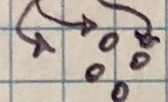
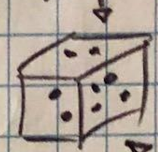
Fluids: substance that deforms continously under applied stress.

→ it "flows".

- it is comprised of particles that interact.
- however, at scales significantly larger than particle seperation it's nearly continuous!

instead of a "particle" of fluid, we refer to "parcels" of fluid





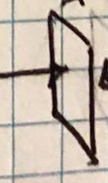
Parcel (or element) is a small volume of fluid.

$$\text{Density} = \frac{\text{Mass of Parcel}}{\text{Vol of Parcel}} = \frac{\Sigma m_i}{V} = \rho \quad \text{"rho"}$$

pure water: $\rho \approx 1{,}000 \ \mathrm{kg/m^3}$

Fluids exert a pressure on all immersed objects / surfaces.

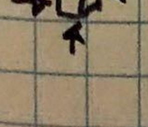
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \Rightarrow P = \frac{F}{A}$$



$$\Delta P = \frac{F_2 - F_1}{A}$$

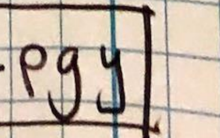
Hydrostatic (water at rest) Pressure = weight of water above.

P_{ATM} = atmoshoric Pressure



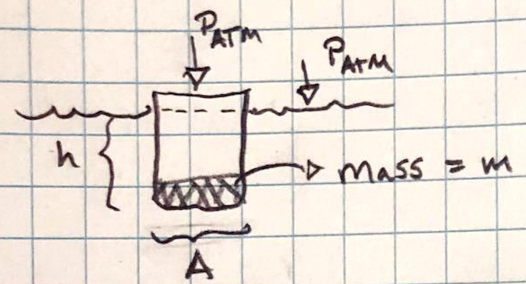
$h \Rightarrow \boxed{P = P_{ATM} + \rho g h}$

iF $y=0$ at surface



the $\boxed{P = P_{ATM} - \rho g y}$

Buoyancy (Force): a submerged object feels an upward force equal to the weight of fluid it displaces.



$$P = P_{ATM} + \rho g h$$

$$F_{net} = -P_{ATM}A - mg + PA$$

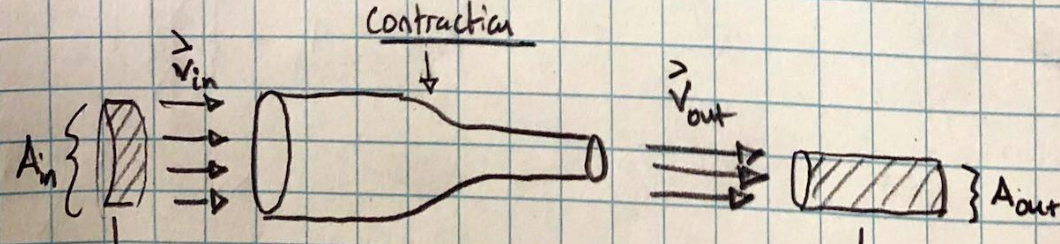
$$= A(P_{ATM} - P_{ATM}) - mg + \overbrace{\rho g(A \cdot h)}^{\rho V = m_w}$$

$$+ m_w g$$

$$F_{net} = -w_{obj} + w_{water}$$

$$\boxed{\text{Buoyant Force} = w_{water} = m_{water}\,g = \rho \cdot V_{obj.}\,g}$$

<u>Continuity</u> = <u>Conservation of Mass</u> $\equiv$ Volume in = Volume out



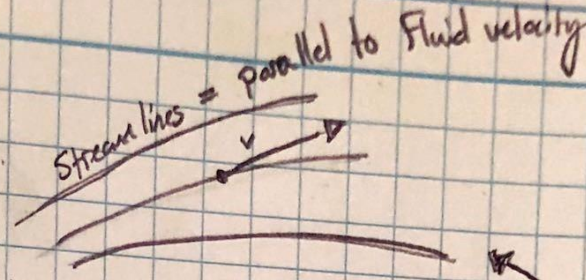
$$\Delta V_{in} = A_{in} v_{in}$$

$$\Delta V_{out} = A_{out} v_{out}$$

$$\boxed{A_{in} v_{in} = A_{out} v_{out}}$$

"Volume flow rate"

