Ross Ward

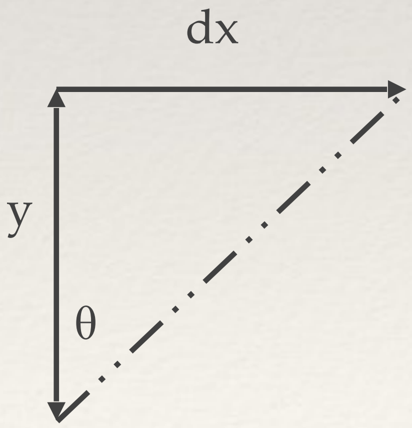
An Overview and Explanation of Fluid Mechanics Formulae and Their Application

What Are Fluids?

A fluid continuously deforms when subjected to shear stress.

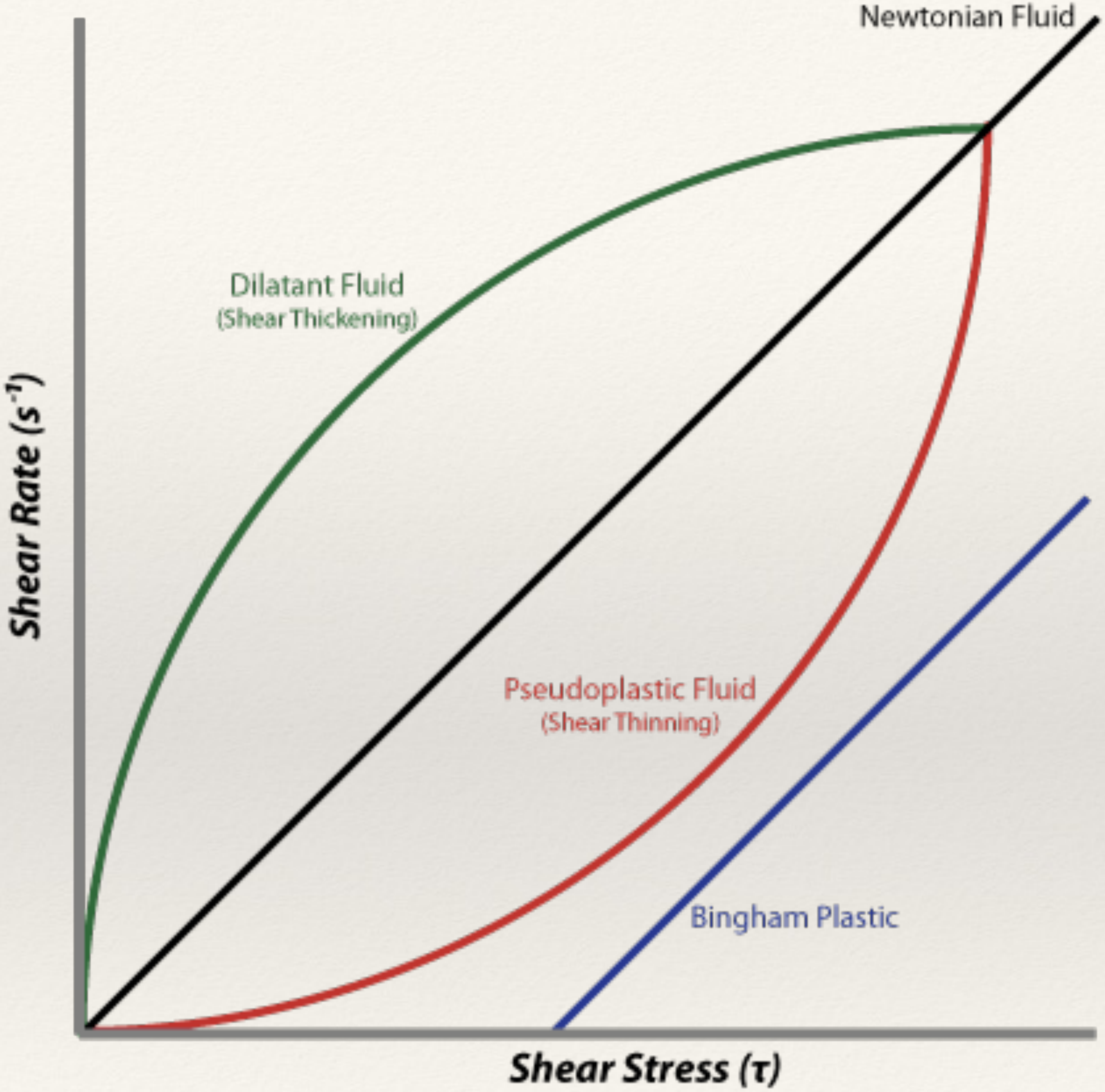
$$\theta = \frac{dx}{y}$$

$$\tau = \mu \frac{du}{dy}$$



Classifying Fluids

- Newtonian fluids μ is not dependent on $\frac{du}{dy}$
- Bingham plastics have a high yield stress
- Psuedo-plastics $\mu\ \alpha \frac{1}{\frac{du}{dy}}$
- Dilatants $\mu\ \alpha \frac{du}{dy}$

