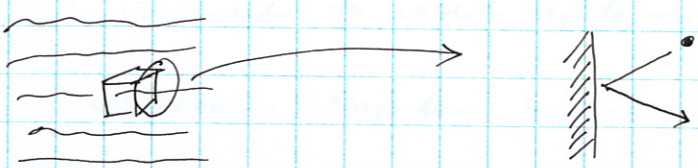
Define Pressure : $P = \frac{F}{A}$ (unit $\frac{N}{m^2}$ = Pa (Pascal))

↳ also : PSI → tire pressure.

(Apply notion of pressure to fluids) .

4. An object in a fluid feels pressure due to the fluid : **(32-ish)**



molecule hits the surface and transfers momentum (IMPULSE)

Pressure vs. t fluctuates → so use <u>average</u>. } "Instantaneous" pressure : not very useful. (lots per second)

Add up contributions from all molecules and average over time gives the force acting on the surface :

$\boxed{\text{Magnitude}}$: $F = \frac{\Delta p}{\Delta t}$ (or $F = \frac{dp}{dt}$) for Δt very small.

$$\text{Pressure} \quad P = \frac{F}{A} = \frac{1}{A}\frac{dp}{dt}$$

What is the direction of the net force $\vec{F}$?

$\boxed{\text{Direction}}$ The net force $\vec{F}$ from all the molecules is perpendicular to the surface. Why? The components of the force parallel to the surface all cancel out.

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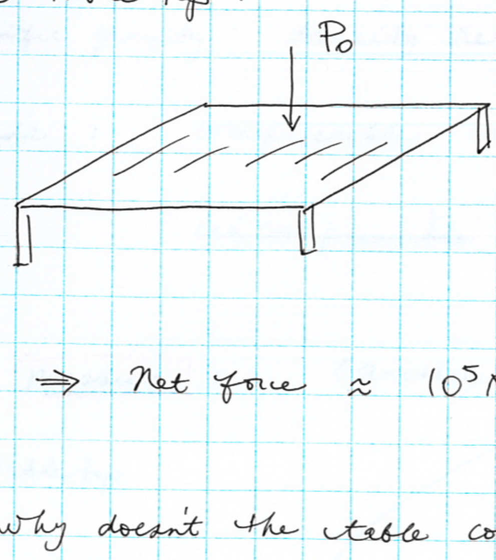
e.g. a table-top :



- $1\ m^2 = A$
- P_0 = air pressure at sea level $= 1.013 \times 10^5\ N/m^2$ (1 atm) (global average; locally, varies w/ weather)

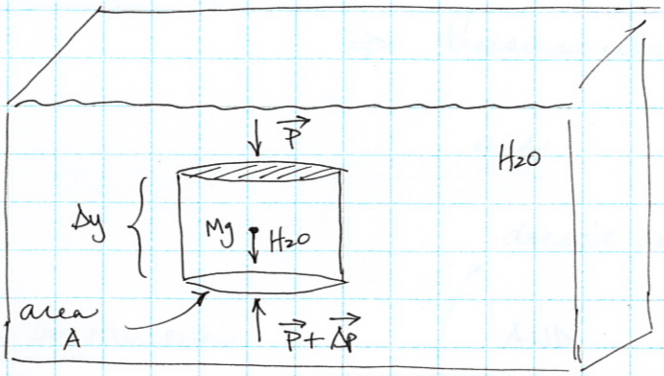
$\Rightarrow$ Net force $\approx 10^5 N \approx$ weight of about 150 people.

Why doesn't the table collapse? (Think of table (a sheet of paper) as "immersed" in a fluid — <u>at a particular depth</u>, pressure is the same from all directions.

- The fundamental law of "hydrostatics" (fluids at rest): pressure goes up as you go deeper into the fluid (know from experience)

BQ: (How does pressure in a fluid change with depth?) → P↑ as depth increases

- Consider a cylinder of water, immersed in water: mass M, area A (top and bottom), height Δy



Look at the forces acting on the cylinder:

- Surrounding water:
  - downward force $P \cdot A$ on top of cylinder
  - upward force $(P+\Delta P)\cdot A$ on bottom of cylinder

- gravity: $Mg = \rho \cdot V \cdot g = \rho \Delta y \cdot A g$

- cylinder is not moving → all forces have to balance out

$$(P+\Delta P)A - P\cdot A - \rho \Delta y A g = 0$$

$$\Delta P \cdot A = \rho \Delta y A g$$

$$\frac{\Delta P}{\Delta y} = \rho \cdot g \qquad (\text{or } \Delta P = \rho g \Delta y)$$

How does this equation solve the puzzle from last time?

for $\Delta y \to 0$, $\Delta P \to 0$

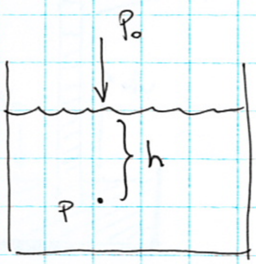
⇒ Pressure from top = Pressure from bottom.

⇒ Table doesn't collapse.

or $\frac{dP}{dy} = \rho \cdot g$. ~~→ integrate~~ : (1)

(2)

So, at depth h from the surface of water in a tank:



$$\boxed{P = P_0 + \rho g h}$$ (note that h is measured <u>downwards</u>) [from the top]

(deeper → higher pressure)

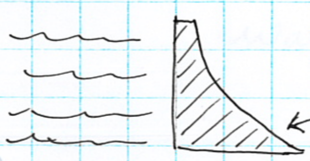
⇒ Pressure increases linearly with depth.

<u>and</u>

doesn't depend on the width of the container.

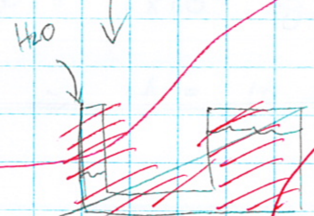
<u>Applications</u>

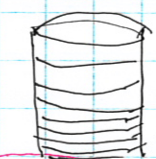
<u>Dam</u> construction ✓



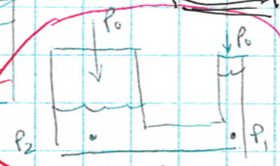
AND

(grain silo) <u>Silo</u> ✓





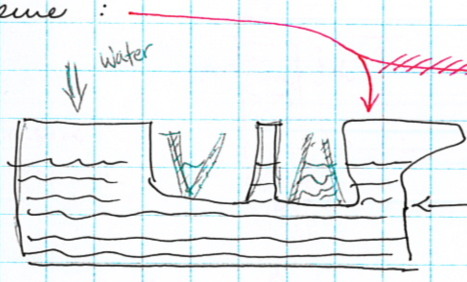
more restraining bands at bottom.



$P_1 > P_2$ → flow from 1 to 2

Also note that all points at a given depth have the same pressure:

[do this as an exercise]



P at this level is the same in all parts of the container.

NB: Blood pressure measurement: why upper arm? (ASK)

- at heart: $P_h = 1.034 \times 10^5$ Pa (3% above P_0)
- At foot: ~ 1.5 m lower (standing)

$$\text{so } P_f = P_h + \rho g h$$
$$= 1.034 \times 10^5 + \underbrace{(1050\ \text{kg/m}^3)}_{\text{density of blood.}}(9.8\ \text{m/s}^2)(1.5\ \text{m})$$
$$= 1.19 \times 10^5\ \text{Pa}$$