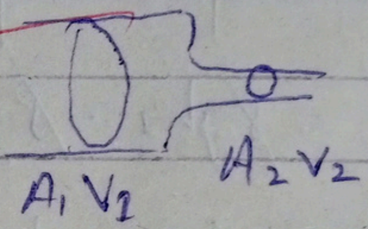
Fluid Dynamics

Continuity:

→ Flow rate must be conserved. (conservation of mass)

Flow rate: $Q = Av$

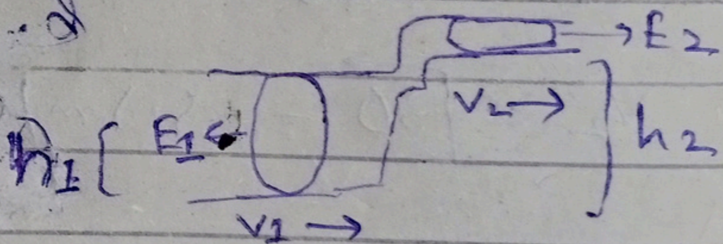


$$Q_1 = Q_2$$

$$A_1 v_1 = A_2 v_2$$

Bernoulli's Principle:

→ Energy is conserved.



$$E_{internal} + \frac{1}{2}mv^2 + mgh$$

Dividing by volume:

$$P + \frac{1}{2}\rho v^2 + \rho gh \qquad \rho = \frac{m}{V}$$

Bernoulli's Equation:

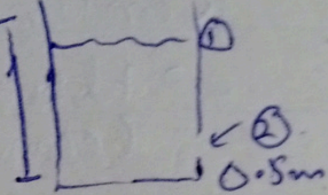
$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

A tank of water 2m tall has an open top and an opening 0.5m from the base. What is the velocity of fluid escaping?

$$\cancel{P_1} + \frac{1}{2}\rho \cancel{v_1^2} + \rho g h_1 = \cancel{P_2} + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

→ velocity is very slow

→ both are atmospheric pressure.



$$\frac{1}{2}\rho v_2^2 = \rho g h_1 - \rho g h_2$$

$$v_2^2 = 2g(h_1 - h_2)$$

$$v_2^2 = 2(10)(2-0.5)$$

$$v_2^2 = 20(1.5)$$

$$v_2^2 = 30$$

$$v_2 = \sqrt{30} = 5.5\ m/s.$$

	20
	1.5
	100
	20x
	30.0

Venturi Effect:

→ higher velocity means lower pressure in a given system.

$$P_2 = P_1 - \frac{1}{2}\rho(v_2^2 - v_1^2)$$

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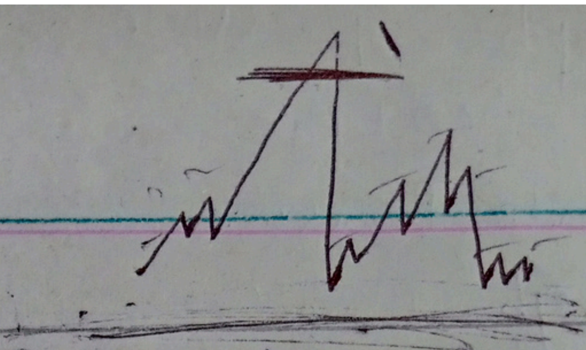


Density:

Density: how much mass per unit volume.

$$\rho = \frac{m}{V}$$

Specific gravity: density relative to water

$$= \frac{\rho_{substance}}{\rho_{water}}.$$

→ gases are fluids!

Pressure:

→ Force per unit area.

$$P = \frac{F_\perp}{A}$$

$$[P] = \frac{Kg}{m s^2} = \text{Pascals (Pa)}$$

$$\text{Pascals} = \frac{N}{m^2} = \frac{J}{m^3}$$

Force perpendicular to wall.

Atmospheric pressure:

1 atm = 100 KPa.

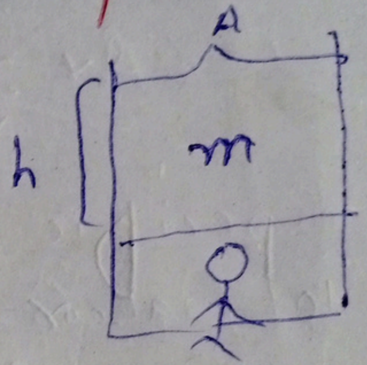
Hydrostatic Pressure:

$P = \rho g h$

↳ Gauge Pressure: amount by which pressure measured in a fluid exceeds atmospheric pressure.

$P_{guage} = \rho g h$

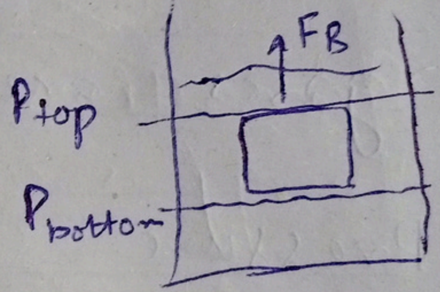
$P_{total} = \rho g h + P_{atm}$

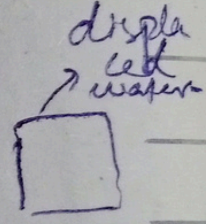


Archimedes Principle:

Buoyancy:

$F_B = (m_{displaced\ water})\, g$





→ Force F_B upwards is equal to the weight of the displaced water.

An object will float if:

→ $F_B > F_g$.

→ $m_{water}\, g > m_{object}\, g$

→ $\rho_{water} V > \rho_{object} V$

→ $\rho_{water} > \rho_{object}$.

if an object is floating, it will emerge from water until:

→ $F_B = F_g$

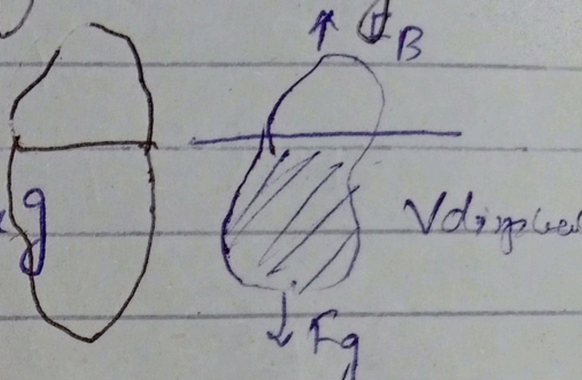
→ $m_{water\ displaced} = m_{object}$

→ $\rho_{water} V_{submerged} = \rho_{object} V_{object}$

For Floating Object

$$\frac{V_{submerged}}{V_{object}} = \frac{\rho_{object}}{\rho_{water}}$$

The specific gravity of ice is approximately 0.9. What fraction of an iceberg is really underwater?



$F_B = mg = (\rho V)g = F_g = m_{ice} g$

$\rho_w V_w g = \rho_i V_i g$

$\frac{\rho_w}{\rho_i} = \frac{V_i}{V_w}$ or $\frac{V_w}{V_i} = \frac{\rho_i}{\rho_w} = 0.9$ → Specific gravity $= 0.9$

90% → under water

Pascal's Law:

→ Pressure is equally distributed throughout a fluid.

- $P_1 = P_2$

- $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

Equal force per unit area.

Hydraulics:

→ you gain a mechanical advantage by making one area greater than another.

- $F_2 = F_1 \frac{A_2}{A_1}$