CHAPTER-9: MECHANICAL PROPERTIES OF FLUIDS

Part–1: Pressure • Pascal's Law • Buoyancy • Archimedes' Principle

1. Pressure

Pressure is the normal force acting per unit area.

Formula

$$P = \frac{F}{A}$$

Where

- P = Pressure
- F = Normal Force
- A = Area

SI Unit: Pascal or N/m^2

$$1Pa = 1N/m^2$$

2. Atmospheric Pressure

Standard Atmospheric Pressure

$$P = 1.013 \times 10^5 Pa$$

or

$$1atm = 760mmHg$$

3. Density

Density is mass per unit volume.

Formula

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

SI Unit: kg/m^3

4. Relative Density (Specific Gravity)

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

Dimensionless Quantity

5. Pascal's Law

Pressure applied to a confined fluid is transmitted equally in all directions.

6. Hydraulic Lift

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

Mechanical Advantage

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

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7. Hydrostatic Pressure

Pressure at depth h

$$P = \rho g h$$

Total Pressure

$$P = P_0 + \rho g h$$

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8. Thrust

Force acting normally on a surface.

$$F = PA$$

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9. Buoyant Force (Upthrust)

According to Archimedes' Principle

$$F_B = \rho V g$$

Where

- ρ = Density of Fluid
- V = Volume of Fluid Displaced

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10. Archimedes' Principle

The buoyant force acting on a body immersed in a fluid is equal to the weight of the displaced fluid.

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11. Floatation Condition

A body floats when

$$F_B = W$$

That is,

$$\rho_{fluid} V g = mg$$

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12. Fraction of Volume Submerged

$$\frac{V_{sub}}{V} = \frac{\rho_{body}}{\rho_{fluid}}$$

Exam Tips

- Pressure depends on **Area** as well as **Force**.
- Hydrostatic Pressure depends only on **Depth**, not on the shape of the container.
- Floating Body → **Buoyant Force = Weight**.

Part–2 : Surface Tension • Viscosity • Bernoulli's Theorem

13. Surface Tension (T)

Surface tension is the force acting per unit length on the free surface of a liquid.

Formula

$$\boxed{T = \frac{F}{L}}$$

SI Unit: N/m

14. Surface Energy

Surface Energy = Work done per unit surface area.

$$\boxed{E = TA}$$

Or

$$\boxed{E = \frac{W}{A}}$$

Where

- T = Surface Tension
- A = Surface Area

15. Capillary Rise

Height of liquid in a capillary tube

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

Where

- r = Radius of Capillary
- θ = Angle of Contact

16. Excess Pressure inside a Liquid Drop

$$\boxed{\Delta P = \frac{2T}{R}}$$

17. Excess Pressure Inside a Soap Bubble

$$\boxed{\Delta P = \frac{4T}{R}}$$

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18. Coefficient of Viscosity

According to Newton's Law of Viscosity

$$\boxed{F = \eta A \frac{dv}{dx}}$$

Where

- η = Coefficient of Viscosity

SI Unit: Pa·s

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19. Stokes' Law

Viscous Force

$$\boxed{F = 6\pi\eta r v}$$

Where

- r = Radius of Sphere
- v = Velocity

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20. Terminal Velocity

$$\boxed{v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}}$$

Where

- ρ = Density of Sphere
- σ = Density of Liquid

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21. Streamline Flow

Fluid particles move in smooth, parallel paths.

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22. Turbulent Flow

Fluid particles move irregularly.

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23. Equation of Continuity

$$\boxed{A_1 v_1 = A_2 v_2}$$

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24. Bernoulli's Theorem

Pressure + Kinetic Energy per unit volume + Potential Energy per unit volume = Constant

$$\boxed{P + \frac{1}{2}\rho v^2 + \rho g h = \text{Constant}}$$

25. Venturimeter Principle

Venturimeter works on Bernoulli's Principle.

Exam Tips

- Soap Bubble → Excess Pressure always double of **Liquid Drop**
- Bernoulli's Theorem→ increase in **Velocity, Pressure decreases**
- Continuity Equation → applicable for **Incompressible Fluid**