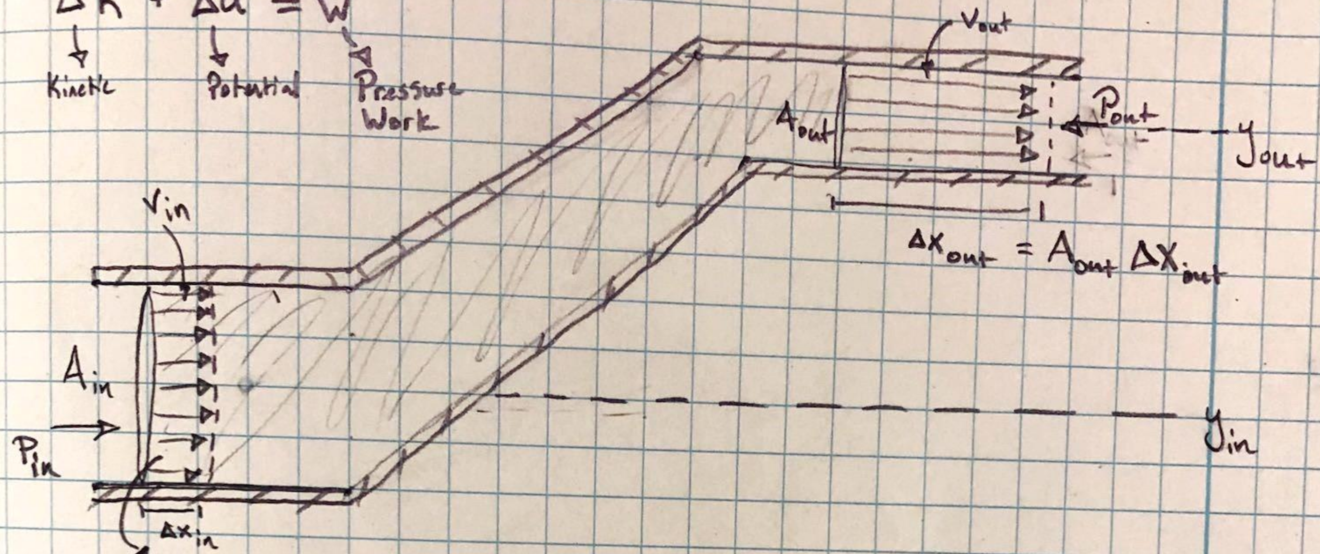
Benoulli's Equation



→ Conservation of Mechanical Energy along a streamline

$$\Delta K + \Delta U = W$$

ΔK → Kinetic, ΔU → Potential, W → Pressure Work



$$\Delta V_{in} = A_{in}\Delta x_{in} = A_{in} v_{in} \Delta t$$

After time Δt, Energy of fluid changes by

Continuity: $\boxed{\Delta V_{in} = \Delta V_{out}}$

Kinetic Energy:

$$\Delta K_{in} = -\frac{1}{2}\rho v_{in}^2 \Delta V_{in} \qquad \Delta K_{out} = +\frac{1}{2}\rho v_{out}^2 \Delta V_{out}$$

Potential Energy:

$$\Delta U_{in} = -\rho g y_{in} \Delta V_{in} \qquad \Delta U_{out} = +\rho g y_{out} \Delta V_{out}$$

Pressure Work

$$W_{in} = \underbrace{P_{in} \cdot A_{in}}_{F_{in}} \Delta x_{in} = P_{in}\Delta V_{in} \qquad \overbrace{A_{in}\Delta x_{in}}^{\Delta V_{in}}$$

$$W_{out} = \underbrace{-P_{out} A_{out}}_{F_{out}} \Delta x_{out} = -P_{out}\Delta V_{out} \qquad \overbrace{A_{out}\Delta x_{out}}^{\Delta V_{out}}$$

$$\therefore \frac{1}{2}\rho\left(v_{out}^2 - v_{in}^2\right)\cancel{\Delta V} + \rho g\left(y_{out} - y_{in}\right)\cancel{\Delta V} = \left(P_{in} - P_{out}\right)\cancel{\Delta V}$$

or

$$\boxed{\frac{1}{2}\rho v_{out}^2 + \rho g y_{out} + P_{out} = \frac{1}{2}\rho v_{in}^2 + \rho g y_{in} + P_{in}}$$