Physics 101

Lecture 29

Wed. March 17, 2004

Topics: Pressure

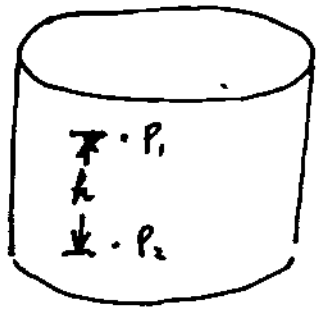
Buoyancy

streamline flow

Ref: 15-1, 2, 3, 4, 5, 6, 7, 8

- Pressure

$P_2 - P_1 = \rho g h$.



e.g: U Tube. same cross section S

given: ρ_1, ρ_2, V_2, S.

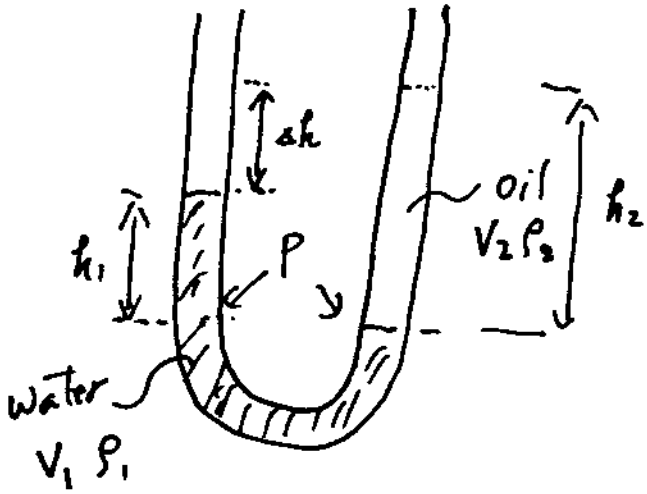
find: Δh.

$V_2 = S \cdot h_2$.

$\rho_2 g h_2 = \rho_1 g h_1 = P - P_{at}$.

$\rho_2 h_2 = \rho_1 h_1$

$h_1 = \frac{\rho_2}{\rho_1} h_2$.

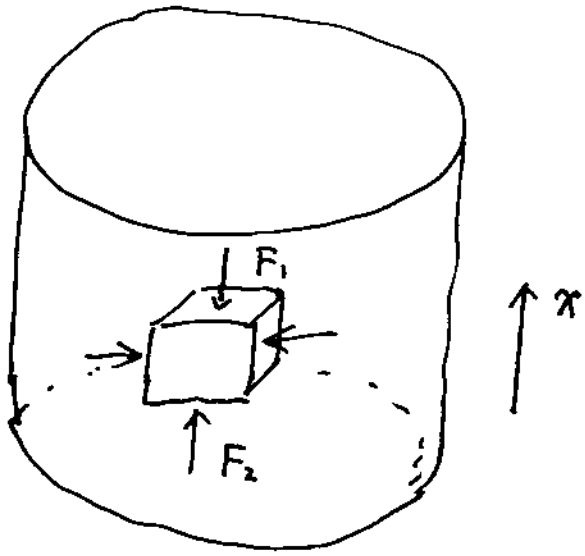


$\Delta h = h_2 - h_1 = h_2 - \frac{\rho_2}{\rho_1} h_2$

$= h_2 \left(1 - \frac{\rho_2}{\rho_1}\right) = \frac{V_2}{S}\left(1 - \frac{\rho_2}{\rho_1}\right)$

• Buoyancy (Floating Force)

B = The fluid exerts a net upward force on the cube



$F_{Lateral} = 0$ (cancelled)

$$\therefore \quad B = F_2 - F_1$$
$$= P_2 A - P_1 A$$
$$= A (P_2 - P_1)$$
$$= A \cdot \rho_l g h$$
$$= \rho_l g V$$

ρ_l — density of the fluid.

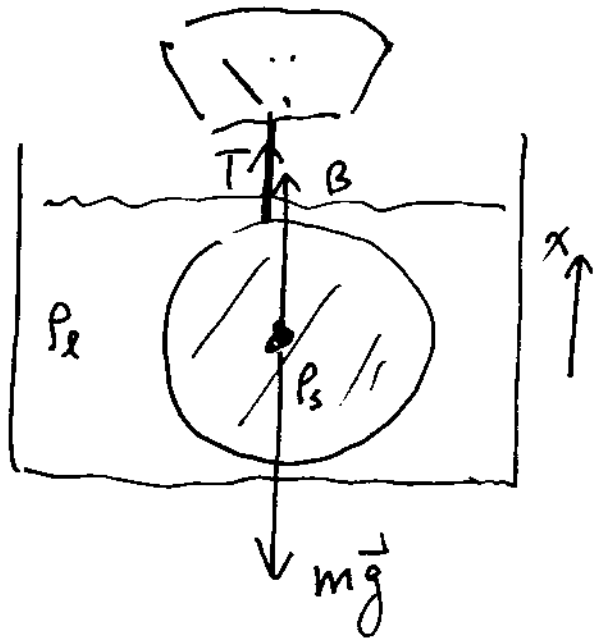
i.e., An object completely immersed in a fluid experiences an upward buoyant force whose magnitude is equal to the weight of fluid displaced by the object.

