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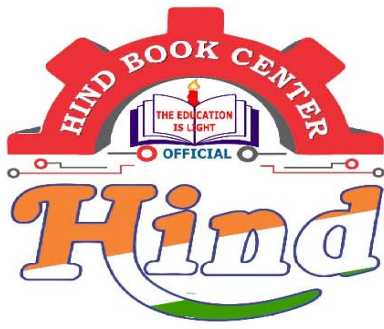
Fluid Mechanics

By- Amit Kakkar Sir

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Fluid Mechanics

Mechanics



Study of motion

(Kinematic)

study of motion without the consideration of basic causes of motion i.e. force.

$$\vec{v} = \frac{d\vec{s}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{j} = \frac{d\vec{a}}{dt}$$

↓
jerk.

not including mass (directly or indirectly)

unit - m , m/s
 m/s^2 , m/s^3

Dynamics -

study of motion with the consideration of basic causes of motion. i.e. force.

$$\vec{F}_{ex} = \frac{d}{dt} (m\vec{v})$$

↓
including mass.

$$\text{Dynamic Viscosity } (\mu) = \frac{N \cdot s}{m^2}$$

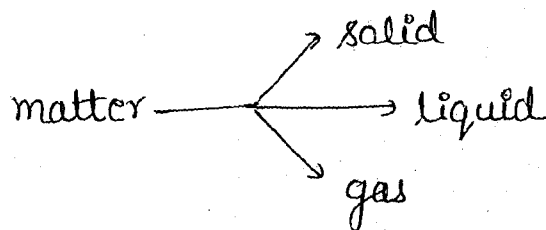
$$\text{kinematic viscosity } (\nu) = \frac{\mu}{\rho} \quad (m^2/s)$$

Fluid Mechanics :-

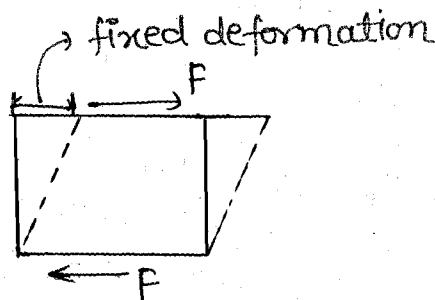
Fluid :- "Liquid & Gases both are having the property of continuous deformation under the action of shear or tangential force. This property of continuously deformation is also known as flow property & Hence liquid & gases are kept in different category which is far away from the solids & this category is known as fluid."

A fluid is a substance which is having & ability to flow under the action of shear & tangential forces.

Fluid -



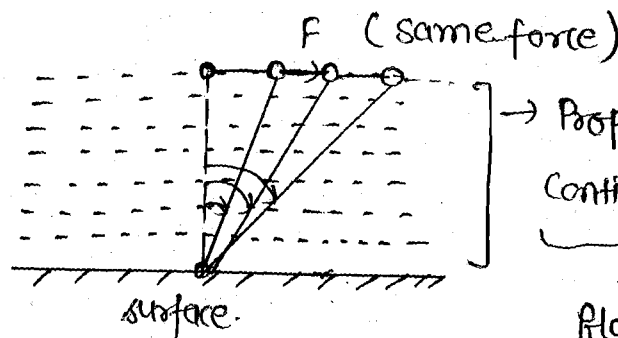
In solid →



deformation change when forces are changes at different-2 time.

In liquid :-

At same force, deformation are changes continuously.



Property of Continuous deformation

⇓
flow property.

Fluid as a Continuum :-

"In macroscopic system, the inter atomic space b/w the molecules of fluid can be treated as negligible as compared to the dimension of the system therefore we can assume adjacent to one molecule there is another molecule & there is no interspace b/w them. Hence the entire fluid molecule system can be treated as continuous distribution of mass system & it is known as Continuum."



BASIC FLUID PROPERTY :-

(i) Density (ρ) :- It is defined as mass per unit body of the substance.

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

unit :- kg/m^3 .

