Density

$$\rho = \frac{m}{V} = \frac{kg}{m^3}$$

$1{,}000{,}000\ cm^3 = 1\ m^3$

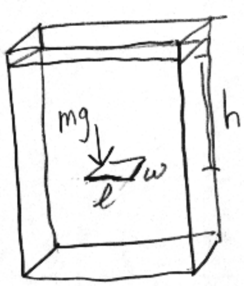
$$sp.\,gr. = \frac{\rho_s}{\rho_w} = \frac{\rho_s}{1000\,kg/m^3}$$

Pressure

$$P = \frac{F_\perp}{A} = \frac{N}{m^3} = \text{Pascal}$$

$$P_{atm} = 101{,}300\,Pa = 1\,atm$$

Hydrostatic Pressure



$$m = \rho V$$

$$F_g = \rho V g = \rho(lwh)g$$ = weight of liquid on top

$$P_{liq} = \frac{F_{g\,liq}}{A_{object}} = \frac{\rho(\cancel{lw}h)g}{\cancel{lw}} = \rho g h$$

$\boxed{P = \rho g h}$ hydrostatic pressure

closed

- Shape of container does not matter

★ Closed vacuum container $P_{tot} = \rho g h$

- Open container

$$P_{tot} = P_{atm} + P_{liquid}$$

$$\boxed{P_{tot} = P_{atm} + \rho g h}$$

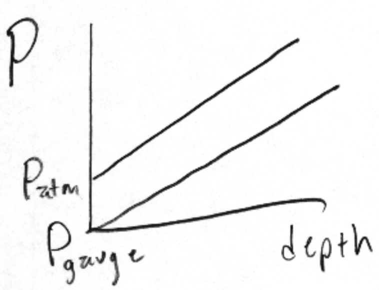
Difference between total Pressure and atmospheric is the <u>gauge Pressure</u>!

$$P_{gauge} = P_{tot} - P_{atm}$$

In other words P_{gauge} is just the pressure of the liquid

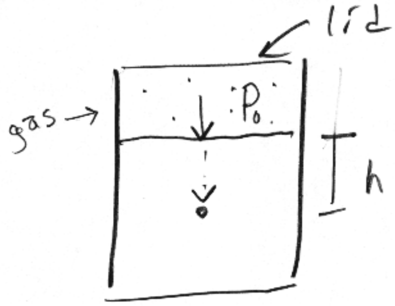
$$\boxed{P_{gauge} = \rho g h}$$

Only gauge pressure is proportional to depth

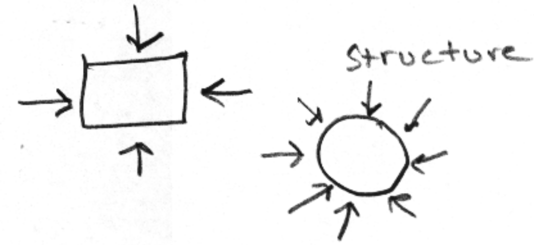


slope $= \rho g$

ρ = constant
(Really it increases w/ depth)



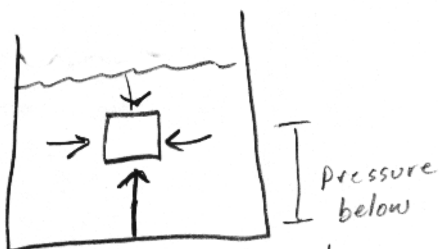
$$P_{tot} = P_0 + \rho g h$$



- with no lid $P_0 = P_{atm}$ *

- Pressure is scalar (only depends on height)

Buoyancy

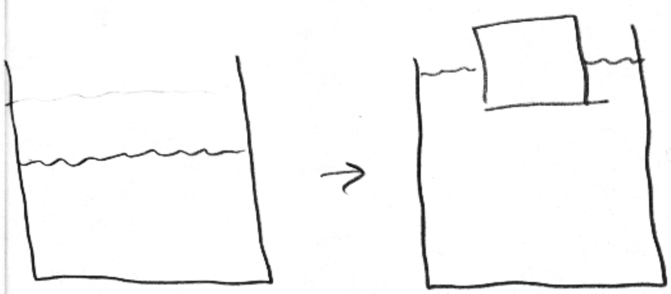


$\Sigma F =$ upward

- Net upward Force

  F_{buoy}

- Use Archimedes' principle
  - Strength of buoyant force is equal to the weight of the fluid displaced by the object.