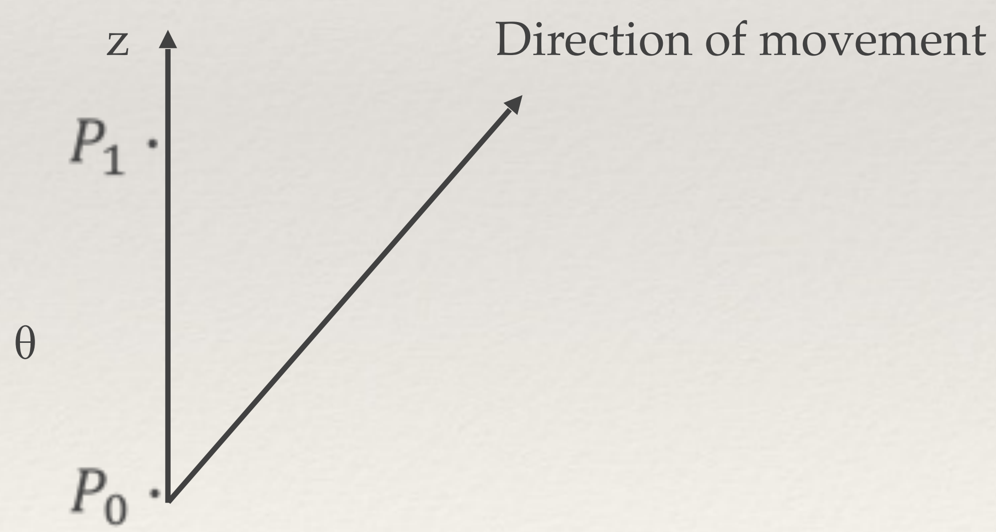

Newtonian Fluid
Dilatant Fluid
(Shear Thickening)
Pseudoplastic Fluid
(Shear Thinning)
Bingham Plastic
Shear Rate (s⁻¹)
Shear Stress (τ)

Pressure

- Gases vary with temperature due to gas laws
- Ideal fluid: non-viscous, incompressible, no shear stress
- Pressure varies with height in a fluid body.

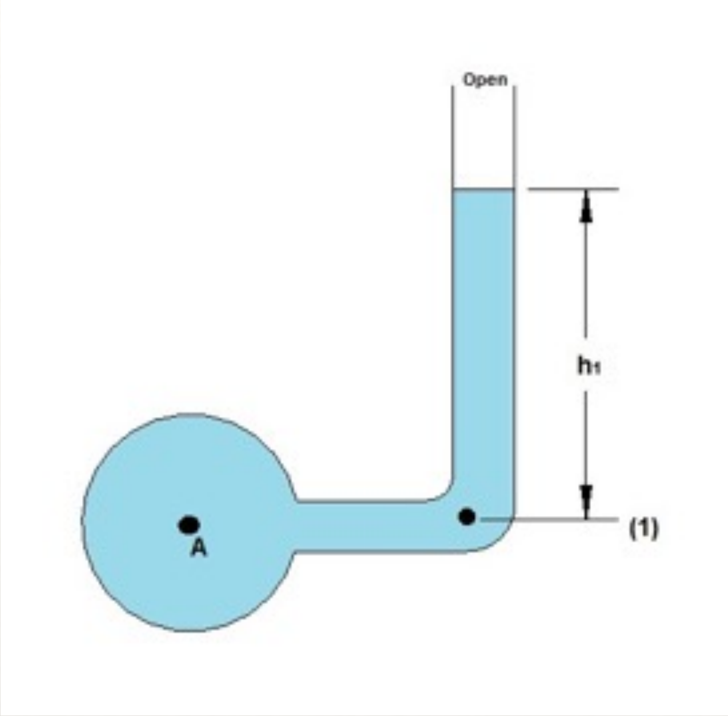
$$\frac{dP}{dz} = -\rho \cdot g \cdot \cos(\theta)$$

