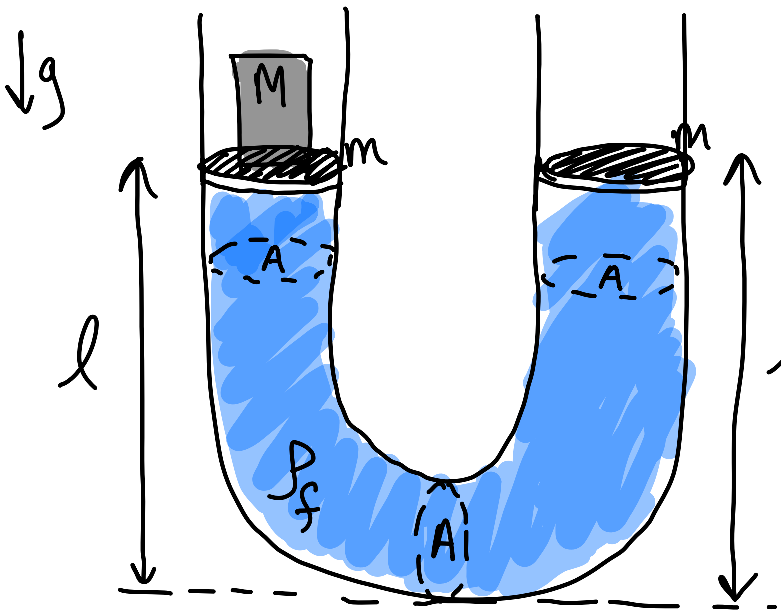
A peculiar way to measure mass:

Discovery: Taaroop

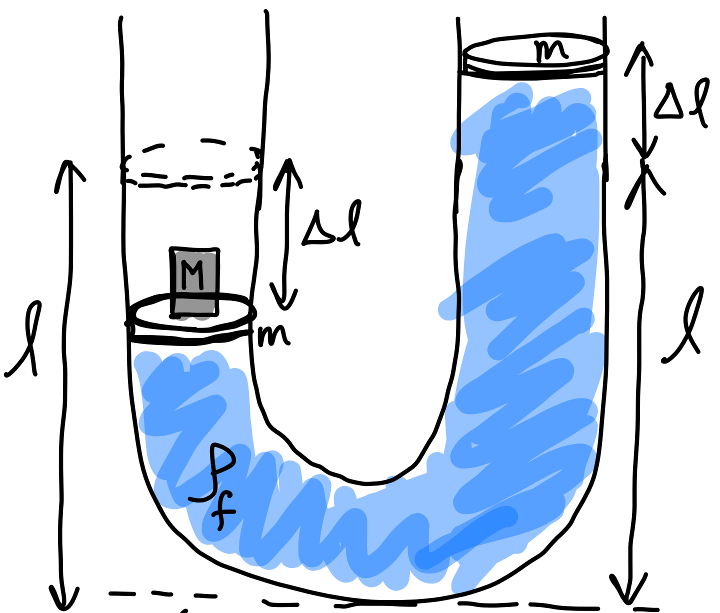
We have a constant-cross section U-shaped vessel containing a fluid of known density $\boxed{\rho_f}$, length of both fluid-filled columns are $\boxed{l}$ and the cross section is $\boxed{A}$.



* We have two identical pistons of tiny thickness and mass m.

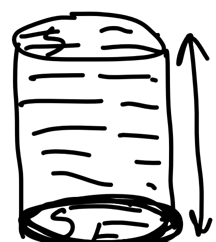
$\Longrightarrow$ We are in an uniform gravitational field (g) and we place a mass M on one of the pistons.

as a result



[The other piston rises by the same amount due to conservation of volume of water].

Quick derivation:



$V = Sh$

$m = \rho V = \rho S h$

$$P = \frac{F}{S} = \frac{mg}{S} = \frac{\rho \cancel{S} h g}{\cancel{S}}$$

$\hookrightarrow$ fluid pressure on bottom surface $= h\rho g$

Now, since the system is in equilibrium, we require a pressure balance at the bottom surface:

From the left hand column:

$$P_{left} = P_{atm} + \frac{mg}{A} + \frac{Mg}{A} + (l - \Delta l)\rho_f g$$

From the right hand column:

$$P_{right} = P_{atm} + \frac{mg}{A} + (l + \Delta l)\rho_f g$$

At equilibrium:

$$P_{left} = P_{right}$$ [This is essentially a force balance, since the cross sectional area is same everywhere]

$$\Rightarrow \cancel{P_{atm}} + \cancel{\frac{mg}{A}} + \frac{Mg}{A} + (l - \Delta l)\rho_f g = \cancel{P_{atm}} + \cancel{\frac{mg}{A}} + (l + \Delta l)\rho_f g$$

$$\Rightarrow \cancel{g}\left(\frac{M}{A} + \cancel{l\rho_f} - \Delta l \rho_f\right) = \cancel{g}\left(\cancel{l\rho_f} + \Delta l \rho_f\right)$$

$$\Rightarrow \frac{M}{A} = 2\Delta l \rho_f$$

$$\therefore \boxed{M = 2\rho_f A \cdot \Delta l}$$

(We require a gravitational field, but we don't need to know its value)

ρ_f: Density of fluid

A: Cross sectional area of U-vessel

Δl: Compression due to the weight of M.