Volume of object under water

$V_{sub} = V$ of displaced fluid

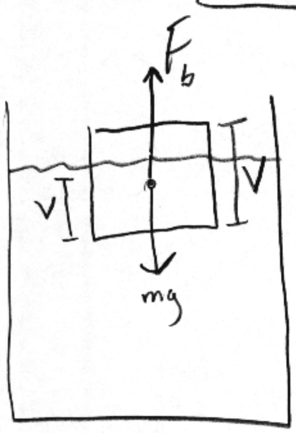
$$\boxed{F_{buoy} = \rho_{fluid} V_{sub}\, g}$$

• When the object floats $mg = F_{buoy}$

$$mg = \rho_{object} V g \qquad F_{buoy} = \rho_{fluid} V_{sub} g$$

$$\rho_{object} V \cancel{g} = \rho_{fluid} V_{sub} \cancel{g}$$

$$\boxed{\frac{V_{sub}}{V_{liquid}} = \frac{\rho_{object}}{\rho_{liquid}}}$$



$$V_{sub} = \frac{\rho_o}{\rho_l} V_l$$

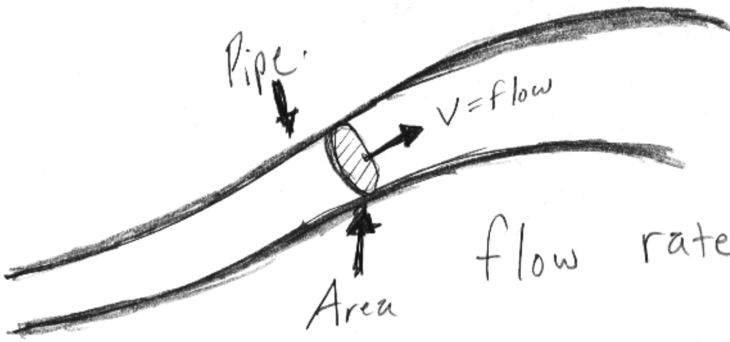
$$V_{sub} = \frac{\frac{2}{3}}{1} V l$$

$$V_{sub} = \frac{3}{2} V l$$

$$\boxed{\frac{2}{3} V_{sub}}$$

The fraction of the object's volume submerged is equal to the ratio of it's density to the fluid's density.

Flow Rate & The Continuity Equation



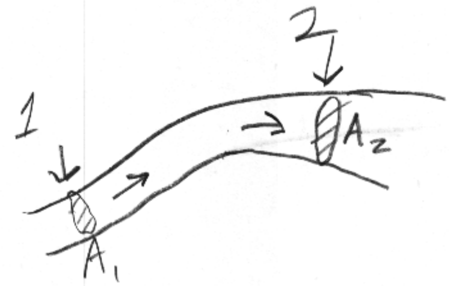
flow rate: $f = Av$

SI

$$f = m^2 \cdot \frac{m}{s} = m^3/s$$

flow rate $\neq$ flow speed

Flow Rate must be the same everywhere along the pipe.



$$f_1 = f_2$$

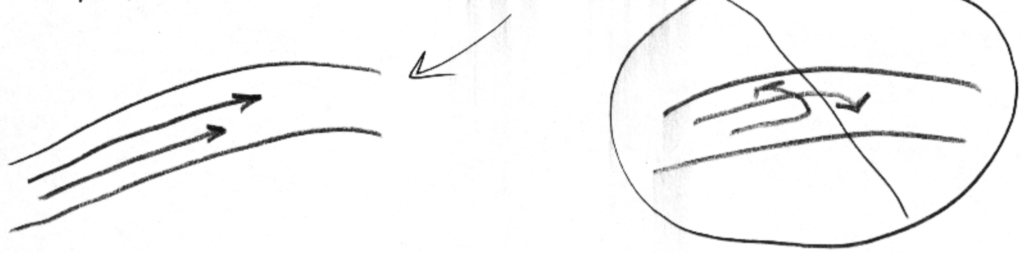
$$f = Av \qquad A_1 V_1 = A_2 V_2$$

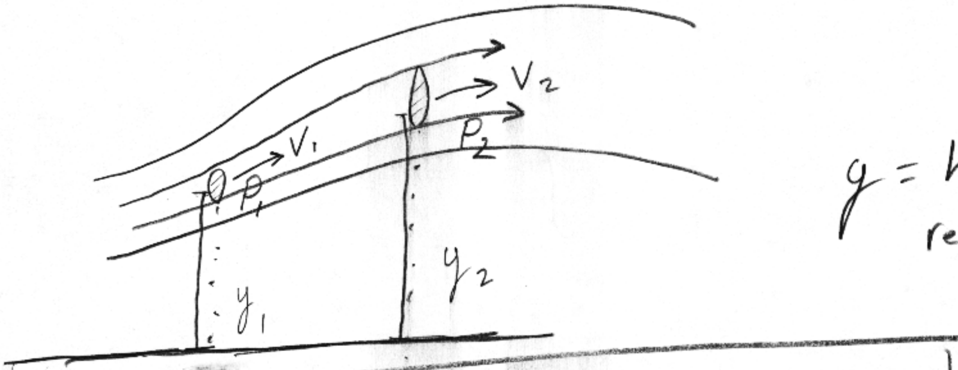
V = increase where the pipe narrows

Bernoulli's Equation

ideal fluids

- Fluid is incompressible (ρ = constant)
- Fluid's viscocity is negligible
- Fluid is streamline





