**DATE:** Aug 23rd 2017

**FLUID STATICS**

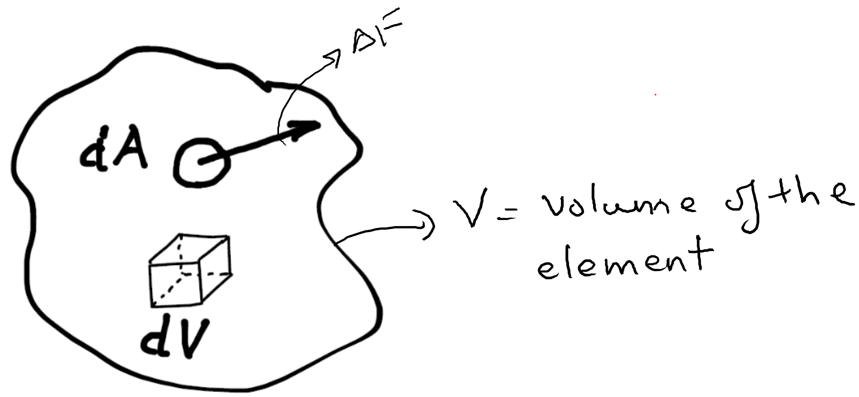
**General Formulation of the Linear Momentum Principle**

Fluid statics deals with fluid at rest and the linear momentum principle will be used to develop equations for studying fluid behavior at rest.

Linear Momentum Principle: This principle states that

Rate of change of momentum = sum of forces acting on the body

Body refers to some material volume within the fluid which can be of any arbitrary shape. Consider a differential volume of dV of a fluid with arbitrary shape as shown in Figure below.




dV: differential volume of the element under focus

dA: differential area of the surface under focus.

$\Delta F$ = Force acting on the body

Mass of the differential volume dV = $\rho \, dV$

$m = \rho \, dV$

$\rho$ = density of the element

The momentum dM of the volume element dV is given by:

$m \vec{V}$

$\vec{V}$ = velocity of the element

$d\vec{M} = \rho \vec{V} \, dV$

Therefore, the total momentum M of the control volume is given by,

$$\vec{M} = \int_V \rho \vec{V} \, dV$$

Where: v = velocity of the element

Note that the momentum is a vector, i.e. it has both magnitude and direction.

Forces on the differential Volume

Surface Forces: forces acting on body due to surrounding surfaces or contact

Body Forces: forces acting on the body due to mass or inherent properties of the body.

→ Gravitational, Electrostatic, Electromagnetic

Not considered in our course (no charge in fluid)

Surface stress t is defined as the surface force acting per unit area. Therefore:

$$\vec{t} = \frac{\vec{F}}{A} = \lim_{\Delta A \to 0} \frac{\Delta \vec{F}}{\Delta A}$$

Body force (B) exerted on the control volume due to its own mass is given by,

$$\vec{B} = \rho \vec{g} \, dV \qquad \vec{g} = \text{gravitational acceleration}$$

Where g is the acceleration due to gravity which is a vector. So, body force is also a vector.

Now, substituting the momentum and forces for the control volume in the linear momentum principle equation:

$$\frac{D}{Dt}(\vec{M}) = \int_V \rho \vec{g} \, dV + \int_A \vec{t} \, dA$$

This equation is known as the General Linear Momentum Balance equation for any control volume. Can be applied to any shape or any fluid material with proper integrals. We will use this general formulation for developing equations for fluid at rest or fluid statics.