Chapter 10
fluids

• Fluids Statics

sec 10.1 → sec 10.7.

- phases of matter:

· Solids → fixed size and shape → mass, Force

· fluids → Liquids, gases → · do not maintain a fixed shape · Able to flow. → density, pressure

- density and Specific Gravity:

• Density = $\frac{\text{mass}}{\text{volume}}$ $\frac{m}{V}$ SI unit = Kg/m3 ρ

→ scalar, intrinsic property of the substance.

• Specific Gravity SG = $\frac{\text{density of a substance}}{\text{density of } H_2O}$ = $\frac{\rho(x)}{\rho(H_2O)}$

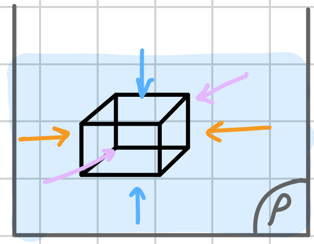
→ pure number [dimentionless]

→ $\rho(H_2O) \approx 10^3$ Kg/m³ "at 4C°"

↳ 1000 Kg/m³

- Pressure in Fluids

$P = \dfrac{\text{Force}}{\text{Area}}$ SI unit : $\dfrac{N}{m^2} = \dfrac{Kg}{m.s^2}$ = Pascal

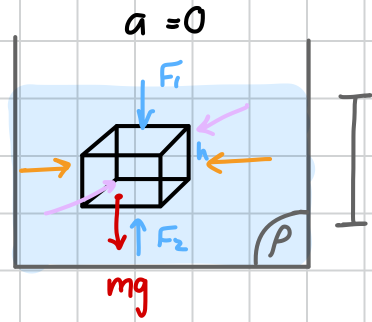


* Forces by fluid on submerged object.

→ Scalar. • $P \propto \dfrac{F}{A}$ ~ directly related (F) ~ inversely related (A)

→ $\vec{F}$ associated with P is Perpendicular to the surface Area that P acts on.

* Relation Between Pressure - Depth.



$F_2 - F_1 - F_g = 0 \rightarrow F_2 = F_1 + F_g$

in terms of P : $P_2 A = P_1 A + mg$

$P_2 A = P_1 A + V \rho g$

$P_2 \cancel{A} = P_1 \cancel{A} + \cancel{A} h \rho g$

• $F = AP$
• $m = V\rho$
• $V = Ah$

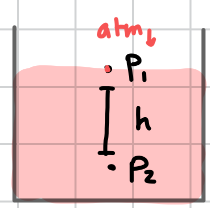
• $P_2 = P_1 + h \rho_f g$ → h is directly related to P

- Atmospheric and gauge Pressure :

• P_{atm} → the Avg pressure of earth's atm (at sea level = 1atm).

$\underbrace{P_2}_{P_{absolute}} = \underbrace{P_1}_{P_{atm}} + \underbrace{\rho_f g h}_{P_{gauge}}$

$P_{absolute} = P_{atm} + P_{gauge}$



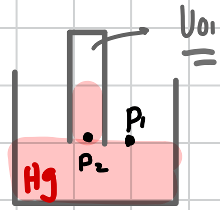
• $P_{absolute}$ → The pressure of the fluid + The pressure of the air.

• P_{gauge} → The difference between the absolute and atmospheric pressure. $[P_2 - P_1]$

→ it can be + → $P_{absolute} > P_{atm}$

− → $P_{absolute} < P_{atm}$

- **Barometer** "measuring atmospheric Pressure"



$P_1 = P_{atm}$

$P_2 = \cancel{P_{atm}}^{0} + P_{Hg}$

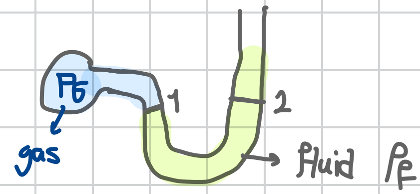
$P_2 = \rho_{Hg} g h$

$P_1 = P_2 = P_{atm} = \rho_{Hg} g h$

→ [h] at (1atm) = 760 mm-Hg

→ $[h_{H_2O}]$ at 1atm = 10.3 m - H_2O

- **manometer** "measures the gauge pressure P_G of a gas"



- $P_1 = P_2$
- $P_2 = P_{atm} + \rho_f g h$
- $P_1 = P_{gas} + P_{atm}$ = absolute pressure of the gas

$P_1 = P_2 = P_{atm} + \rho_f g h$

$P_2 - P_{atm} = \rho_f g h \implies P_{gauge} = \rho_f g h$

$P_G = P_{atm} + \rho_f g h = P_1$ (Absolute)

→ Blood pressure is measured using a gauge

Systolic → maximum pressure when heart is pumping. Normal = 120 mm-Hg

diastolic → pressure at the resting part of the cycle. Normal = 80 mm-Hg

→ Absolute Pressure = $P_{atm} + P_{systolic} / P_{diastolic}$.

