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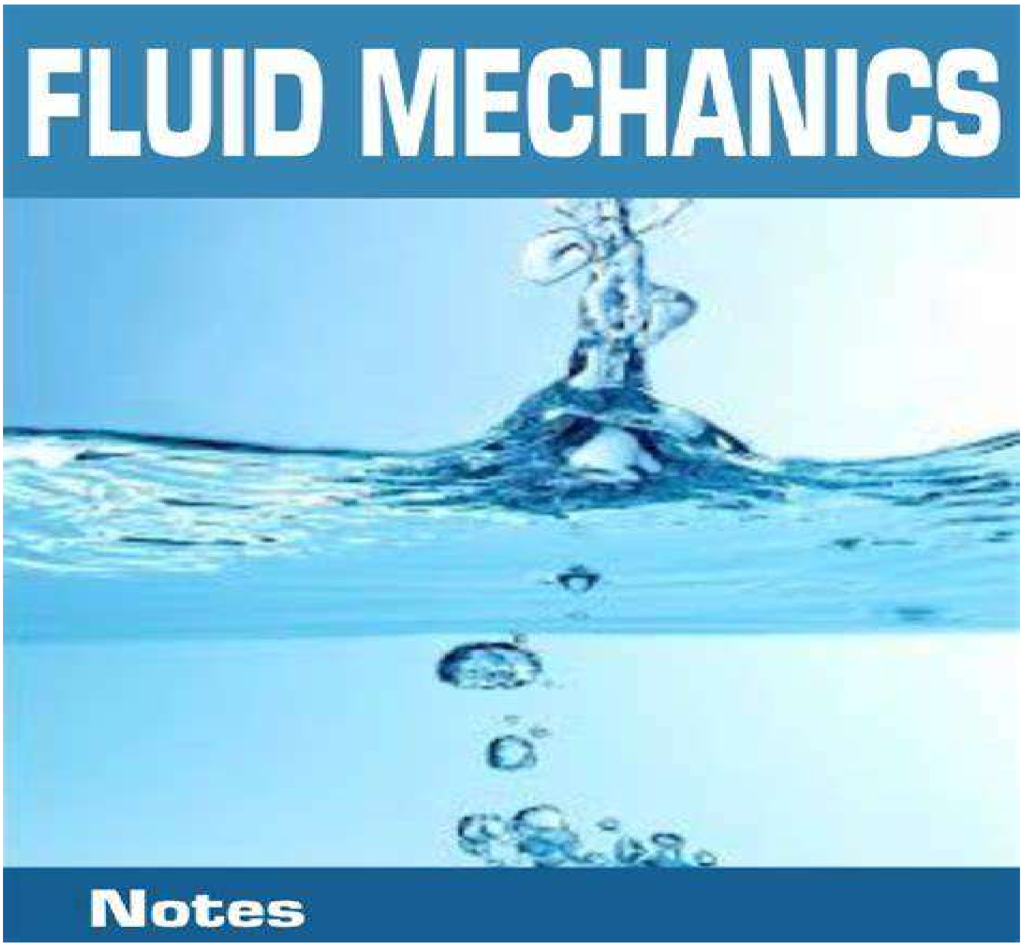

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Fluid mechanics

Fluid mechanics is a science in study the fluid of liquids and gases in the cases of silence and movement and the forces acting on them can be divided materials found in nature into two branches.

A- Solid Matters.

B-Fluid Matters:

Fluid material is divided into two parts:

1- Liquid Matters.

2- Gaseous Matters.

Fluid mechanics include fluid materials such as water, air and other while unique science (Hydraulics) in the water as a liquid within the fluid material.

Hydrodynamics science is the study of the (Flow Fields) for materials may be not the viscosity or compression or correlation but may even be a few special the weight important and fluid called (Ideal fluid).

A fluid: is any substance that conforms the shape of its container and does not permanently resist distortion. Gases, liquids and vapors are considered to have the characteristic of fluids.

If a fluid affected by changes in pressure, it is called compressible fluid otherwise, it is called incompressible fluid [1].

1.1 Units

The basic dimensions in fluid mechanics are below:

Property	Symbol	SI Unit	English Unit
Force	F	N	Ib
Length	L	m, cm	Ft, in
Mass	M	Kg	Slug
Time	T	S, min, hr	S, min, hr
Temperature	t	C°	F°

1.1 Introduction

- Fluid mechanics is a branch of engineering science which deals with the behavior of fluids (liquid or gases) at rest as well as in motion.

1.2 Properties of Fluids

- **Density or Mass Density**
- Density or mass density of fluid is defined as the ratio of the mass of the fluid to its volume.
- Mass per unit volume of a fluid is called density.
- It is denoted by the symbol **'ρ' (rho).**
- The unit of mass density is kg per cubic meter i.e. kg/m^3.
- Mathematically,

$$\rho = \frac{\text{Mass of fluid}}{\text{Volume of fluid}}$$

- The value of density of water is 1000 kg/m^3.

- **Specific Weight or Weight Density**
- Specific weight or weight density of a fluid is defined as the ratio of weight of a fluid to its volume.
- Thus weight per unit volume of a fluid is called weight density.
- It is denoted by the symbol 'w'.
- Mathematically,

$$w = \frac{\text{Weight of fluid}}{\text{Volume of fluid}}$$

$$= \frac{(\text{Mass of fluid}) \times (\text{Acceleration due to gravity})}{\text{Volume of fluid}}$$

$$= \frac{(\text{Mass of fluid}) \times g}{\text{Volume of fluid}}$$

$$= \rho \times g$$

$$\boxed{w = \rho g}$$

- The value of specific weight of water is 9.81 X 1000 N/m^3 in SI unit.