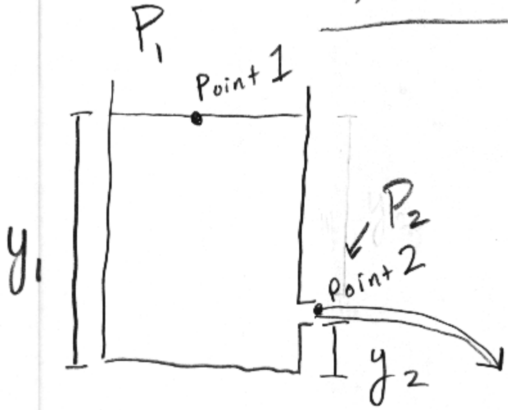
y = height above reference level

$$\boxed{P + \rho g y + \frac{1}{2}\rho v^2 = \text{constant}}$$

☆ This is conservation of energy

$$\left.\begin{aligned} \rho g y &\approx mgh \\ \frac{1}{2}\rho v^2 &\approx \frac{1}{2}mv^2 \end{aligned}\right\rangle \text{analogous}$$

Torricelli's Theorem



$h = y_1 - y_2$

- Use Bernoulli's to find the efflux speed

$P_1 = P_2$ (both atm)

V_1 = is so small that $V_1 = \emptyset$

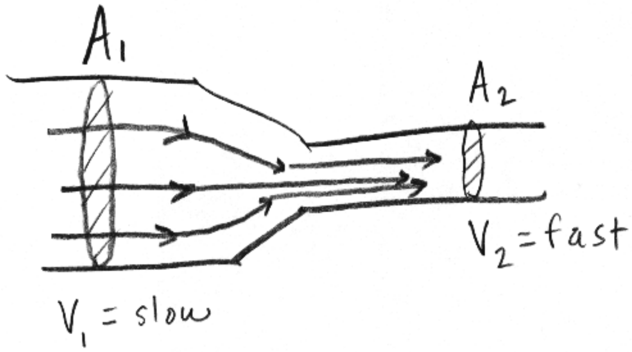
$$\cancel{P_1} + \rho g y_1 + \cancel{\tfrac{1}{2}\rho v_1^2} = \cancel{P_2} + \rho g y_2 + \tfrac{1}{2}\rho v_2^2$$

$$\cancel{\rho} g y_1 = \cancel{\rho} g y_2 + \tfrac{1}{2}\cancel{\rho} v_2^2$$

$$V_2 = \sqrt{2g(y_1 - y_2)}$$

$$\boxed{V_2 = \sqrt{2gh}}$$ yes!

The Bernoulli Effect



$y_1 = y_2$ so...

$$P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \tfrac{1}{2}\rho v_2^2$$

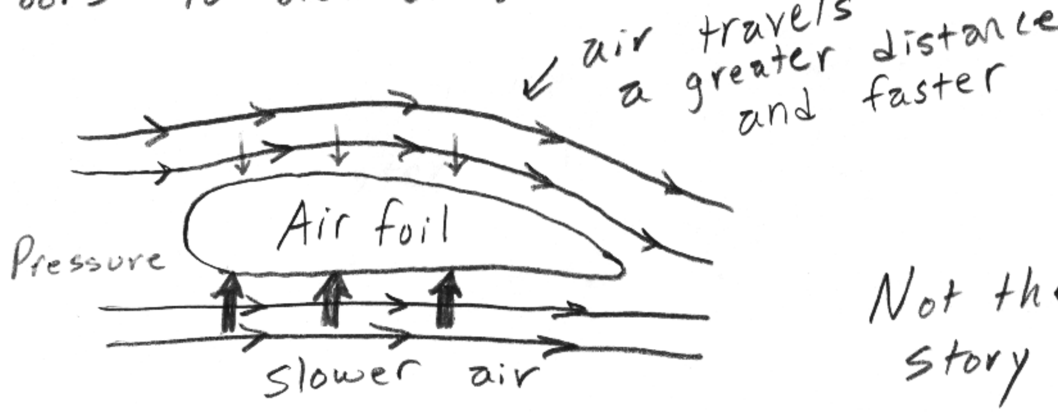
$V_1 < V_2$ then...

$$P_1 > P_2$$

☆ The pressure is lower where the flow speed is greater!

- This is called the Bernoulli effect

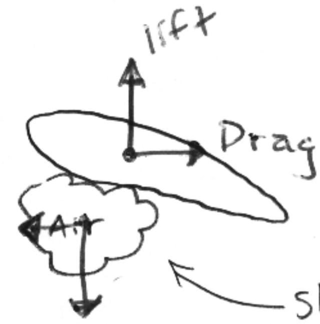
- This allows airplanes to fly.
- curve balls to curve
- House roofs to blow off!



Not the whole story

You must also deflect air downwards
Newton's 3rd Law!

angle of attack!



Both together explain lift!