Fluid Properties

- Any characteristic of a system is called a property
- Properties are considered to be either intensive or extensive
- Intensive properties are those that are independent of the mass of the system, such as temperature, pressure, and density.
- Extensive properties are those whose values depend on the size—or extent—of the system.
- Total mass, total volume V, and total momentum are some examples of extensive properties
- Extensive properties per unit mass are called specific properties
- Some examples of specific properties are specific volume (v 5 V/m) and specific total energy (e 5 E/m).
- The number of properties required to fix the state of a simple system is given by the state postulate: The state of a simple compressiblee system is completely specified by two independent, intensive properties.

Fluid Properties

- **Mass Density:**
- The density (also known as mass density or specific mass) of a liquid may be defined as the mass per unit volume m/Vat a standard temperature and pressure. It is usually denoted by ρ (rho). Its units are kg/m3, i.e.,

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

- **Weight Density:** The weight density (also known as specific weight) is defined as the weight per unit volume at the standard temperature and pressure. It is usually denoted by w. w = g
- In S.I. Units: w = 9.81 kN/m3 (or 9.81× 10–6 N/mm3)
- In M.K.S. Units: w = 1000 kgf /m3
- **Specific volume:** It is defined as volume per unit mass of fluid. It is denoted by v.

$$v = \frac{V}{m} = \frac{1}{\rho}$$

- **SPECIFIC GRAVITY:**
- Specific gravity is the ratio of the specific weight of the liquid to the specific weight of a standard fluid. It is dimensionless and has no units. It is represented by S. For liquids, the standard fluid is pure water at 4°C.

$$\text{Specific gravity} = \frac{\text{Specific weight of liquid}}{\text{Specific weight of pure water}} = \frac{w_{liquid}}{w_{water}}$$

- Ex. Calculate the specific weight, specific mass, specific volume and specific gravity of a liquid having a volume of 6 m3 and weight of 44 kN.

Solution: Volume of the liquid = $6\ m^3$

Weight of the liquid = 44 kN

Specific weight, w :

$$w = \frac{\text{Weight of liquid}}{\text{Volume of liquid}} = \frac{44}{6} = 7.333\ kN/m^3 \text{ (Ans.)}$$

Specific mass or mass density, ρ :

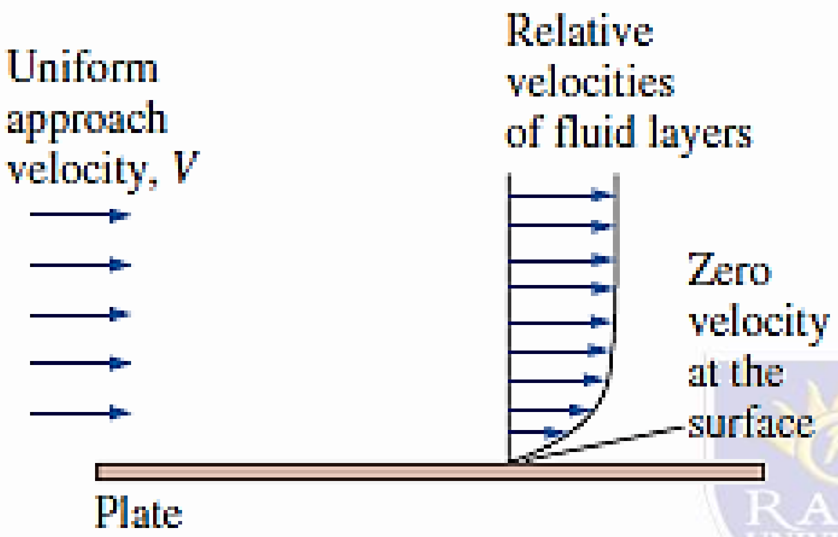
$$\rho = \frac{w}{g} = \frac{7.333 \times 1000}{9.81} = 747.5\ kg/m^3 \text{ (Ans.)}$$

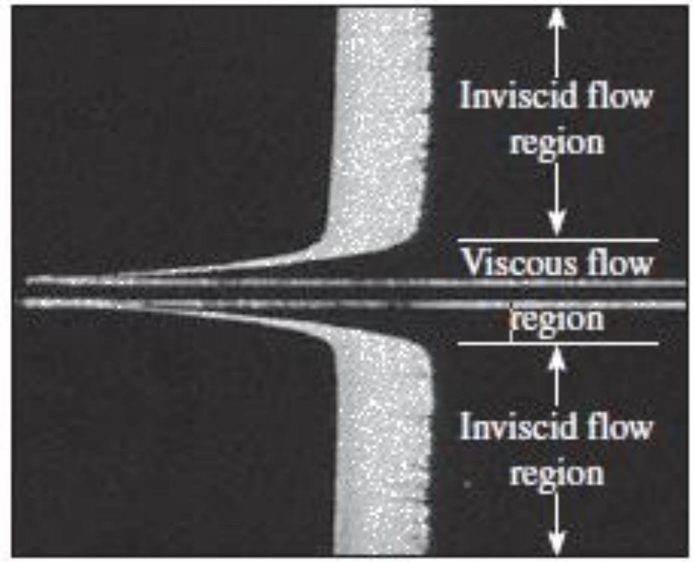
Specific volume, $v = \frac{1}{\rho} = \frac{1}{747.5} = 0.00134\ m^3/kg$ (Ans.)

