FLUID MECHANICS
(BTME 301-18)

Unit 1: Fundamentals of Fluid Mechanics

Fundamentals of Fluid Mechanics

- Fluid Mechanics is basically a study of:
  - Physical behavior of fluids and fluid systems and laws governing their behavior.
  - Action of forces on fluids and the resulting flow pattern.
- Fluid is further sub-divided in to liquid and gas.
- The liquids and gases exhibit different characteristics on account of their different molecular structure.

- Design of wide range of hydraulic structures (dams, canals, weirs etc) and machinery (Pumps, Turbines etc).
- Design of complex network of pumping and pipe lines for transporting liquids. Flow of water through pipes and its distribution to service lines.
- Fluid control devices both pneumatic and hydraulic.
- Design and analysis of gas turbines and rocket engines and air-craft.
- Power generation from hydraulic, stream and Gas turbines.
- Methods and devices for measurement of pressure and velocity of a fluid in motion.

UNITS AND DIMENSIONS:

- A dimension is a name which describes the measurable characteristics of an object such as mass, length and temperature etc. a unit is accepted standard for measuring the dimension. The dimensions used are expressed in four fundamental dimensions namely Mass, Length, Time and Temperature.
- Mass (M) - Kg
- Length (L) - m
- Time (T) - S
- Temperature (t) - ^{o}C or K (Kelvin)

Density or Mass 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 .
- **Specific weight or Specific density:** 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 and it is denoted by **w**.

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

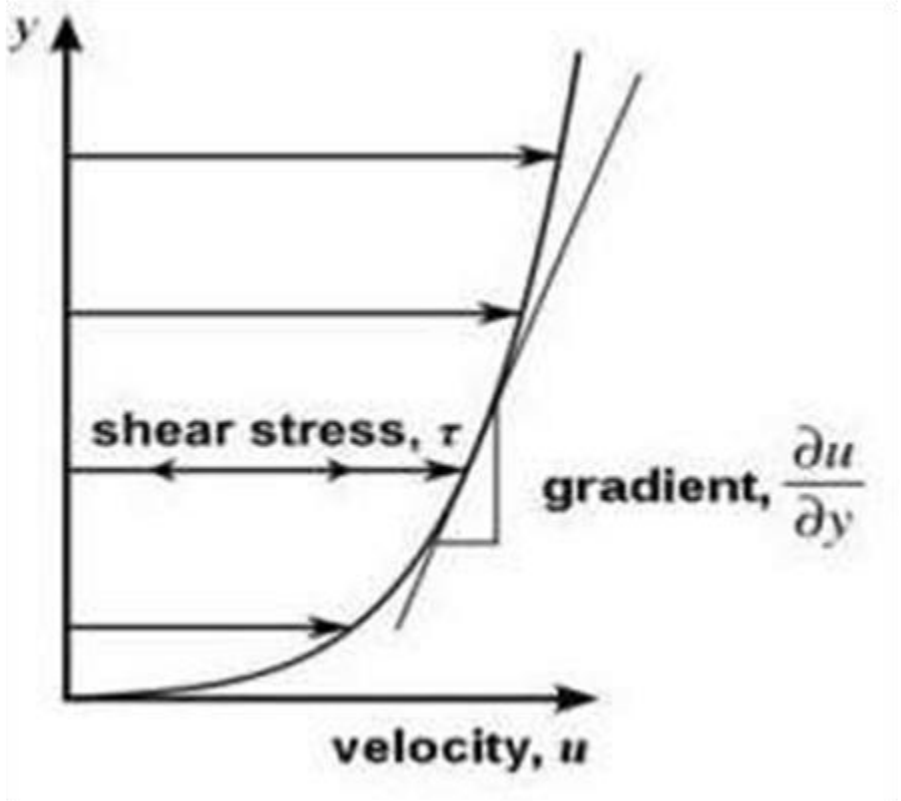
PROPERTIES OF FLUID

- Viscosity
- Surface tension
  - on liquid droplet
  - on hollow bubble
  - on liquid jet
- Capillarity
  - Capillary rise
  - Capillary fall

