MADE EASY

Mechanical Engineering

Toppers Handwritten Notes

Fluid Mechanics

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Fluid Mechanics

Mechanics

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Study of motion

(Kinematics) 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/s², m/s³

Dynamics – study of motion with the cosideration of basic causes of motion. i.e- force.

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

(m) → including mass.

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

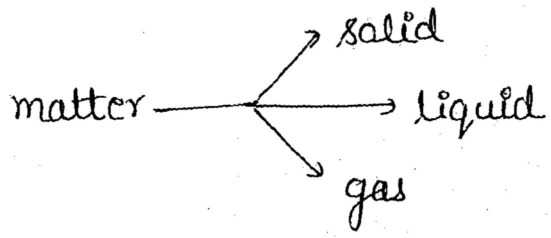
Kinematic viscosity (ν) = $\frac{\mu}{\rho}$ (m^2/s)

Fluid Mechanics :-

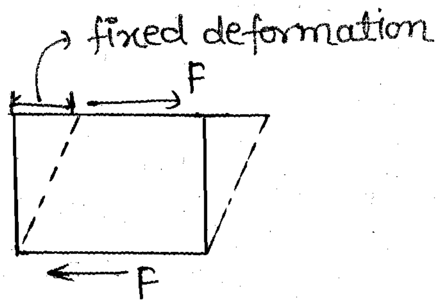
Fluid :- "Liquid & Gases both are having the property of contineous deformation under the action of shear or tongential force. This property of contineously deformation is also known as flow property & Hence Liquid & gases are kept in diffrent catagory which is far away from the solids & this catagory is known as fluid."

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

Fluid —



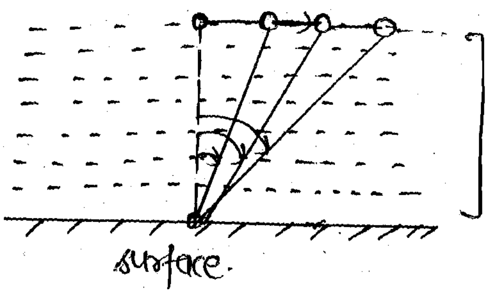
In solid →



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

In liquid :-

At same force, deformation are changes contineously.



→ Property of Contineous deformation

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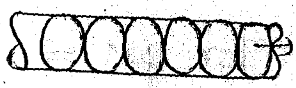
Flow property.

Fluid as a Continuum :—

" In macroscopic system, the inter atomic space b/w the molecules of fluid can be treated as neglegible as compared to the dimension of the system therefore we can assume adjacent to one molecule there is a another molecule. & there is no interspace b/w them. Hence the entire fluid molecule system can be treated as contineous 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.

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

unit :- kg/m^3.

In C.G.S unit —

$$1gm/c.c = 1gm/cm^3 = \frac{10^{-3}kg}{10^{-6}m^3} = \frac{1000kg}{m^3}$$

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

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

$$\boxed{sp.\ wt. = \rho g} \ N/m^3.$$

$\frac{E}{L^3}$

(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.

$$(s.g)_{fluid} = \frac{\text{Density of fluid}}{\text{Density of standardred fluid}}$$

for lq ⇒ Standard fluid ⇒ water ($1000\ kg/m^3$).

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

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

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

(5) Compressibility (β) :-

$$\beta = \frac{-\frac{d\forall}{\forall}}{dP} \quad \text{--- (1)}$$

$$m = \rho \times \forall = \text{Constant}$$

$$\rho \cdot d\forall + \forall \cdot d\rho = 0$$

$$\frac{-d\forall}{\forall} = \frac{d\rho}{\rho}$$

Put these value in eq^n (1)

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

If ρ is not changing w.r.t pressure —

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

Incompressive

If ρ is changing w.r.t pressure —

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

Compressive.

Liquid

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Compressible

For water :-

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

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

$\therefore\ \Delta\rho = 5\ kg/m^3$.

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

$$\approx 0.5\%$$

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

Liquid are treated as Incompressible.

Gases

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Highly Compressible

$$P = \rho RT$$

$$\boxed{P \propto \rho}$$

NOTE :- The Reciprocal of compressibility is known as Bulk modulus of elasticity.

(6) **Isothermal Compressibility of gas :-**

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

Ideal gas eqⁿ —

$$P = \rho RT$$

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

[Isothermal T = Constant].

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

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

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

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

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

(7) Adiabatic Compressibility of gas :-

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

Adiabatic eqn —

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

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

$$\left[\rho = \frac{m}{V} \qquad V = \frac{m}{\rho} \right]$$

$$\therefore \; P\rho^{-\gamma} = \text{constant}$$

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

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

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

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

γ - gama

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

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

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

$$\gamma_{Air} = 1.4$$