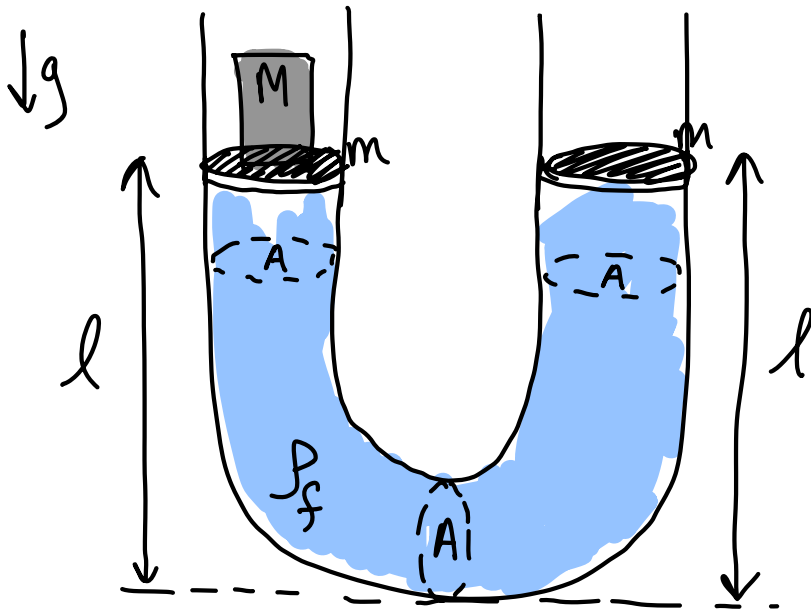


A peculiar way to measure mass:

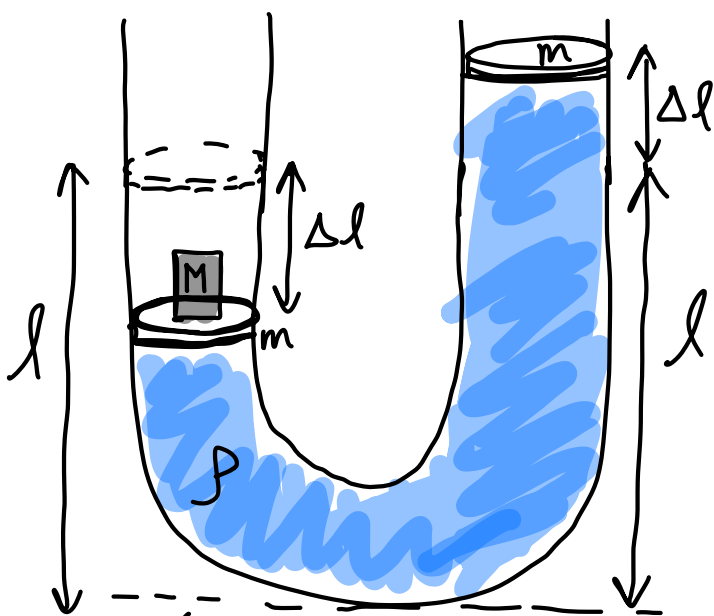
Discovery: Taarop

We have a constant-cross section U-shaped vessel containing a fluid of known density ρ_f , length of both fluid-filled columns are l and the cross section is A .



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

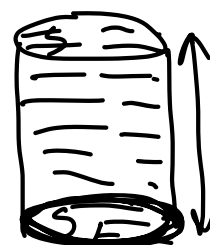
⇒ We are in an uniform gravitational field (g) and we place a mass M on one of the pistons.



← as a result

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

Quick derivation:



$$\begin{aligned} V &= Sh \\ m &= \rho V \\ &= \rho Sh \end{aligned}$$

$$P = \frac{F}{S} = \frac{mg}{S} = \frac{\rho Shg}{S}$$

→ Fluid pressure = $h \rho g$
on bottom surface

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

From the left hand column:

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

From the right hand column:

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

At equilibrium:

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

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

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

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

$$\therefore M = 2 \rho_f A \cdot \Delta l$$

Density
of fluid

Cross
sectional
area of U-vessel

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

compression due to
the weight of M.