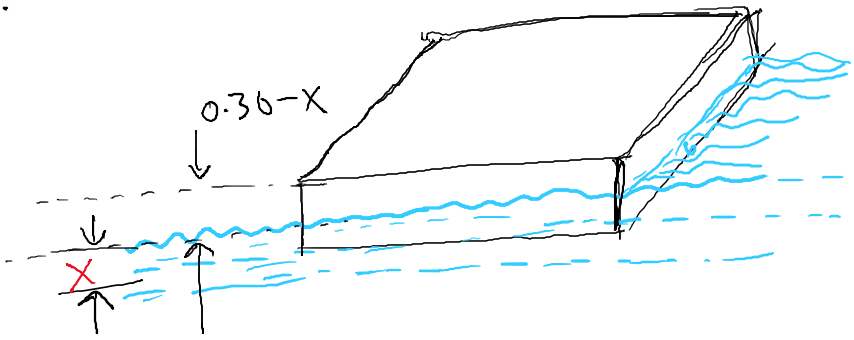
Review Class Problems
Friday, 29th Sep 2017

1. A wooden raft with dimensions of 5 x 4 m and thickness 30 cm is floating on water. How much of the raft is under water? (Density of wood = 500 kg/m3; Density of water = 1 gm/cc)

Buoyancy balances weight.




Volume of water displaced $= (5 \times 4 \cdot x)$

Force Balances

$$(5 \times 4 \times x)\rho_{water} g = (5 \times 4 \times 0.30)\rho_{wood} g$$

$$x = \frac{0.30\,\rho_{wood}}{\rho_{water}}$$

$$x = 0.30 \times \frac{500}{1000} = 0.15 \text{ m}$$

2. Show through calculations why a water barometer is not used in practical situations?

$P_{atm} = \rho_{water} g h$

$h$ = height of liquid column calibrated for $P_{atm}$.

$$h = \frac{P_{atm}}{\rho_{water} \times g} = \frac{103{,}000\ N/m^2}{1000 \times 9.8} \simeq 10.5\ m$$

very high column needed (impractical)

3. Explain how a hydrometer can be used by a food engineer to detect problems in a brewing/wine making industry?

→ To measure the density or specific gravity of the fluid.

Fluid density of food/drinks is an important property to monitor for quality control of food production.

4. Solve Problem 2B.4 from the textbook BSL. (Problem asks about laminar slit flow with a moving wall also known as "plane Couette Flow").

The shell momentum balances for this situation is exactly same as the test problem (refer to the test problem solution)

So, we use the equation

$$\tau_{xz} = \left(\frac{P_0 - P_L}{L}\right)x + C_1$$

Boundary conditions

$x = B$, $v_z = V_0$ (wall is moving with speed $V_0$)

$x = -B$, $v_z = 0$

$$-\mu \frac{dv_z}{dx} = \left(\frac{P_0 - P_L}{L}\right)x + C_1$$

$$v_z = -\left(\frac{P_0 - P_L}{2\mu L}\right)x^2 - \frac{C_1}{\mu}x + C_2$$

$$C_1 = -\frac{\mu V_0}{2B}$$

$$\tau_{xz} = \left(\frac{P_0 - P_L}{L}\right)x - \frac{\mu V_0}{2B}$$

Using $v_2 = 0$ at $x = -B$

$$C_2 = \left(\frac{P_0 - P_L}{2\mu L}\right) B^2 + \frac{v_0}{2}$$

$$v_2 = \left(\frac{P_0 - P_L}{2\mu L}\right) B^2 \left[1 - \left(\frac{x}{B}\right)^2\right] + \frac{v_0}{2}\left(1 + \frac{x}{B}\right)$$