Properties of Fluid

The fluid properties enable us to understand the behaviour of fluids under various forces and atmospheric conditions and select the appropriate fluid for a wide range of applications. Fluid Mechanics is one of the essential subjects in Mechanical Engineering for GATE and other exams. These properties of fluids can be classified into the following categories:

- **Mechanical properties of fluid:** These characteristics help in understanding fluid motion. The kinematic properties of fluids are velocity and acceleration.
- **Thermodynamic properties of fluid:** These qualities help to determine the fluid's thermodynamic state. The thermodynamic properties of fluids are temperature, density, pressure, and specific enthalpy.
- **Physical properties of fluid:** These characteristics, such as colour and odour, help determine the fluid's physical state.

Various Properties of Fluid

The properties of the fluid are as follows:

- **Intensive properties:** Intensive properties are those properties which do not dependent on mass. Example: Temperature, pressure, density, Boiling and Melting point, refractive index, etc.
- **Extensive properties:** Extensive properties are those properties that are dependent on mass—for example – Mass, Energy, Volume, Momentum, etc.

Even though each fluid is unique in terms of composition and specific attributes, there are several characteristics that all fluids share. Let's take a closer look at the properties of the liquid.

Ideal Fluid Properties

- Ideal fluid should have zero viscosity and zero surface tension.
- Ideal fluid is incompressible, and various questions are formulated in this property in the GATE question paper.
- No ideal fluid possesses all the properties, but air and water are considered ideal fluids.

Real Fluid Properties

- Genuine fluid has viscosity and surface tension.
- Real fluids are compressible.
- They are divided into two types: Newtonian fluids and Non-Newtonian Fluids.

There are several types of properties. The most important properties of the fluid are given below.

Various Properties of Fluid	
Density	Specific Gravity

Viscosity	Surface Tension
Temperature	Vapour Pressure
Pressure	Capillarity
Specific Volume	Cavitation
Specific Weight	

Let us explore all these properties of fluids in detail.

Density

The density of a substance is its mass per unit volume (more accurately, its volumetric mass density; also known as specific mass). The symbol for density is ρ. Density is defined mathematically as mass divided by volume:

ρ=m/V

where the density is ρ, the mass is m, and the volume is V.

Viscosity

A fluid's viscosity measures its resistance to deformation at a specific rate. It corresponds to the informal sense of "thickness" in liquids: syrup, for example, has a higher viscosity than water. The internal frictional force between neighbouring fluid layers in relative motion is measured by viscosity.

The viscosity defines the type of fluid flow. When a viscous fluid is driven through a tube, it flows faster towards its axis than near its walls. Experiments have shown that some stress is required to keep the flow going. This is because a force is necessary to overcome the friction between the fluid layers in relative motion. The compensatory force is proportional to the fluid's viscosity in a tube with a constant flow rate.

Temperature

Temperature is a measure of the average kinetic energy of the atoms or molecules in a system or a physical quantity that expresses hot and cold When a body comes into contact with another that is colder or hotter. It is the manifestation of thermal energy, which is present in all matter and is the source of the occurrence of heat, a flow of energy.

Heat should not be confused with temperature. A thermometer is used to determine the temperature. Thermometers are calibrated in various temperature scales that have traditionally defined temperatures using a variety of reference points and thermometric substances. The Celsius, Fahrenheit, and Kelvin scales are the three most popular scales.

Pressure

The physical force exerted on an item is known as pressure. The force applied per unit area is perpendicular to the surface of the objects. Fluid pressure is calculated using the F/A formula (Force per unit area). Pascals is the unit of pressure (Pa). There are four different kinds of stress:

- Atmospheric Pressure
- Absolute Pressure
- Differential Pressure
- Gauge Pressure

Specific Volume

The specific volume of a substance (symbol v) is a property of the substance defined as the ratio of the substance's volume (V) to its mass (M) in thermodynamics (m). It is the reciprocal of density (ρ) and has the following relationship with molar volume and mass:

$$v = V/m = 1/\rho$$

The cubic meter per kilogram (m^3/kg) is the standard unit of specific volume.

Specific Weight

A material's specific weight (γ) is calculated by multiplying its density (ρ) by its standard gravity (g).

$$\gamma = \rho g$$

Specific weight, unlike density, is not a material's fixed fluid property. It is determined by gravitational acceleration, which changes depending on location. Pressure can alter results depending on the material's bulk modulus, but it has a less significant effect than the other components at modest pressures.

Specific Gravity

The ratio of a substance's density (mass per unit volume) to the density of specified reference material is known as relative density or specific gravity. This is not to be confused with the gravity of the earth. For liquids, the reference is almost always water at its densest temperature (4 °C); for gases, the reference is air at room temperature (20 °C).

In scientific circles, the term "relative density" is frequently used. If the relative density of a substance is less than one, it is less dense than the reference; if it is larger than one, it is denser. The densities are equivalent if the relative density is exactly 1; equal volumes of the two substances have the same mass. A substance with a relative density (or specific gravity) of less than 1 will float in water if the reference material is water. An ice cube, for example, with a relative density of 0.91, will float. A substance sinks if its relative density is larger than one.

Surface Tension

Surface tension is the propensity of liquid surfaces to shrink to the smallest possible surface area while resting. Surface tension is what allows items with a higher density than water, such as razor blades and insects, to float on a water surface without submerging.

Vapour Pressure

Equilibrium or vapour pressure At a given temperature in a closed system, vapour pressure is defined as the pressure exerted by a vapour in thermodynamic equilibrium with its condensed phases (solid or liquid). The equilibrium vapour pressure determines the evaporation rate of a liquid. It relates to the tendency of particles to escape from the liquid. Volatile refers to a substance with a high vapour pressure at room temperature. Vapour pressure is the pressure exerted by vapour existing above a liquid surface.

Capillarity

Capillary action (also known as capillarity, capillary motion, capillary effect, or wicking) is the process of a liquid flowing in a narrow space without the aid of, or even against, external forces such as gravity. Liquids can be drawn up between the hairs of a paintbrush, in a narrow tube, in porous materials like paper and plaster, in non-porous materials like sand and liquefied carbon fibre, or in a biological cell. Intermolecular forces between the liquid and the surrounding solid surfaces create this.

Cavitation

Cavitation occurs when the static pressure of a liquid falls below the vapour pressure of the liquid, resulting in the creation of small vapour-filled cavities in the liquid. These cavities, known as "bubbles" or "voids," collapse under increasing pressure and can generate shock waves that might harm machinery. Cavitation is essential for the GATE exam. These shock waves are powerful while they are close to the imploded bubble, but they diminish fast as they go away from it.