GATE PATHSHALA

Properties of Fluids

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1. Density ρ

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

Where:
ρ = Density [kg/m^3]
m = Mass [kg]
V = Volume [m^3]

2. Specific Weight γ

$$\gamma = \rho g$$

Where:
γ = Specific weight [N/m^3]
g = Gravitational acceleration $\approx 9.81\,\text{m/s}^2$

3. Specific Volume v

$$v = \frac{1}{\rho}$$

Where:
v = Specific volume [m^3/kg]

4. Specific Gravity SG

$$SG = \frac{\rho_{\text{fluid}}}{\rho_{\text{water}}}$$

Where:
SG = Specific gravity (dimensionless)
ρ_{fluid} = Density of fluid
$\rho_{\text{water}} \approx 1000\,\text{kg/m}^3$

5. Dynamic Viscosity μ

$$\tau = \mu \frac{du}{dy}$$

Where:
τ = Shear stress [Pa = N/m^2]
μ = Dynamic viscosity [Pa $\cdot$ s]
$\frac{du}{dy}$ = Velocity gradient

6. Kinematic Viscosity ν

$$\nu = \frac{\mu}{\rho}$$

Where:
ν = Kinematic viscosity [m^2/s]

7. Bulk Modulus of Elasticity K

$$K = -V \frac{dP}{dV} = \rho \frac{dP}{d\rho}$$

Where:
K = Bulk modulus [Pa]
P = Pressure, V = Volume

8. Compressibility β

$$\beta = \frac{1}{K} = -\frac{1}{V} \frac{dV}{dP}$$

Where:
β = Compressibility [Pa^{-1}]

9. Vapor Pressure P_{vap}

Definition: Pressure at which a liquid is in equilibrium with its vapor.
Units: [Pa]

10. Surface Tension σ

Definition: Force per unit length at fluid interface.
Units: [N/m]

11. Capillary Rise/Depression h

$$h = \frac{2\sigma \cos\theta}{\rho g r}$$

Where:
h = Capillary rise or fall [m]
θ = Contact angle
σ = Surface tension [N/m]
ρ = Density [kg/m^3]
r = Radius of tube [m]

12. Ideal Gas Law

Specific form:

$$P = \rho R T$$

Molar form:

$$PV = nRT$$

Where:
P = Pressure [Pa]
ρ = Density [kg/m^3]
T = Absolute temperature [K]
R = Gas constant
n = Number of moles
V = Volume

13. Speed of Sound c

In liquids:

$$c = \sqrt{\frac{K}{\rho}}$$

In ideal gases:

$$c = \sqrt{\gamma \frac{P}{\rho}}$$

Where:
c = Speed of sound [m/s]
γ = Ratio of specific heats C_p/C_v

14. Relationship Between Atmospheric Pressure and Gauge Pressure

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

Where:

- P_{absolute}: **Absolute pressure** — pressure measured relative to a perfect vacuum.
- P_{gauge}: **Gauge pressure** — pressure measured relative to atmospheric pressure (typical gauge reading).
- P_{atm}: **Atmospheric pressure** — standard atmospheric pressure at sea level:

$$P_{\text{atm}} \approx 101.325\,\text{kPa} = 1\,\text{atm} = 760\,\text{mmHg}$$

Special Cases

1. **Perfect vacuum:**

   $$P_{\text{gauge}} = -P_{\text{atm}}$$

   (i.e., absolute pressure is zero)

2. **Gauge reads zero:**

   $$P_{\text{absolute}} = P_{\text{atm}}$$