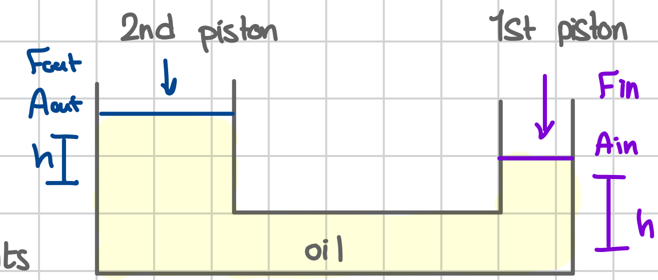
– Pascal's Principle

" if pressure is exerted on a part of the fluid, that pressure will be transmitted to all parts of the fluid without loss. "

$\rightarrow$ $P_{absolute} = P_{atm} + \rho g h \xrightarrow[\text{increased}]{P_{atm}} P_{absolute} = P_{atm} + \Delta P + \rho g h$

$$P_{absolute} = (P_{atm} + \rho g h) + \Delta P$$

• Hydraulic Lift



$\rightarrow$ $\Delta P = \dfrac{F_{in}}{A_{in}} = \dfrac{F_{out}}{A_{out}}$ $\rightarrow$ Change in P is transmitted to All points

$\rightarrow$ $F_{out} = F_{in}\left[\dfrac{A_{out}}{A_{in}}\right] \rightarrow A_{in} < A_{out}$

$F_{out} > F_{in}$ $\rightarrow$ the Force is magnified

• large output force from small input force.

$\rightarrow$ $V = A_{in} h_{in} = A_{out} h_{out}$ $\rightarrow$ Volume that is moved is the same when there's no leakage "confined"

$\rightarrow$ $h_{out} = h_{in}\left[\dfrac{A_{in}}{A_{out}}\right] \rightarrow A_{in} < A_{out}$

$h_{out} < h_{in}$ $\rightarrow$ Piston 2 moves a Smaller distance than piston 1

$\rightarrow$ $W = F d$

$= F_{out}\, h_{out} = \left[\dfrac{\cancel{A_{out}}}{\cancel{A_{in}}} F_{in}\right] \cdot \left[h_{in} \dfrac{\cancel{A_{in}}}{\cancel{A_{out}}}\right] = F_{in}\, h_{in}$

$W_{out} = W_{in}$ $\rightarrow$ work done on piston 2 equals work done on piston 1

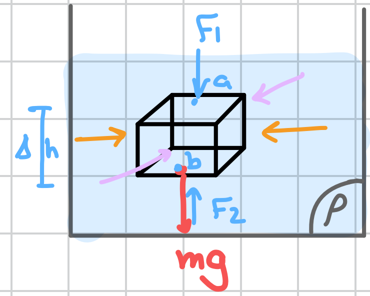
• Force is magnified while distance is reduced

- Buoyancy & Archimedes principle

• Buoyant Force F_B

→ the upward force exerted by a fluid on any fully or partially submerged object.

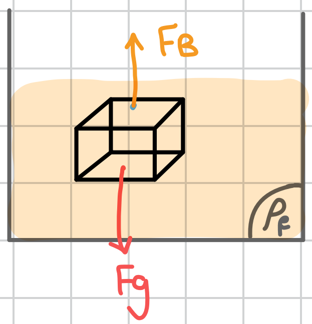
→ $F_1 - F_2 = mg$ → the weight is supported by the force resulting from the pressure difference between a, b.



• Archimedes's Principle

" when an object is fully or partially submerged in a fluid, the fluid pushes upward with a buoyant force with the magnitude "

$$F_B = m_f g$$



→ $\Sigma F = F_B - F_g$

$F_g = m_o g = \rho_o V_o g$
↳ mass of the object.

$F_B = m_f g = \rho_f V_f g$
↳ mass of the displaced fluid

→ $F_{Net} = \rho_f V_f g - \rho_o V_o g = g(\rho_f V_f - \rho_o V_o)$

⇓

Two Situations

Totally submerged

$V_f = V_o$

$$F_{Net} = g V_o (\rho_f - \rho_o)$$

$\rho_f = \rho_o$

F_{Net} = Zero

remains in equilibrium

$\rho_f > \rho_o$

$F_{Net} = +$

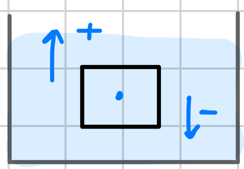
accelerates upward "rise"

$\rho_f < \rho_o$

$F_{Net} = -$

accelerates downward "sink"

Direction of motion is only determined by Densities



$V_f = V_o$

Partially submerged

$V_o > V_f$

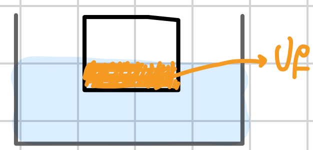
$$F_{Net} = g(\rho_f V_f - \rho_o V_o)$$

→ object will be Floating at static equilibrium

→ $F_{Net} = 0$

→ $\rho_o V_o g = \rho_f V_f g$

$$\frac{\rho_o}{\rho_f} = \frac{V_f}{V_o}$$



→ Apparent weight = Actual weight − F_B