$$P_1 - P_0 = \rho \cdot g \cdot (z_1 - z_0)$$



Measuring Pressure

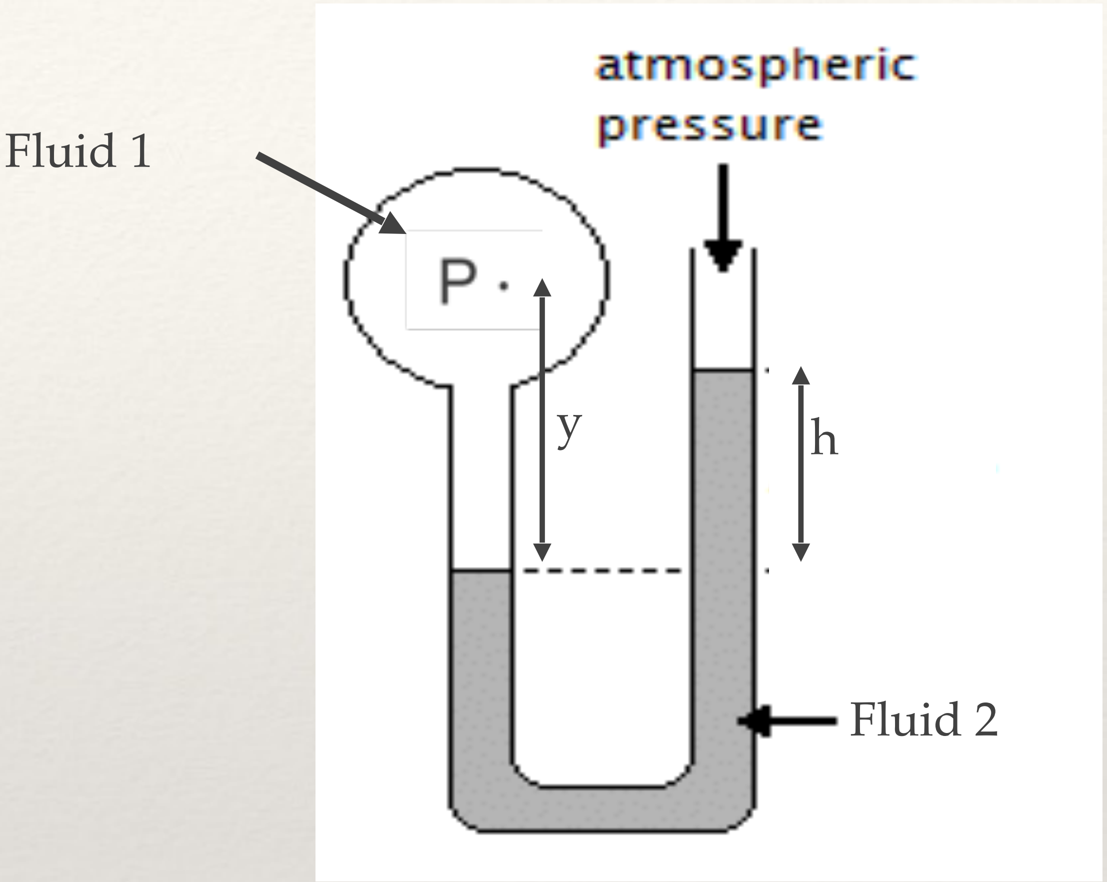
- Piezometer



$$P_A = P_1 = P_a + \rho \cdot g \cdot h_1$$

Measuring Pressure

- U-tube manometer



$$P = \rho_2 \cdot g \cdot h - \rho_1 \cdot g \cdot y$$

Fluid Flow

- Volumetric flow rate:

$$Q = \bar{v} \cdot A$$

- Mass flow rate:

$$\dot{m} = \bar{v} \cdot A \cdot \rho$$

Bernoulli's principle

$$P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g z_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g z_2$$

$$E = \left(P + \frac{1}{2}\rho v^2 + \rho g z\right) \cdot V$$

$$E = P \cdot V + \frac{1}{2}m v^2 + m g z$$

$$E_{loss} = \left[\frac{P_1}{\rho g} + \frac{{v_1}^2}{2g} + z_1\right] - \left[\frac{P_2}{\rho g} + \frac{{v_2}^2}{2g} + z_2\right]$$

$$E_{loss} = E_1 - E_2 = ((P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g z_1) - (P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g z_2)) \cdot V$$

$$E_{loss} = (P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g z_1) - (P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g z_2)$$

$$Head\ loss = \left[\frac{P_1}{\rho g} + \frac{{v_1}^2}{2g} + z_1\right] - \left[\frac{P_2}{\rho g} + \frac{{v_2}^2}{2g} + z_2\right]$$