VISCOSITY

DEFINITION

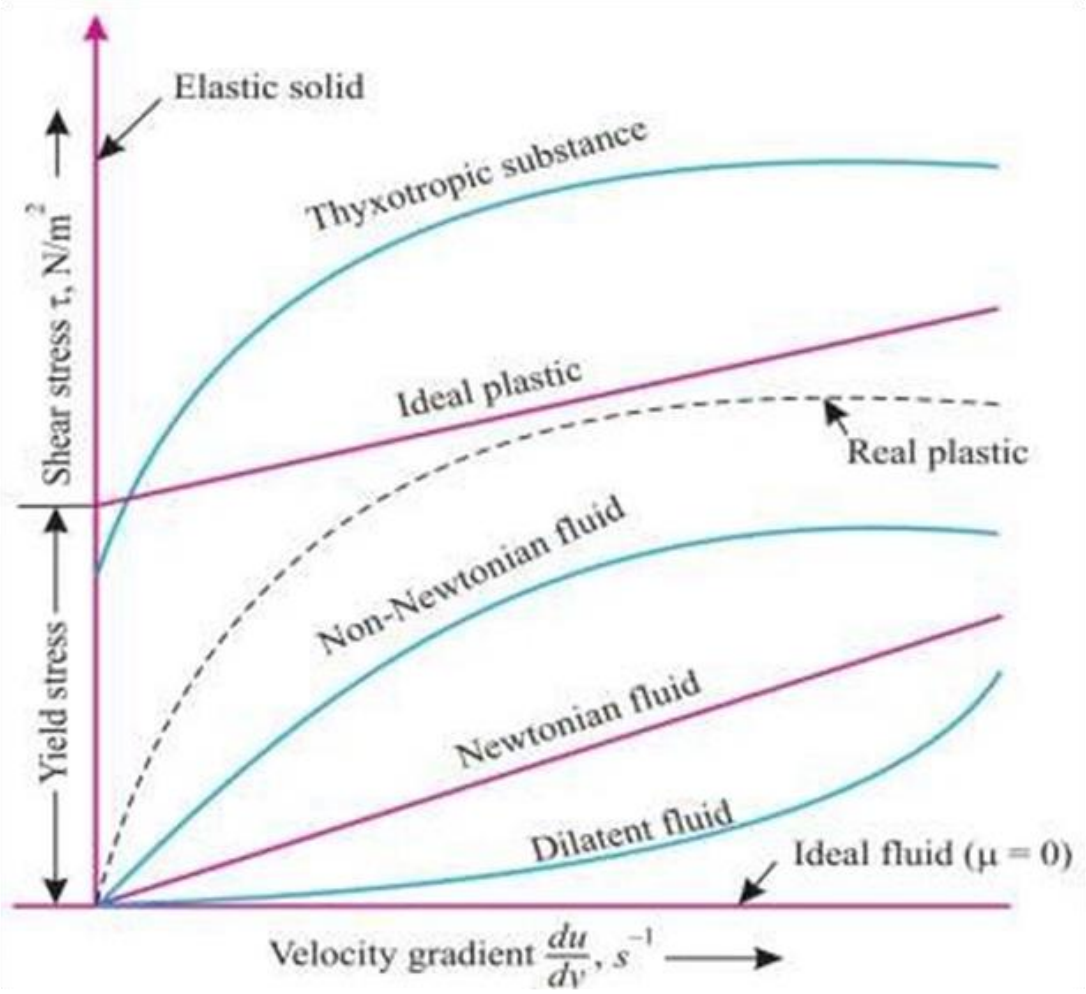
- It is defined as the property of a fluid which offers resistance to the movement of one layer of the fluid over another adjacent layer of the fluid.
- When the two layers of a fluid, at a distance 'dy' apart, move one over the other at different velocities, say u and u+du.
- The viscosity together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



TYPES OF FLUIDS

- The fluids may be classified in to the following five types.

- Ideal fluid
- Real fluid
- Newtonion fluid
- Non-Newtonion fluid
- Ideal plastic fluid



TYPES OF FLUIDS

- **Ideal fluid**: A fluid which is compressible and is having no viscosity is known as ideal fluid. It is only an imaginary fluid as all fluids have some viscosity.
- **Real fluid**: A fluid possessing a viscosity is known as real fluid. All fluids in actual practice are real fluids.
- **Newtonian fluid**: A real fluid, in which the stress is directly proportional to the rate of shear strain, is known as Newtonian fluid.
- **Non-Newtonian fluid**: A real fluid in which shear stress is not proportional to the rate of shear strain is known as Non-Newtonian fluid.
- **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 is known as ideal plastic fluid.

SURFACE TENSION

- Surface tension is defined as the tensile force acting on the surface of a liquid is contact with a gas or on the surface behaves like a membrane under tension.
- The magnitude of this force per unit length of free surface will have the same value as the surface energy per unit area.
- It is denoted by σ (sigma).
- In MKS units it is expressed as Kg f/m while in SI units as N/m

CAPILLARITY

- Capillarity is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid.
- The rise of liquid surface is known as capillary rise, while the fall of the liquid surface is known as capillary depression.
- It is expressed in terms of ‘cm’ or ‘mm’ of liquid.
- Its value depends upon the specific weight of the liquid, diameter of the tube and surface tension of the liquid.

VAPOUR PRESSURE

- A change from the liquid state to the gaseous state is known as Vaporizations.
- The vaporization (which depends upon the prevailing pressure and temperature condition) occurs because of continuous escaping of the molecules through the free liquid surface.
- Consider a liquid at a temp. of 20°C and pressure is atmospheric is confined in a closed vessel.
- This liquid will vaporize at 100°C, the molecules escape from the free surface of the liquid and get accumulated in the space between the free liquid surface and top of the vessel.
- These accumulated vapours exert a pressure on the liquid surface. This pressure is known as vapour pressure of the liquid or pressure at which the liquid is converted in to vapours.