

# Fluids & Pressure

## 1. Core Definitions

- $\rho = \frac{m}{V}$  — Density      SI unit:  $\frac{\text{kg}}{\text{m}^3}$        $\left[ 1 \frac{\text{kg}}{\text{m}^3} = 10^3 \frac{\text{g}}{\text{cm}^3} \right]$
- $P = \frac{F}{A}$  — Pressure      SI unit: "Pascals"       $\left[ 1 \text{ Pa} = 1 \frac{\text{kg}}{\text{m}\cdot\text{s}^2} = 9.87 \times 10^{-6} \text{ atm} \right]$

## 2. Fluids on Their Own (no solid objects involved)

### 2.1. Fluids At Rest (aka "Hydrostatics")

- $P_{\text{observed}} = P_{\text{surface}} + \rho gh$  — Hydrostatic pressure
  - ( $P_{\text{surface}}$  is **surface pressure**;  $h$  is **depth** below the surface)
  - This can help with U-tubes: "In a connected fluid at rest, pressures at the same horizontal level are equal".
- $P_{\text{gauge}} = P_{\text{observed}} - P_{\text{surface}} = \rho gh$  — Gauge pressure (i.e., pressure relative to normal surface/atmospheric conditions)

### 2.2. Fluids Moving/Flowing (ideal, steady, incompressible)

- $A_1 v_1 = A_2 v_2$  — Continuity (total amount of fluid is conserved, i.e. no sources [+] or sinks/drains [-])
- $P + \frac{1}{2}\rho v^2 + \rho gz = \text{CONSTANT}$  — Bernoulli (along a streamline)
  - Tip: Often used to compare two situations...
    - e.g. if *height* is the same ( $\Delta z = 0$ ), then the  $\rho gz$  terms cancels out
    - e.g. if *velocity* is the same ( $\Delta v = 0$ ), then the  $\frac{1}{2}\rho v^2$  terms cancels out
- $v = \sqrt{2gh}$  — Torricelli (outward flow from a hole depth  $h$  below the surface)

## 3. Fluids with Solid Objects Involved

- $F_{\text{buoyant}} = \rho_{\text{fluid}} \cdot g \cdot V_{\text{displaced}}$  — Buoyant force (Archimedes' principle)
  - $\implies$  "**Buoyant force equals weight of displaced fluid**"
- $W_{\text{in water}} = W_{\text{out of water}} - F_{\text{buoyant}}$  — Apparent weight / scale reading
  - Think of "weight" as how *heavy* something feels — weight is a *force*, so it has units of *Newtons!!!*

## 4. Misc/Useful

- *Conversions:*
  - $1 \text{ mL} = 1 \text{ cm}^3 = 10^{-6} \text{ m}^3$
  - $1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$
- *Constants:*
  - $\rho_{\text{Water}} = 1000 \frac{\text{kg}}{\text{m}^3}$