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Viscosity

- Viscosity is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.

- For liquids, it corresponds to the informal concept of "thickness": for example, syrup has a higher viscosity than water.

- To think of viscosity in everyday terms, the easier a fluid moves, the lower the viscosity. Using our earlier example, which fluid has a greater viscosity? Honey would move slower than water, so honey would have a greater viscosity.

- When two layers of a fluid, a distance 'dy' apart move one over the other at different velocities say u and u+ du as shown in Fig. 1 , the viscosity together with relative velocity causes a shear stress acting between the fluid layers:

- The top layer causes a shear stress on the adjacent lower layer while the lower layer causes a shear stress on the adjacent top layer.
- This shear stress is proportional to the rate of change of velocity with respect to y. It is denoted by symbol τ called Tau.

$$\tau \propto \frac{du}{dy}$$

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

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

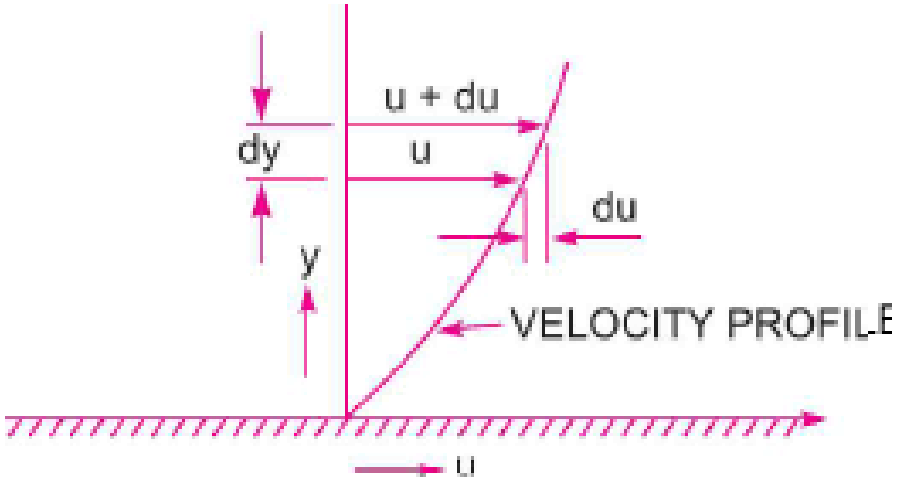


Fig 1 .Velocity variation near a solid boundary

Where,.

