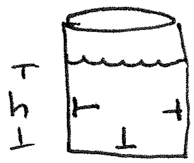
AP Physics Review

Fluid Mechanics

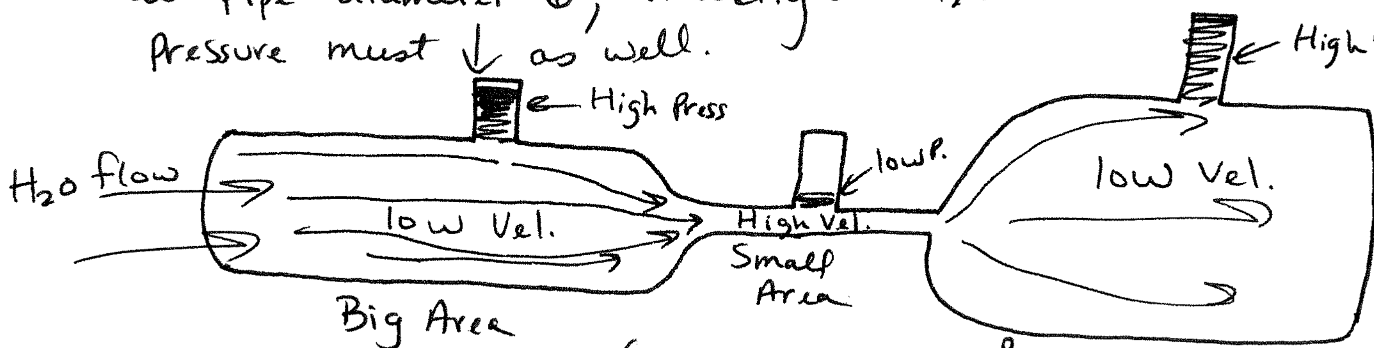
- Fluids exert pressure in all directions (fluids include liquids & Gases)
- Fluids @ rest exert a force ⊥ to The Surface upon which They rest. (including walls) eg:



$$\Delta \text{Pressure} = \rho_{liquid}\, g\, h = \frac{\text{Force}}{\text{Area}}$$ (ρ = density)

- Bernoulis law: Pressure of a flowing liquid (or gas) is low where Velocity is high.
- Flowrate equation: $\text{Area}_1 \text{Velocity}_1 = \text{Area}_2 \text{Velocity}_2$ So That as the diameter of a pipe carrying fluid decreases, the Velocity of the water in The pipe must increase!

Couple This w/ Bernouli and you should see That as pipe diameter ↓, Velocity of H_2O ↑ and so pressure must ↓ as well.

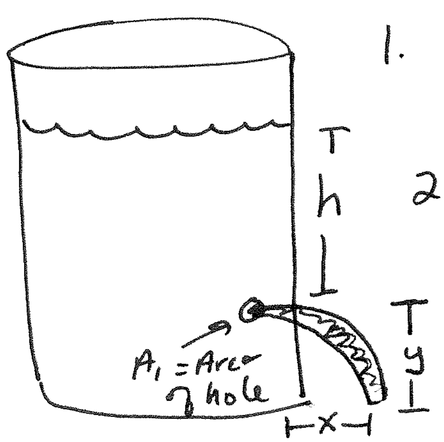


(Fig 9.20 p. 318)

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$ (usually $\rho_1 = \rho_2$ because liquid doesn't change)

Application Problem:

3. Velocity out of hole $= \sqrt{2gh}$



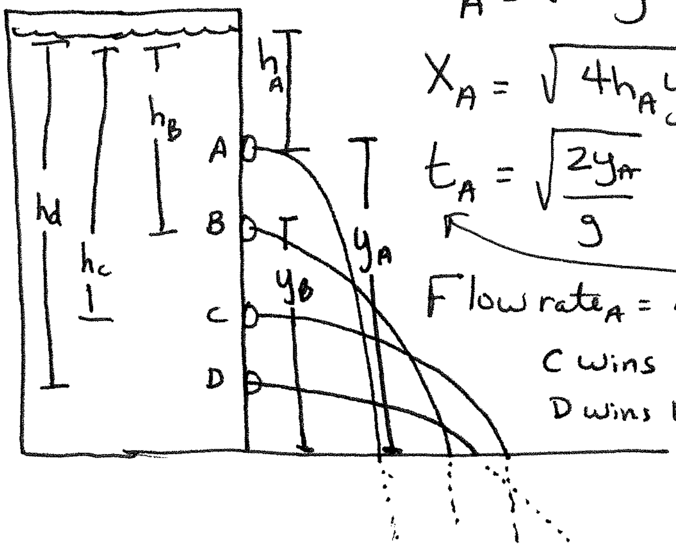
1. Flow rate out of hole:
   Flow rate $= A_1 V_1 = A_1 \sqrt{2gh} = \frac{m^3}{sec}$ (units)
2. How far will it go in x direction?
   $y = \frac{1}{2} g t^2$ solve for t $\boxed{t = \sqrt{2y/g}}$