- **Specific Volume**
- Specific volume of a fluid is defined as the volume of a fluid occupied by a unit mass of fluid.
- Thus specific volume is volume per unit mass of fluid.
- It is expressed as m^3/kg.

- Mathematically,

$$\text{Specific volume} = \frac{\text{Volume of fluid}}{\text{Mass of fluid}}$$

$$= \frac{1}{\dfrac{\text{Mass of fluid}}{\text{Volume of fluid}}}$$

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

- Thus specific volume is the reciprocal of mass density.

- **Specific Gravity or Relative Density**
  - Specific gravity is define as the ratio of the density (or weight density) of a fluid to the density (or weight density) of a standard fluid.

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- For liquids, standard fluid is taken water and for gases, standard fluid is taken air.
- Specific gravity is also called relative density.
- It is dimensionless quantity and is denoted by symbol S.
- Mathematically,

$$S(\text{for liquid}) = \frac{\text{Weight density (Density) of liquid}}{\text{Weight density (Density) of water}}$$

$$S(\text{for gases}) = \frac{\text{Weight density (Density) of gas}}{\text{Weight density (Density) of air}}$$

- Specific gravity of mercury is 13.6.

1.3 Viscosity

- Viscosity is defined as the property of fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of fluid.
- When two layers of a fluid distance 'dy' apart, move one over the another at different velocities, say u and u + du as shown in fig., the viscosity together with relative velocity causes a shear stress acting between the fluid layers.

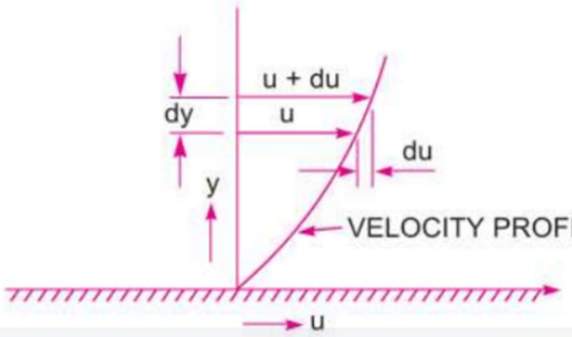

Fig.1.1 Velocity variation near a solid boundary

- The top layer causes a shear stress on the adjacent lower layer while the lower layer causes 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 (Tau).

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

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

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

$$\mu = \frac{\tau}{\left(\frac{du}{dy}\right)}$$

- Viscosity is also defined as the shear stress required to produce unit rate of shear strain.

Unit:

$$\therefore\ \mu = \frac{\text{Shear stress}}{\dfrac{\text{Change of velocity}}{\text{Change of distance}}}$$

$$= \frac{\text{Force}/\text{Area}}{\dfrac{\text{Length}}{\text{Time}} \times \dfrac{1}{\text{Length}}}$$

$$= \frac{\text{Force} \times \text{Time}}{(\text{Length})^2}$$

- **In SI system,** Unit of viscosity is $\frac{N \bullet s}{m^2} = pa \bullet s$
- **In MKS system,** Unit of viscosity is $\frac{kgf \bullet sec}{m^2}$
- **In CGS system,** Unit of viscosity is $\frac{dyne \bullet sec}{cm^2}$ (or Poise)

Note:

$$\boxed{1\ \text{Poise} = \frac{1}{10} \frac{N \bullet s}{m^2}}$$

- **Newton's Law of Viscosity**

- Its 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 of viscosity.
- Mathematically,

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

- The fluid may be classified into the following five types:
    1. Ideal fluid
    2. Real fluid
    3. Newtonian fluid
    4. Non-Newtonian fluid
    5. Ideal plastic fluid.

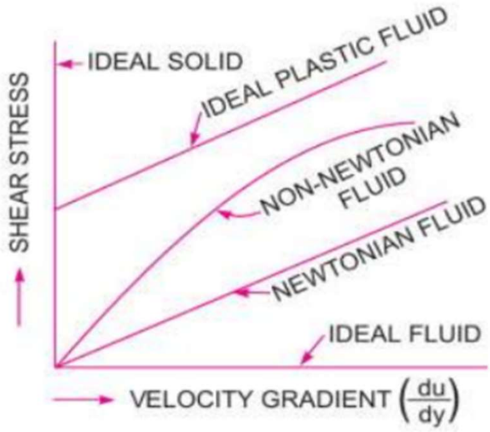

Fig.1.2 Types of fluid

1. Ideal Fluid
- A fluid, which is incompressible and is having no viscosity, is known as ideal fluid.
- Ideal fluid is only an imaginary fluid because all the fluids, which exit, have some viscosity.

2. Real Fluid
- A fluid which possesses viscosity is known as real fluid.
- All the fluids in practice are real fluids.

3. Newtonian fluid
- A real fluid, in which the shear stress is directly proportional to the rate of shear strain (or velocity gradient), is known as the Newtonian fluid.
- Example : Water, Air, Thin motor oil

4. Non-Newtonian Fluid
- A real fluid, in which the shear stress is not proportional to the rate of shear strain (or velocity gradient), is known as the non-Newtonian fluid.
- Example : Tooth Paste

5. Ideal-Plastic Fluid
- A fluid, in which shear stress is more than the yield value and shear stress is proportional to the rate of shear strain(or velocity gradient), is known as ideal plastic fluid.
- Example : Sewage sludge