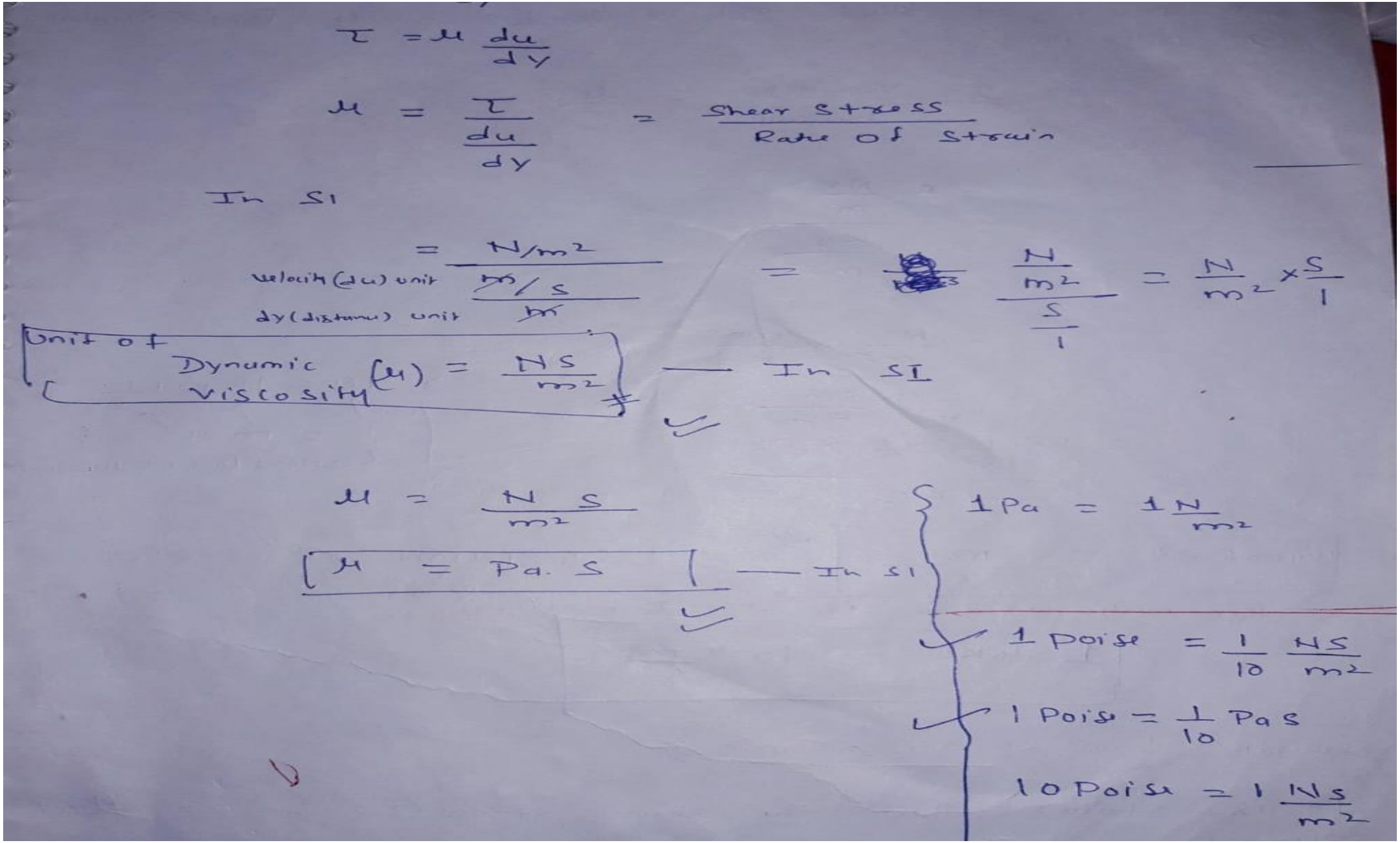
μ = Viscosity

τ = Shear stress= F/A

$\frac{du}{dy}$ = Rate of shear deformation

- where μ (called mu) is the constant of proportionality and is known as the coefficient of dynamic viscosity or only viscosity.
- $\frac{du}{dy}$ represents the rate of shear strain or rate of shear deformation or velocity gradient.

Unit of Dynamic viscosity



Kinematic Viscosity.

- It is defined as the ratio between the dynamic viscosity and density of fluid.lt is denoted by the Greek symbol (ν) called 'nu' .

Thus, mathematically,

$$\nu = \frac{\text{Viscosity}}{\text{Density}} = \frac{\mu}{\rho}$$

- The SI unit of kinematic viscosity is m^2/s.

Unit of kinematic viscosity

$$D = \frac{\text{Viscosity}}{\text{Density}} = \frac{\eta}{\rho}$$

$$= \frac{\frac{Ns}{m^2}}{\frac{kg}{m^3}}$$

$$= \frac{Ns}{m^2} \times \frac{m^3}{kg}$$

$$= \frac{Ns\,m}{kg}$$

$$= \frac{kg \cdot \frac{m}{s^2} \times s \times m}{kg}$$

$1\,N = 1\,kg \cdot 1\,\frac{m}{s^2}$

unit: $F = m\,a$ (Second law of Newton)

$$\text{Unit of } D = \frac{m^2}{s}$$ ⇒ MKS & SI unit or in CGS cm^2/s

∴ Kinematic viscosity is also known Stoke.

$$1 \text{ Stoke} = 10^{-4}\,\frac{m^2}{s}$$

Newton's Law of Viscosity.

- It states that the shear stress (τ) on a fluid element layer is directly proportional to the rate of shear strain. The constant of proportionality is called the co-efficient viscosity

$$\tau \propto \frac{du}{dy}$$

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

- Fluid which obey the above relation are known as Newtonian fluids and fluid which do not obey the above relation are called Non-Newtonian fluid.

THANKYOU