Fluid Mechanics Machinery

<mark>💧 **UNIT 1 – Properties of Fluid**</mark>

◆ 1.1 Concept of Fluid

A **fluid** is a substance that **can flow and change its shape easily** when an external force is applied. It includes **liquids, gases, and vapors**.

📌 *Real-life Example:* Water flowing in pipes, air moving through a fan, or engine oil in a machine.

👉 **Key Characteristics:**

- No fixed shape

- Can be compressed (gases)

- Can take shape of container

- Offers less resistance than solids

◆ 1.2 Properties of Fluid

✅ **1. Density (ρ):**

The **mass per unit volume** of a fluid.

📘 Formula:

$$\rho = \frac{mass}{volume}$$

📏 Unit: kg/m³

📌 *Example:* Water = 1000 kg/m³

✅ **2. Specific Gravity (SG):**

The **ratio of the density** of a fluid to the **density of water** (at 4°C).

📘 Formula:

$$\frac{\rho_{fluid}}{\rho_{water}}$$

📏 Unit: None (it's a ratio)

📌 *Example:* SG of petrol ≈ 0.7

✅ **3. Specific Weight (γ):**

The **weight per unit volume** of a fluid.

📘 Formula:

$$\gamma = \rho \times g$$

📏 Unit: N/m³ (Newton per cubic metre)

🧠 *g = 9.81 m/s² (acceleration due to gravity)*

✅ **4. Specific Volume (v):**

The **volume occupied by a unit mass** of fluid.

📘 Formula:

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

📏 Unit: m³/kg

◆ 1.3 Viscosity & Newton's Law of Viscosity

✅ **What is Viscosity?**

Viscosity is the **internal resistance** of a fluid to flow. Thicker the fluid, higher the viscosity.

📌 *Example:* Honey has more viscosity than water.

✅ **Newton's Law of Viscosity:**

" The frictional force (resistance) between layers of fluid is directly proportional to the difference in their speed (velocity) and inversely proportional to the distance between them."

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

- τ = Shear stress (N/m²)
- μ = Dynamic viscosity (Pa·s)
- $\frac{du}{dy}$ = Velocity gradient (rate of change of velocity)

💡 **In simple words**:

"Thicker the fluid (like honey), more it resists flow. Newton explained this resistance with a formula."

📦 Example:
Water flows easily (low μ), honey flows slowly (high μ).

✅ **Dynamic Viscosity (μ):**

Dynamic viscosity is the **internal resistance** of a fluid to flow when a **shear force** is applied.

Or in your words:

"How lazy the fluid is to move when we try to push it."

📏 Unit: N·s/m² or Pa·s

✅ **Kinematic Viscosity (v):**

Kinematic viscosity is the **ratio** of **dynamic viscosity** to **density** of the fluid.

📘 Formula:

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

📏 Unit: m²/s

◆ 1.4 Types of Fluids

Fluid Type	Description	Example
Ideal Fluid	Imaginary fluid with no viscosity	Not real
Real Fluid	Actual fluids with viscosity	Water, oil, air
Newtonian Fluid	Fluids with constant viscosity regardless of stress	Water, air
Non-Newtonian Fluid	Viscosity changes with applied stress	Paint, blood, ketchup

◆ 1.5 Cohesion, Adhesion, Surface Tension & Capillarity

✅ **Cohesion:**

Attractive force between **same kind of molecules**.

📌 *Example:* Water sticking to itself to form droplets.

✅ **Adhesion:**

Attractive force between **different types of molecules**.

📌 *Example:* Water sticking to glass.
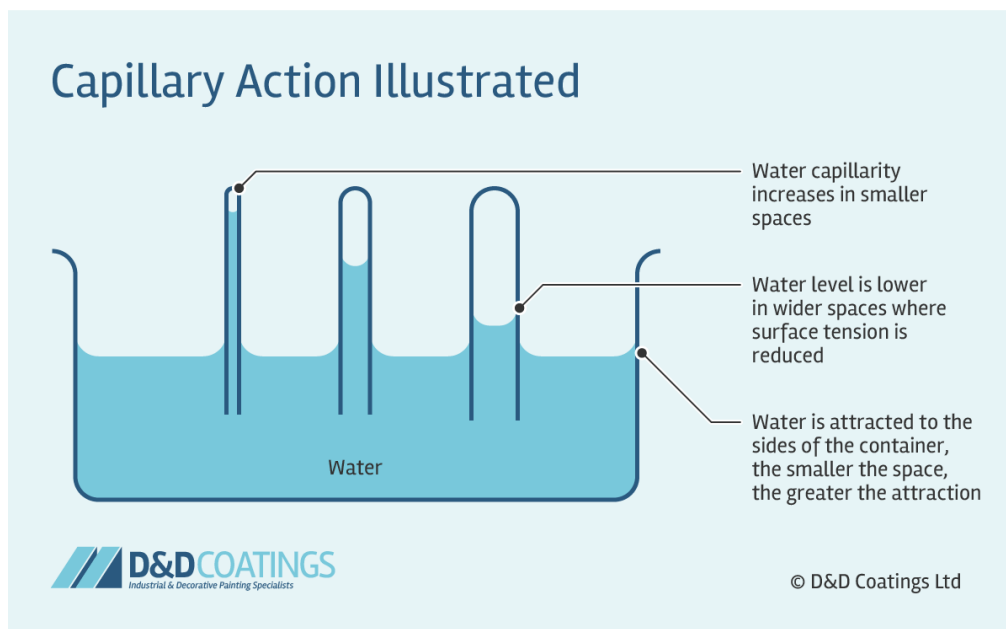
✅ **Surface Tension:**

