

Chapter 14: Fluid Dynamics

Laminar Flow

- Smooth flow of fluid.
- Molecules move orderly in streamlines that do not intersect.
- Tends to occur at lower velocities.

Turbulent Flow

- Rough flow of fluid.
- Molecules move irregularly with overlapping paths.
- Tends to occur at higher velocities.

* Continuity Equation:

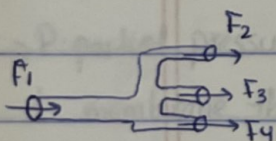
→ For an incompressible fluid moving through a pipe, the flow rate is the same at any point in the pipe.

$$m^3/sec \leftarrow \dot{V} = \frac{\Delta V}{\Delta t} = A \frac{\Delta x}{\Delta t} = \boxed{AV}, \quad \begin{array}{l} \dot{V}: \text{flow rate.} \\ A: \text{cross-sectional area.} \\ v: \text{flow speed.} \end{array}$$

→ The flow rate into the pipe = the flow rate out of the pipe.

$$F_1 = F_2$$

$$\boxed{A_1 v_1 = A_2 v_2}$$



$$F_1 = F_2 + F_3 + F_4$$

* Bernoulli's Equation:

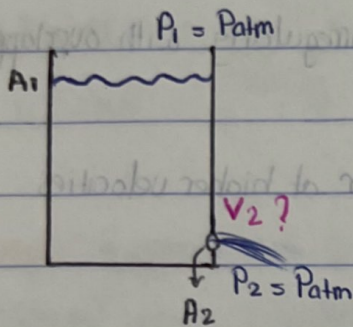
→ Describes ideal fluid flow. (Incompressible fluid, laminar flow, no viscosity).

→ Derived from conservation of energy.
 $\downarrow$ P constant $\downarrow$ no turbulence
 flow is continuous

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2$$

* faster flowing fluids $\Rightarrow$ lower pressure.

Example: what is the speed of the fluid coming out of the leak in the tank?



$$\frac{1}{2} \rho v_1^2 + \rho g h_1 = \frac{1}{2} \rho v_2^2 + \rho g h_2$$

$$\frac{1}{2} v_1^2 + g h_1 = \frac{1}{2} v_2^2 + g h_2$$

$$A_1 \gg A_2 \Rightarrow v_2 \gg v_1 \Rightarrow \boxed{v_1 \approx 0}$$

$$g h_1 = \frac{1}{2} v_2^2 + g h_2$$

$$g h_1 - g h_2 = \frac{1}{2} v_2^2$$

$$2g(h_1 - h_2) = v_2^2$$

$$v_2 = \sqrt{2g(h_1 - h_2)}$$

$$\boxed{vA}$$

$$v \Delta A = \Delta V = \frac{\Delta V}{\Delta t} = \frac{\Delta V}{\Delta t} \Rightarrow$$

$$\boxed{v_2 A = v_1 A}$$