Unit – I

Pressure and Pressure Measurement

Session - I

Introduction

- A matter exists in nature, either in the solid state or the fluid state. The fluid state is further divided into the liquid and the gaseous states.
- The two classes of fluids i.e. gases and liquids also exhibit quite different characteristics.
- Practically all fluids (liquids as well as gases) are compressible.
- Gases can be compressed much readily under the action of external pressure, hence considered as compressible. On the other hand under ordinary conditions liquids are quite difficult to compress and therefore they may for most purposes be regarded as incompressible.

Fluid

❑ Definition of a Fluid

- A fluid may be defined as a substance which is capable of flowing.
- It has no definite shape of its own, but conforms to the shape of the containing vessel.
- A liquid is a fluid, which possesses a definite volume, which varies only slightly with temperature and pressure. Since under ordinary conditions liquids are difficult to compress, they may be for all practical purposes regarded as incompressible.

❑ Types of a Fluids

- The fluids are also classified as ideal fluids and real fluids.
- Ideal fluids are those fluids which have no viscosity and surface tension and they are incompressible. As such for ideal fluids no resistance is encountered as the fluid moves. However, in nature the ideal fluids do not exist and therefore, these are only imaginary fluids. The fluids which have low viscosity such as air, water etc., may however be treated as ideal fluids.
- Real fluids are those fluids which are actually available in nature. These fluids possess the properties such as viscosity, surface tension

and compressibility and therefore a certain amount of resistance is always offered by these fluids when they are set in motion.

Difference in behaviour of Fluids w.r.to Solids

Solids	Fluids
They cannot flow	They can flow
They have their own shape	They have no definite shape
Spacing between molecules is less	Spacing between molecules is more
Require less space	Require more space
Density is more	Density is less
Specific gravity is more	Specific gravity is less

Hydraulics and Fluid Mechanics

❑ Hydraulics

Hydraulics is that branch of science which deals with the behaviour of the water at rest as well as in motion. i.e. Hydraulics is only deals with the study of water.

❑ Fluid Mechanics

Fluid mechanics is that branch of science which deals with the behaviour of the fluids at rest as well as in motion. In general the scope of fluid mechanics is very wide which includes the study of all liquids and gases.

Branches of Hydraulics

Hydraulics is classified as :

I. Hydrostatics II. Hydrodynamics III. Hydrokinematics

❑ Hydrostatics

Hydrostatics is the branch of Hydraulics which deals with the study of the water at rest.

❑ Hydrodynamics

Hydrodynamics is the branch of Hydraulics which deals with the study of the water in motion with considering the forces causing the motion.

❑ Hydrokinematics

Hydrodynamics is the branch of Hydraulics which deals with the study of the water in motion without considering the forces causing the motion.

Applications of Hydraulics in Civil Engineering

- To measure the velocity of flowing fluid in a pipe
- To calculate the pressure at any in a flowing fluid in an open channel
- To determine the discharge of fluid flowing through a pipe
- To design water distribution system and most economical channel section and hydraulic structures
- To design water treatment plant (WTP) and sewage treatment plant (STP)

Physical Properties of Fluids

The physical properties of fluids are as follows :

- Mass density
- Specific Volume
- Specific Weight
- Specific Gravity
- Viscosity
- Compressibility
- Surface Tension and Capillarity
- Cohesion and Adhesion

❑ Mass Density or Specific Mass or Density

- The density or mass density of a fluid is defined as the ratio of the mass of the fluid to its volume. Thus the mass per unit volume of the fluid is called density.
- It is denoted by 'ρ' (rho) .
- The unit of mass density is Kg/m^3

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

- The value of density of water is $1000Kg/m^3$

❑ Specific Volume

- It is defined as the volume of the fluid occupied by a unit mass or volume per unit mass of fluid is called Specific volume.
- It is denoted by 'V_S' .

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

$$V_s = \frac{1}{\left(\frac{\text{Mass of fluid}}{\text{Volume of fluid}}\right)}$$

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

- Thus the Specific volume is the reciprocal of Mass density. It is expressed as m^3/kg and is commonly applied to gases.

❑ Specific Weight or Weight density or Unit Weight

- It is the ratio between the weights of the fluid to its volume. The weight per unit volume of the fluid is called weight density .
- It is denoted by 'w' or 'γ'.

$$w = \frac{\text{Weight of fluid}}{\text{Volume of fluid}} = \frac{\text{Mass of fluid x Acceleration dueto gravity}}{\text{Volume of fluid}}$$

$$w = \left(\frac{\text{Mass of fluid}}{\text{Volume of fluid}}\right) x\, g = \rho\, x\, g$$

$$w = \rho \times g$$

- The value of Specific Weight of water is 9810N/m^3.

❑ Specific Gravity or Relative Density

- It is defined as the ratio of the Weight density (or Mass density) of a fluid to the Weight density (or Mass density) of a standard fluid.
- For liquids the standard fluid taken is water and for gases the standard liquid taken is air.
- The Specific gravity is also called relative density.
- It is a dimension less quantity and it is denoted by 'S' or 'G'.

For liquid,

$$S = \frac{\text{Weight density of liquid}}{\text{Weight density of water}} \quad \text{or} \quad S = \frac{\text{Mass density of liquid}}{\text{Mass density of water}}$$

- The value of Specific Gravity of water is 1.

Problems :

1. Calculate the density, specific weight and weight of one liter of petrol of specific gravity.

Sol^n :

$1\ m^3 = 10^3\ lit \qquad 1\ lit = \frac{1}{10^3}\ m^3 = 1 \times 10^{-3}\ m^3 = 10^{-3}\ m^3$

$\text{Volume of Petrol, } V = 1\ lit = 1 \times 10^{-3}\ m^3 = 10^{-3}\ m^3$

$\text{Specific gravity of petrol, } S = 0.7$

$\text{Specific gravity of petrol, } s = \frac{\text{Density of petrol}}{\text{Density of water}} = \frac{\rho_p}{\rho_w}$

$\text{Density of petrol, } \rho_p = S \times \rho_w = 0.7 \times 1000 = 700\ Kg/m^3$

$\text{Specific Weight, } w_p = \rho_p \times g = 700 \times 9.81 = 6867\ N/m^3$

$\text{Also we know, } w_p = \frac{W}{V}$

$\text{there fore Weight of fluid, } W = w_p \times V = 6867 \times 10^{-3} = 6.867\ N$