References:

1. Fluid dynamics by Cohen and Kundu.
2. Fluid Mechanics by Spurk and Aksel.
3. Introduction to Fluid dynamics by Schaffer, Katz and Shaughnessy.
4. Elementary Fluid ~~dynamics~~ mechanics by Kambe

Chapter I Introduction

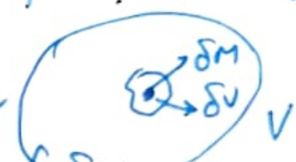
I. Fluid and types of fluid: Fluid is defined as a substance that flows and solid is defined as a substance that does not flow. Fluids are of two types: (i) liquids which are incompressible, i.e their volumes do not change under pressure change (ii) Gases which are compressible as their volume may change under pressure change.

II. Continuum Hypothesis and fluid particle: It is well known that matter is made up of molecules/atoms which are always in motion. We consider the macroscopic/continuum behavior of the fluid by assuming the fluid particles to be continuously distributed in the given space/region/domain. This is called as continuum hypothesis.

iii. Isotropic: A fluid is said to be isotropic w.r.t. some properties such as pressure, density etc. if that property is same in all directions at a point. A fluid is said to be anisotropic w.r.t. a property if that property is not same in all directions. (Remark: $\nabla p = \underline{0}$?)

iv) Density: The density of a fluid is defined as mass per unit volume. Mathematically, the density ρ at a point P in a fluid is

$$\rho = \lim_{\delta v \to 0} \frac{\delta M \to \text{mass}}{\delta v \to \text{volume}} \qquad \cancel{\rho = \int_V \frac{\delta M}{\delta V}}\cdot \delta V = \int_V \delta M$$



The specific weight γ of a fluid is defined as the weight per unit volume. Then

$$\gamma = \lim_{\delta v \to 0} \frac{\delta M g}{\delta V} = \lim_{\delta v \to 0} \frac{\rho\, \delta v\, g}{\delta v} = \rho g$$

v. Pressure: When a fluid is contained in a vessel, it exerts a force at each point of the inner side of the vessel. Such a force is called pressure and mathematically, it is given by

$$p = \lim_{\delta s \to 0} \frac{\delta F \to \text{force}}{\delta s \to \text{surface area}}.$$

$\int \delta M$

§ Compressible fluids and incompressible fluids:

Gases are compressible and their density ~~readily~~ changes readily with temperature and pressure. Liquids on the other hand are rather difficult to compress and in most problems we treat liquids as incompressible.

§. Viscous and inviscous fluids: A fluid is said to be viscous when normal as well as shearing stresses exist. A fluid is called inviscid when it does not exert any shearing stress.

§ Newtonian and Non-newtonian: The fluids which obeys Newton's law of viscosity are called Newtonian fluid, for example water, air etc. Viscous fluids such as tar, and polymers which donot obey Newton's law of viscosity are called Non-Newtonian fluids.

Newton's law of viscosity: If we consider a small element of fluid, the shear stress τ on the top is given by

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

, where μ is the constant propotionality which is called the co-efficient of viscosity and the relation is called Newton's law of viscosity

u is the velocity of
the velocity