Surface tension is the **stretchy skin** on the surface of a liquid caused by the **tight pulling** between liquid molecules.

📌 *Example:* Small insects walking on water surface.

✅ **Capillarity:**

It's the **ability of a liquid to flow in narrow spaces** (like a thin tube) **without** external force (even **against gravity** sometimes!).

📌 *Example:* Water rising in a plant stem or test tube 🌿

Capillary Action Illustrated

Water capillarity increases in smaller spaces

Water level is lower in wider spaces where surface tension is reduced

Water is attracted to the sides of the container, the smaller the space, the greater the attraction

Water

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◆ 1.6 Vapour Pressure & Compressibility

✅ **Vapour Pressure:**

Vapour pressure is the **pressure created by the vapor** (gas) of a liquid when the **liquid and vapor are in balance** (closed container).

Basically:

"How hard the liquid is trying to become gas."

💧 Liquids with **high vapour pressure** = **Evaporate fast** (like petrol, alcohol)

Example : **Perfume smell** 💐 (High vapour pressure → evaporates quickly into air)

📌 *Important in pumps to avoid cavitation*

✅ **Compressibility:**

Compressibility is the ability of a substance (usually a fluid) to decrease in volume when pressure is applied.

📏 **Formula:**

$$C = -\frac{1}{V} \cdot \frac{dV}{dP}$$

- **C** = Compressibility

- **V** = Volume

- **dV** = Change in volume

- **dP** = Change in pressure

🧠 **Unit**: 1/Pa or Pa^{-1}

🧠 **In your words:**

"How squishable a fluid is when you press it."

- **Gases** = Highly compressible 🫧

- **Liquids** = Slightly compressible 💧

- **Solids** = Barely compressible 🪨

📌 *Example:* Air can be compressed in a tire, water cannot compress easily.

📄 Suggestion Paper

✍️ Short Questions (2–3 Marks)

1. Define fluid. Give 2 examples.

2. What is density? State its unit and formula.

3. Define viscosity.

4. What is kinematic viscosity?

5. Write the formula of Newton's law of viscosity.

6. What is cohesion and adhesion?

7. Define surface tension.

8. Define capillarity.

9. What is vapor pressure?

10. Define compressibility.

✍️ Medium Questions (3–4 Marks):

1. Explain any three properties of fluid.

2. Differentiate between Newtonian and Non-Newtonian fluids.

3. Explain surface tension and capillarity with examples.

4. Discuss the types of fluids with a proper classification table.

5. Explain the concept of viscosity and Newton's law of viscosity.

6. Write a note on cohesion, adhesion, and surface tension.

📝 Long Questions (5–7 Marks):

1. Describe different types of fluids with neat classification and example.

2. Explain Newton's law of viscosity and its terms in detail.

3. Write detailed notes on: **a)** Surface tension **b)** Capillarity **c)** Viscosity

4. Explain in detail the fluid properties – density, specific gravity, specific weight, and specific volume with their formulas.

5. Explain the concept of vapor pressure and compressibility with proper examples.

🧠 MCQ Sheet

1. Which of the following is considered a fluid?

a) Solid

b) Gas

c) Liquid

d) **Both b and c**

2. The density of water at 4°C is:

a) 0.1 kg/m³

b) 1 g/cm³

c) **1000 kg/m³**

d) 1 kg/litre

3. Specific gravity has:

a) No unit

b) Unit of N/m³

c) Unit of kg/m³

d) **No unit**

4. Newton's law of viscosity is expressed as:

a) $\tau = \rho g H$

b) $\tau = \mu du$

c) **$\tau = \mu \ (du/dy)$**

d) $\tau = \gamma \times v$

5. Viscosity is defined as:

a) Resistance to heat

b) **Resistance to flow**

c) Resistance to pressure

d) Resistance to compression

6. Which fluid has highest viscosity?

a) Water

b) **Honey**

c) Petrol

d) Air

7. Surface tension is mainly due to:

a) Gravity

b) Atmospheric pressure

c) **Cohesion**

d) Adhesion

8. Capillary rise is more in:

a) **Thin tubes**

b) Thick tubes

c) Short tubes

d) Large tanks

9. An ideal fluid is:

a) **Frictionless and incompressible**

b) Has no weight

c) Realistic

d) Non-flowing

10. Compressibility is more in:

a) **Gases**

b) Water

c) Solids

d) Mercury