   $x = V_1 t = V_1 \sqrt{\frac{2y}{g}} = \sqrt{2gh \cdot \frac{2y}{g}} = \boxed{\sqrt{4hy}}$

That's Gold Jerry! Pure Gold!

AP Physics Review
Fluids

Application #2



$V_A = \sqrt{2gh_A}$

$X_A = \sqrt{4h_A y_A}$ ← distance of hole A to surface

$t_A = \sqrt{\frac{2y_A}{g}}$ ← time for water from A to hit ground

Flow $rate_A = Area_A V_A$

C wins above line

D wins below line ← D will always win below line because the bottom hole has the highest pressure and thus the highest velocity.

How to use Bernouli to explain this:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

- Pressure on the liq → P
- Velocity of liq → v
- Vertical drop → y
- Pressure on H_2O @ top of container (1atm) → P_1
- Pressure on H_2O @ Hole A is also about 1atm → P_2
- V_1 = Velocity of water @ top of container (This is zero!)

density cancels because it remains water the whole time

Notice pressure of air on surface of container and on each hole is about the same @ 1atm (∴ they cancel)

$$\therefore\ g y_1 = \frac{1}{2} V_2^2 + g y_2$$

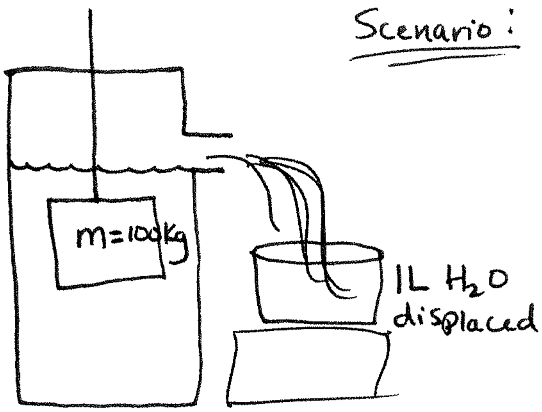
$$V_2 = \sqrt{2g\Delta y}$$ (looks like an old friend)

AP Physics Review
Fluid Mechanics

Buoyancy:

$$F_{buoyant} = m_{\text{fluid displaced by object}}\, g = \rho_{fluid}\, g\, Vol_{\text{fluid displaced by object}}$$

> Recall H_2O has a density of $\frac{1\,Kg}{1\,L}$
>
> ∴ for every L of H_2O displaced, That is 1 Kg!



Scenario: A 100 Kg block displaces 1L of H_2O. What is The buoyant force and the net force on This block?

$$F_{gravity} = m_{block} \cdot g = 100\,Kg \cdot 9.8\,m/s^2 = 980\,N$$

$$F_{buoyant} = m_{fluid}\, g = 1\,Kg \cdot 9.8\,m/s^2 = \boxed{9.8\,N}$$

$$F_{net} = F_g - F_b = 980\,N - 9.8\,N = \boxed{970.2\,N}$$

AP Physics
Buoyancy

$$\frac{\text{density of object}}{\text{density of } H_2O} = \% \text{ of object submerged beneath } H_2O$$

also = Amount of water Volume displaced by Volume of object

Example:

An ice cube w/ a mass of 700g and a volume of 1000 cm³ is in a glass of H_2O.

ⓐ How much of the ice cube's Volume is below H_2O?

ⓑ How much H_2O Volume is displaced by the ice cube

ⓒ What happens as the ice melts?

ⓓ what happens to water level?

