MECH 314 Introduction to Fluid Mechanics | February 19, 2009
American University of Beirut, Spring 2009 | Handout # 3

Fluid Statics

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1. (Lecture 1) In a static fluid shear stresses are zero. The only surface stress acting on a fluid element is pressures. The pressure acting at a point in a fluid is independent of the orientation of the plane on which it is acting. This a consequence of the fact that in the limit of a vanishing element size, body forces cannot balance surface forces, the normal stresses have to balance themselves.

2. (Lecture 1) Pressure force per unit volume acting at point in fluid is $\mathbf{F}_{\text{pressure}} = -\nabla p$.

3. (Lecture 1) Momentnum equation for flow in the absence of viscous forces:
   Newton's second law on a differential element dV: $\rho \frac{D\mathbf{u}}{Dt} = -\nabla p + \rho \mathbf{g}$

4. (Lecture 1) Conditions under which viscous forces vanish:
   (1) Hydrostatics: Flow at rest or at constant velocity.
   (2) Rigid body translation and rotation.
   (3) Inviscid flow (Bernoulli's equation)

5. (Lecture 2) Hydrostatics: $\nabla p = \rho \mathbf{g}$ with $\mathbf{g} = -g\hat{\mathbf{z}}$, then
   $\frac{\partial p}{\partial x} = 0$
   $\frac{\partial p}{\partial y} = 0$
   $\frac{\partial p}{\partial z} = -\gamma$, where specific weight $\gamma \equiv \rho g$.

   Analysis: Pressure is constant at all points in a given horizontal plane. The pressure increases with depth.

   Examples:
   (1) Static bodies of fluid in atmosphere: $p(z) = p_a - \gamma z$, with z pointing upwards from surface.
   (2) The mercury barometer.
   (3) Manometry; the simple manometer (*will be covered in the homework.*)
   (4) Hydrostatic pressure in ideal gases (*will be covered in the homework.*)
   (5) Hydrostatic forces on plane and curved surfaces.

6. (Lecture 3) Rigid body translation and rotation.

7. (Lecture 4) Buoyancy and stability (for floating and submerged bodies).

Read: White Chapter 2