This is Archimede's Principle:

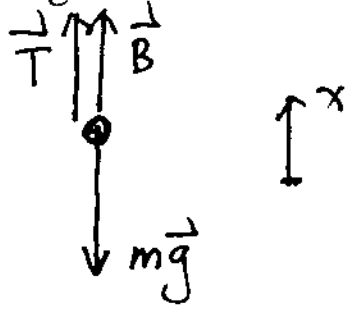
In general, if the object only partly immersed in the fluid, e.g. if a volume V is submerged in the fluid, then $B = \rho_l \cdot g V$

V — Volume in the fluid.
= Volume of displaced fluid. ✱ Volume of the object.

• e.g. Apparent Weight of a completely immersed object.



Free Body Diagram



$$T + B - mg = 0$$

$$T = mg - B$$

$$= \rho_s V g - \rho_\ell V g$$

$$= \rho_s V g \left(1 - \frac{\rho_\ell}{\rho_s}\right)$$

$$= mg \left(1 - \frac{\rho_\ell}{\rho_s}\right)$$

e.g.: A ball weighs 70 N in air and 20 N in water. What is its average density?

[solution]: $mg = 70\,N$, $\rho_\ell = 1000\ kg/m^3$

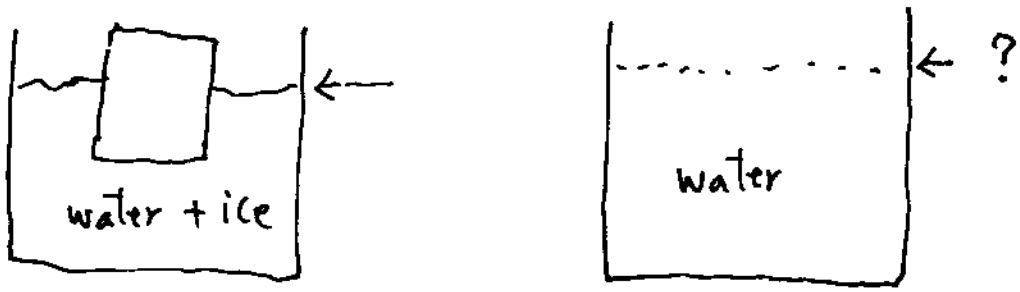
$T = 20\,N$, $\rho_s = ?$

$$T = mg\left(1 - \frac{\rho_\ell}{\rho_s}\right). \qquad \frac{T}{mg} = 1 - \frac{\rho_\ell}{\rho_s}$$

$$\rho_s = \frac{\rho_\ell}{1 - \frac{T}{mg}}$$

$$= \frac{1000}{1 - \frac{20}{70}} = 1400\ kg/m^3$$

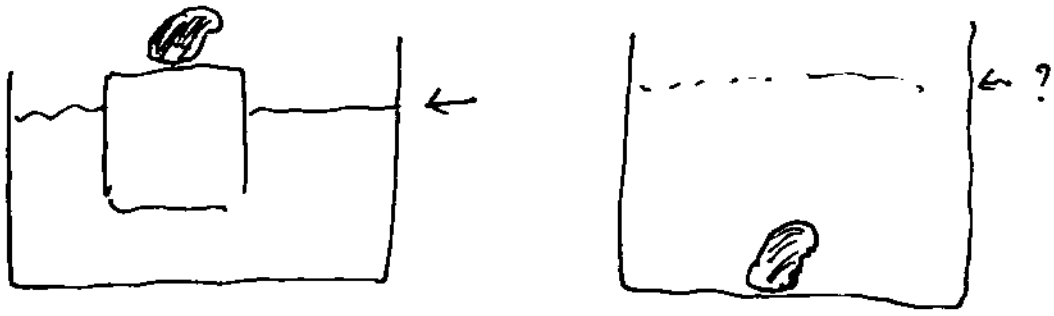
e.g.: Ice floating in water (p. 480-481)



If ice melts,
will the water level drop ? rise ? OR unchanged ?

Answer: unchanged.

What if there was a stone on the top of ice ?



Then, the water level will drop !

Why ?

A similar question: A boat in a pool