

11. MECHANICAL PROPERTIES OF FLUIDS

IMP DEFINITIONS & FORMULAS

1. **Viscosity:** The property of a fluid which resists the relative motion between different layers is called viscosity.

SI units : poiseuille (PI)

Dimensions : $[ML^{-1}T^{-1}]$.

2. **Coefficient of viscosity(η)** for a fluid is the ratio of shearing stress to the strain rate.

$$\text{Coefficient of viscosity } \eta = \frac{F/A}{v/l} = \frac{Fl}{vA}$$

3. **Bernoulli theorem :** For an ideal fluid flow (steady flow of a non-viscous, incompressible fluid) the sum of the pressure energy, kinetic energy and the potential energy, per unit volume of the fluid, remains constant, at all points in the path of the flow.

Bernoulli equation is given by $P + \rho gh + \frac{1}{2} \rho v^2 = \text{constant}$.

4. **Stokes law:** Viscous force acting on a smooth spherical body moving in a fluid is directly proportional to (i) coefficient of viscosity of fluid (η) (ii) radius of the spherical body (r) (iii) velocity of body (v) Thus, $F \propto \eta r v \Rightarrow F = k \eta r v$

Experimentally the value of 'k' is found to be 6π $\therefore F = 6\pi \eta r v$

BULLET MASTER'S PHYSI BEATS!

MECHANICAL PROPERTIES OF FLUIDS [2 VSAQ]

Any Flowing substance is called a **Fluid**.

Two Imp. Mechanical Properties of Fluids: 1) Viscosity 2) Capillarity

Fluids are Liquids (Water, Blood, Petrol, Oil, Mercury,...) and Gases (H_2 , O_2 ...)

Fluids have **Female like Properties**, while Solids have **Male like Properties!**

Fluids cannot resist Force!.

Fluids are not Rigid, but Solids are Rigid.

Fluids can flow but Solids can't.

Fluids take the 'shape of the container' but Solids aren't that much.

Fluid gases diffuse into Air but Solids don't diffuse or expand.

Fluids(Petrol, Grease, Water,...) run **Automobile Engines**.

Fluids(Petrol) generate Power.

Fluids(Grease) are used as Lubricants.

Fluids(Water) cool the Engine.

Fluids in our body help to Digest our Food.

Fluids help to carry Nutrients around the body.

IV Fluids (Intra Venum) are given to Patients in Hospitals who can't drink or eat!



5. **Reynolds Number (R_e):** Reynolds defined a dimensionless number called Reynolds number, whose value gives an approximate idea whether the flow would be turbulent.

$$R_e = \rho v d / \eta$$

where ρ is the density of the fluid flowing with a speed v , d stands for the dimension (length or diameter) of the pipe and η is the viscosity of the fluid.

Note: Critical Velocity: The maximum velocity of a fluid in a tube for which the flow remains streamlined is called the critical velocity.

6. **Angle of contact :** “Angle of contact is the angle between solid surface and the tangent drawn to the liquid surface at the point of contact inside the liquid”.

Remarks :

- i) The angle of contact depends only on the nature of the solid .
- ii) Angle of contact for pure water and glass is 0° .
- iii) Angle of contact for glass and mercury is 140° .

7. **Capillarity:** The phenomenon of rise or fall of liquid level in a capillary tube is called capillarity.

IMP FORMULAE

1) $P_{av} = \frac{F}{A}$

2) $P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$

3) $v = \sqrt{2gh}$

4) $P_i - P_0 = \frac{2S}{r}$ (liquid drop)

5) $P_i - P_0 = \frac{4S}{r}$ (Soap bubble)

6) $w = 8\pi S(r_2^2 - r_1^2)$

BULLET MASTER'S

PHYSI BEATS!

IPE POINT OF VIEW:

Two VSAQ (2+2 = 4 Marks)

Basic concepts in Fluid Mechanics:

- 1) Viscosity
- 2) Angle of Contact
- 3) Bernoulli's Principle
- 4) Magnus Effect
- 5) Excess Pressure in Bubbles
- 6) Pascal's Law
- 7) Stoke's Law
- 8) Surface Energy
- 9) Surface Tension
- 10) Hydrostatic Paradox
- 11) Reynold's Number
- 12) Torricelli's Law

Applications:

Dynamic Lift, Hydraulic Lift, Hydraulic breaks, Baro Meter, Mano Meter, Venturi Meter,....