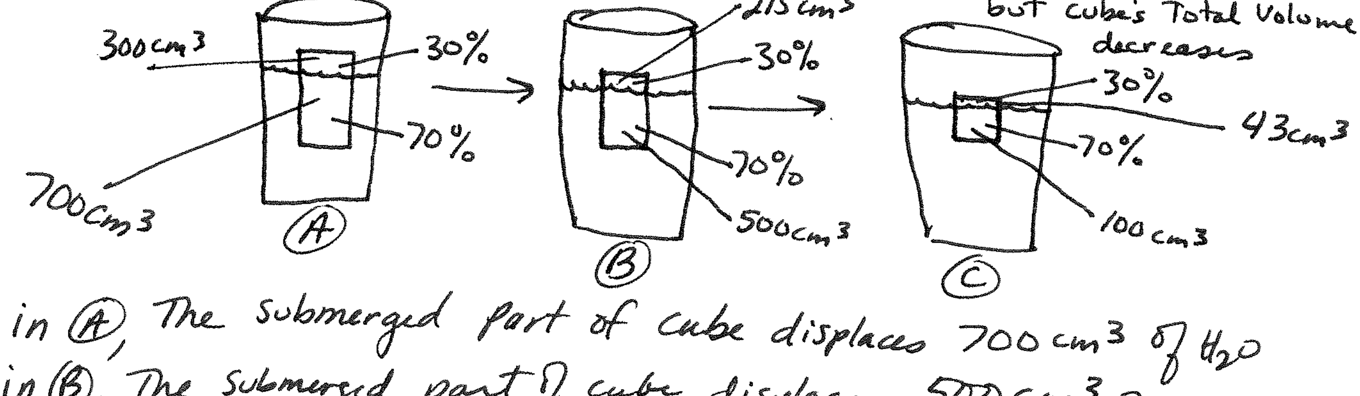
ⓐ $\rho_{ice} = \frac{700g}{1000cm^3} = 0.7\,g/cm^3 \qquad \rho_{H_2O} = 1\,g/cm^3$

$\frac{\rho_{ice}}{\rho_{H_2O}} = \frac{0.7}{1} = 0.7$ or 70% of ice is below H_2O

ⓑ $0.7(V_{ice}) = 0.7(1000\,cm^3) = 700\,cm^3$ H_2O is displaced

(recall that since $\rho_{H_2O} = 1\,g/mL$, $700\,cm^3\ H_2O = 700\,g\ H_2O$!)

ⓒ As it melts, 30% will remain above surface + 70% below but cube's Total Volume decreases



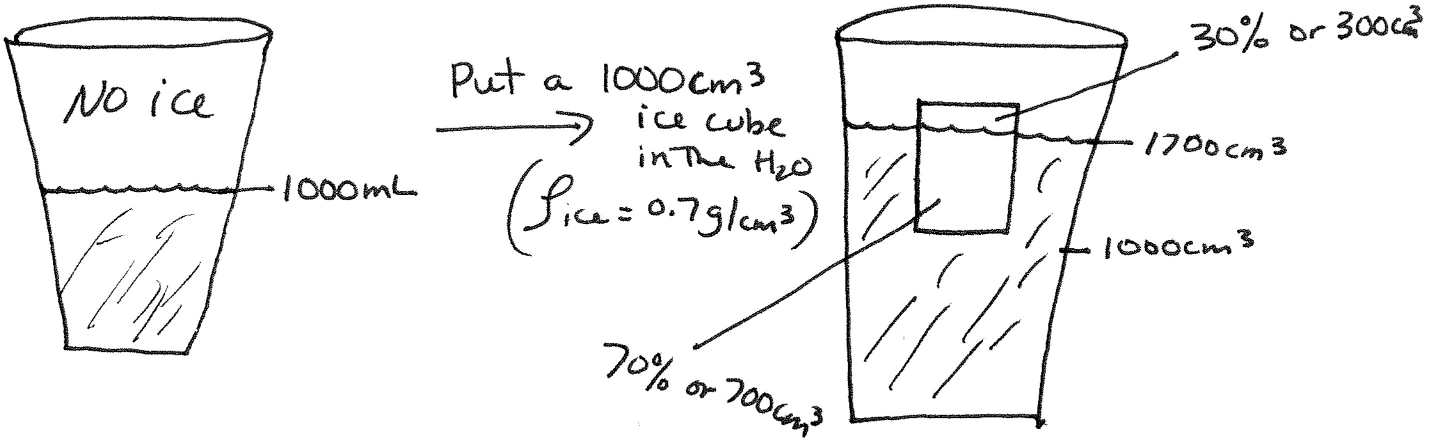
in Ⓐ, The submerged part of cube displaces 700 cm3 of H_2O

in Ⓑ, The submerged part of cube displaces 500 cm3 of H_2O

in Ⓒ, The submerged part of cube displaces 100 cm3 of H_2O

ⓓ Water level will remain the same throughout because as ice melts, it's volume turns to H_2O to replace displaced space.
@ The end, all 700g of ice becomes 700 cm3 of H_2O it originally displaced.

