An object immersed in a fluid can be considered as part of the container and experiences some force. The magnitude of this force per unit area is called pressure. Actually we can say that each point in a fluid is characterised by a function called pressure (amongst others).

Pressure as we study in 102 is a scalar quantity, \( P(x,y,z) \). \( \vec{F} = P \cdot \vec{dA} \) is the infinitesimal force on the infinitesimal area \( dA \).

Unit: \( N/m^2 \) = Pascal in SI.

Assume incompressible fluid, i.e. the density, \( \rho \), is constant.

The condition \( \nabla \cdot \vec{F} = 0 \) for equilibrium:

\[
\frac{dp}{dy} = -\rho g \quad \text{or} \quad \frac{dp}{dx} = 0
\]

\[ P(y) = P_0 + \rho g y \]

\( P_0 \) in everyday life would be the atmospheric pressure. \( \approx 10^{5} \text{Pa} \).

Ex/ Force exerted by water on a dam:

\[
F = \int p g w d h = \frac{1}{2} p g w H^2
\]

Ex/ Barometric formula. Assuming that the temperature of the atmosphere is relatively constant show that the atmospheric pressure as a function of altitude is given by \( P(y) = P_0 e^{-\alpha y} \), where \( \alpha = \frac{R}{\rho_0} \).

\( P_0 \) is the pressure at some reference level \( y = 0 \).

\( \rho_0 \) the density at that level. [Serway 14.7B]

Ideal gas law (to be covered later in 102): \( PV = nRT \)

\[
\frac{Mx}{(PV)_{\text{NRT}}} \Rightarrow \frac{Mx}{P} = \frac{nM}{V} \Rightarrow \rho = \frac{nM}{RT}
\]

\[
\frac{dp}{dy} = -\rho g = -\frac{Mg}{RT} \cdot P(y)
\]

\[ P(y) = P_0 e^{-\alpha y} \]

\( P(0) = P_0 \Rightarrow \alpha = \frac{Mg}{kP_0} \]

\[
\rho = \frac{P_0}{RT} \Rightarrow \alpha = \frac{Mg}{kP_0}
\]

Fluid Mechanics

From Serway: A fluid is a collection of molecules that are randomly arranged & held together by weak cohesive forces & by forces exerted by the walls of a container. [Question: What do we mean by "weak"? A more mathematically meaningful definition is needed.]

A fluid is a substance that continually deforms (flows) under an applied shear stress.

Gases, liquids are examples of fluids. While liquids form a free surface, gases don’t. [Non-Newtonian fluids undergo strain not proportionally with the applied shear stress.]