In C.G.S unit -

$$\begin{aligned} 1\text{gm/cc} &= 1\text{gm/cm}^3 \\ &= \frac{10^{-3}\text{kg}}{10^{-6}\text{m}^3} = \frac{1000\text{kg}}{\text{m}^3} \end{aligned}$$

(2) Specific Weight :- It is the weight of the substance per unit volume.

$$\text{sp. wt.} = \frac{mg}{V} = \rho \cdot g$$

$$\boxed{\text{sp. wt.} = \rho g} \quad \text{N/m}^3. \quad \frac{F}{L^3}$$

- (3) Specific Gravity (S.G) :- A sp. gravity of a fluid is defined as a ratio of density of fluid to the density of standard fluid.

$$\boxed{(S.G)_{\text{fluid}} = \frac{\text{Density of fluid}}{\text{Density of standard fluid}}}$$

for liq \Rightarrow Standard fluid \Rightarrow water (1000 kg/m^3).

for gas \Rightarrow Standard fluid \Rightarrow Atm. Air (1.21 kg/m^3).

- (4) Relative density (R.D) :-

$$\boxed{(R.D.)_{1/2} = \frac{\rho_1}{\rho_2}}$$

- (5) Compressibility (β) :-

$$\boxed{\beta = \frac{-\frac{dV}{V}}{dP}} \quad \text{--- (1)}$$

$$\boxed{m = P \times V = \text{Constant}}$$

$$P \cdot dV + V \cdot dP = 0$$

$$\boxed{\frac{-dV}{V} = \frac{dP}{P}}$$

Put these value in eqⁿ (1)

$$\beta = \frac{1}{\rho} \cdot \frac{d\rho}{dP}$$

If ρ is not changing w.r.t pressure —

$$\frac{d\rho}{dP} \rightarrow 0 \Rightarrow \boxed{\beta = 0}$$

Incompressible

If ρ is changing w.r.t pressure —

$$\frac{d\rho}{dP} \neq 0 \Rightarrow \boxed{\beta \neq 0}$$

Compressible.

Liquid



Compressible

For water ρ —

at 1 atm $\rightarrow \rho_{\text{water}} = 998 \text{ kg/m}^3$

at 100 atm $\rightarrow \rho_{\text{water}} = 1003 \text{ kg/m}^3$.

$$\therefore \Delta\rho = 5 \text{ kg/m}^3$$

$$\% \text{ change} = \frac{5}{998} \times 100 = \frac{\Delta\rho}{\rho} \times 100$$

$$\approx 0.5\%$$

$$\boxed{\beta_{\text{liq}} = 0}$$

Liquid are treated as Incompressible.

Gases



Highly Compressible

$$P = \rho RT$$

$$P \propto \rho$$

NOTE :-

The Reciprocal of compressibility is known as Bulk modulus of elasticity.

(6) Isothermal Compressibility of gas :-

$$\beta = \frac{1}{\rho} \frac{d\rho}{dP}$$

Ideal gas eqⁿ —

$$P = \rho RT$$

$$\rho = \frac{P}{RT}$$

[Isothermal
T = Constant]

$$\frac{d\rho}{dP} = \frac{1}{RT}$$

$$\therefore \beta_{iso} = \frac{1}{\rho} \cdot \frac{1}{RT}$$

$$\beta_{iso} = \frac{1}{\rho RT}$$

$$\beta_{iso} = \frac{1}{P}$$

$$\kappa_{iso} = \frac{1}{\beta_{iso}} = P$$

(7) Adiabatic compressibility of gas :-

$$\beta = \frac{1}{P} \cdot \frac{dP}{dP}$$

Adiabatic eqⁿ -

$$PV^\gamma = \text{Constant}$$

$$P \cdot \frac{m^\gamma}{P^\gamma} = \text{Constant}$$

$$\left[\begin{aligned} P &= \frac{m}{V} \\ V &= \frac{m}{P} \end{aligned} \right]$$

$$\therefore PP^{-\gamma} = \text{Constant}$$

$$P(-\gamma) P^{-\gamma-1} dP + dP \cdot P^{-\gamma} = 0$$

$$dP = \frac{\gamma P}{P} \cdot dP$$

$$\frac{dP}{P} = \frac{dP}{\gamma P}$$

$$\frac{dP}{dP} = \frac{P}{\gamma P}$$

$$\therefore \beta_{\text{Adia}} = \frac{1}{P} \times \frac{P}{\gamma \cdot P} = \frac{1}{\gamma \cdot P}$$

γ - gamma

$$\beta_{\text{Adia}} = \frac{1}{\gamma \cdot P}$$

$$K_{\text{adia}} = \gamma \cdot P$$

$$\gamma_{\text{Air}} = 1.4$$