Lecture 25, Nov 3, 2022

Measuring Pressure

- Pressure values must be states with respect to a reference
  - For gauge pressure, this is the local atmospheric pressure or the reference pressure for the gauge
  - For absolute pressure, this is with respect to the absolute zero pressure reference, with is a vacuum
  - Absolute pressure is the sum of gauge and atmospheric pressures
  - Gauge pressure can be positive or negative, but absolute pressure can never be negative
- Manometers can be used to measure pressure
  - Mercury barometers are usually used to measure atmospheric pressure
    - Pressure at the mercury level in the tube $P_A = P_{atm} - \rho_{\text{Hg}} gh = P_{vapour} \approx 0$
  - Piezometers are vertical tubes open at the top; use the level of the liquid to measure the pressure of the liquid in the container
    - $P_A - \rho g h_1 = P_{atm}$
    - Pressure in the container must be greater than that of the atmosphere
    - The fluid inside must be liquid, and the pressure measured must be small
- A U-tube manometer can be used to measure pressures in a gas; a gauge liquid is used

Hydrostatic Forces on Submerged Surfaces

- We know:
  1. The force of pressure is always normal to a surface
  2. No shear stresses
  3. For an incompressible fluid at rest, the pressure varies linearly with depth
- If we want to find the total pressure force on a *planar* surface:
  1. Using integration, we can use a double integral
     - $\vec{F}_p = \iint_A \mathrm{d}\vec{F}_p = \iint_A -p\vec{n}\,\mathrm{d}A$
  2. Using moment of inertia (will not be using in this course)
  3. "Pressure Prism" concept allows us to skip integration using geometry
     - The pressure force can be found by finding the volume of the "pressure prism"
       - One side is the pressure, the other side is the area
     - This force acts at the centroid of the prism (not the centroid of the object it acts on!)
     - This is the easiest when we have a vertical surface, in which case we get a triangular prism; if the surface does not extend up to the fluid surface, we have a trapezoid
       - The two sides of the triangle are $\rho g h_1$ and $\rho g h_2$ if we consider gauge pressure
       - For the trapezoid, the area is easy but the centroid is hard, so we can break it up into a triangular and rectangular prism, both of which we know the centroids of, and analyze the pressure as 2 forces
     - When the surface is not vertical, make sure the pressure forces are normal to the surface!

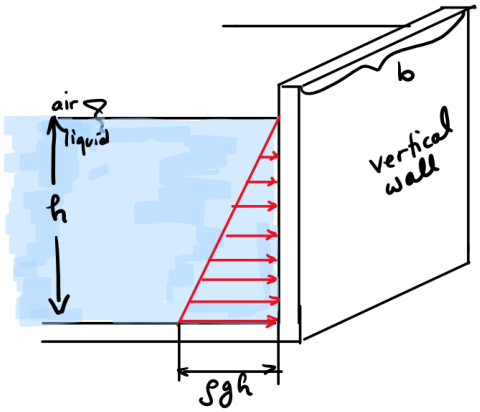

Figure 1: Triangular pressure prism

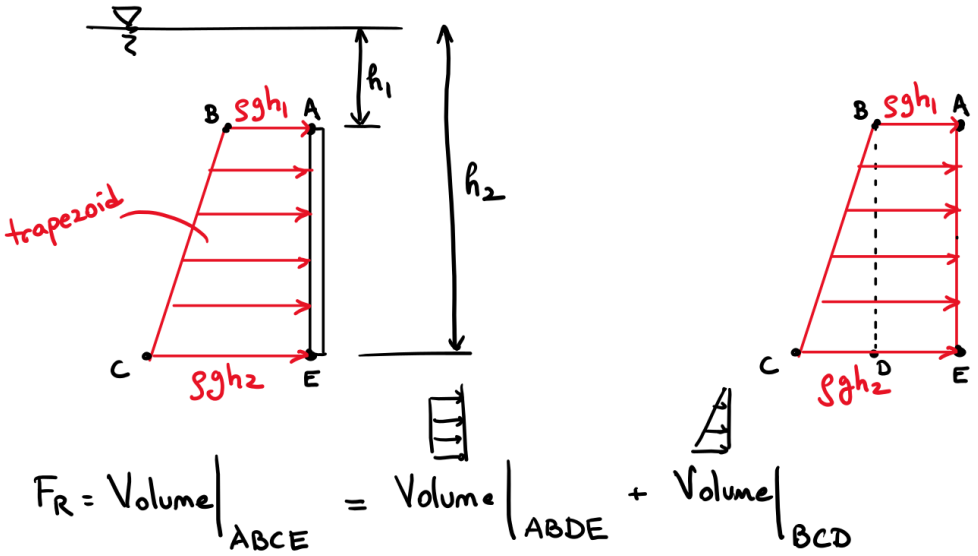

Figure 2: Trapezoidal pressure prism

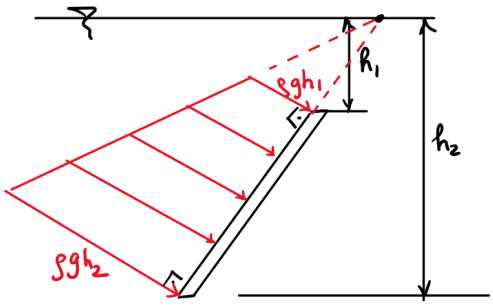

Figure 3: Non-vertical pressure prism