Specific gravity, S :

$$S = \frac{w_{liquid}}{w_{water}} = \frac{7.333}{9.81} = 0.747 \text{ (Ans.)}$$

- **VISCOSITY:** This internal resistance to flow is quantified by the fluid property viscosity,
- which is a measure of internal stickiness of the fluid.



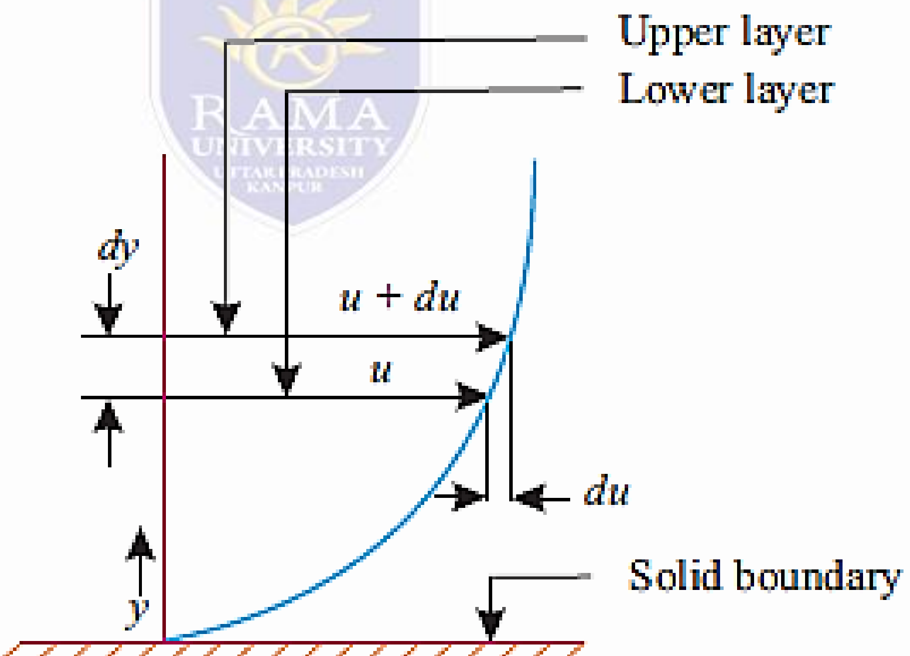


- Viscosity is caused by cohesive forces between the molecules in liquids and by molecular collisions in gases.
- There is no fluid with zero viscosity, and thus all fluid flows involve viscous effects to some degree.
- Flows in which the frictional effects are significant are called viscous flows. However, in many flows of practical interest, there are regions (typically regions not close to solid surfaces) where viscous forces are negligibly small compared to inertial or pressure forces. Neglecting the viscous terms in such inviscid flow regions greatly simplifies the analysis without much loss in accuracy.
- The development of viscous and inviscid regions of flow as a result of inserting a flat plate parallel into a fluid stream of uniform velocity is shown in Fig.

Fluid Properties

- Viscosity may be defined as the property of a fluid which determines its resistance to shearing stresses. It is a measure of the internal fluid friction which causes resistance to flow. It is primarily due to cohesion and molecular momentum exchange between fluid layers, and as flow occurs, these effects appear as shearing stresses between the moving layers of fluid
- An ideal fluid has no viscosity. There is no fluid which can be classified as a perfectly ideal fluid. However, the fluids with very little viscosity are sometimes considered as ideal fluids.
- Viscosity of fluids is due to *cohesion and interaction between particles*.

- When two layers of fluid, at a distance ‘dy’ apart, move one over the otherat different velocities, say u and u + du, 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 τ (called Tau).



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

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

where, μ = Constant of proportionality and is known as *co-efficient of* ***dynamic viscosity*** or *only viscosity*.
du/dy = Rate of shear stress or rate of shear deformation or velocity gradient.

Units of Viscosity:

In *S.I. Units*: N.s/m2
In *M.K.S. Units:* kgf.sec/m2

The unit of viscosity in C.G.S. is also called *poise* = dyne- sec/cm2
One poise = 1/10 N.s/m2