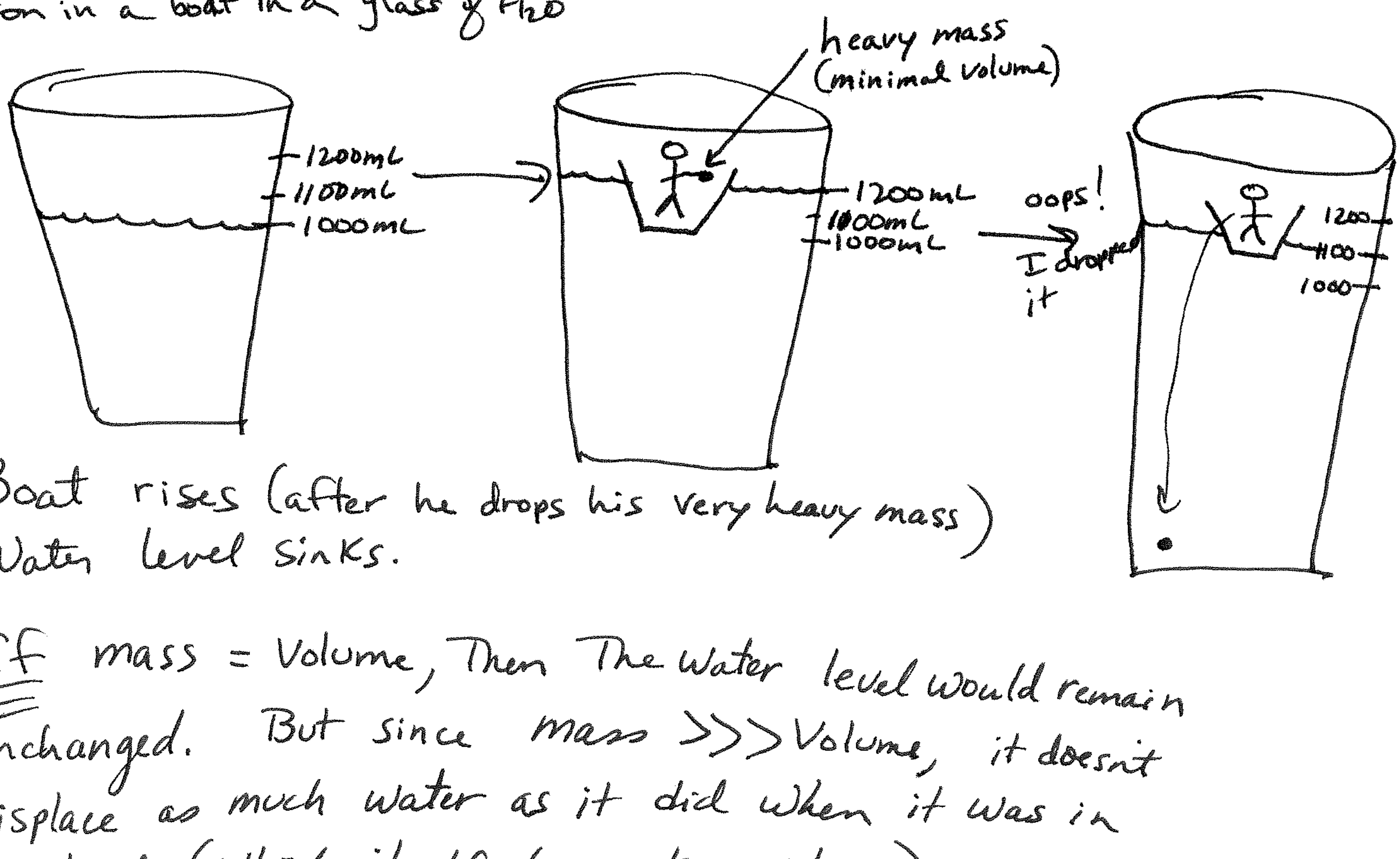
Ice Cube revisited:



→ So, Putting a 1000 cm^3 piece of ice in a glass of H_2O is like Pouring 700 cm^3 of H_2O into The Water. Think of The 30% as air all concentrated on Top.

As ice melts, H_2O level will remain @ 1700 cm^3

Person in a boat in a glass of H_2O



- Boat rises (after he drops his very heavy mass)
- Water level sinks.

- If mass = Volume, Then The Water level would remain Unchanged. But since mass >>> Volume, it doesn't displace as much water as it did when it was in the boat (which itself has a large volume)