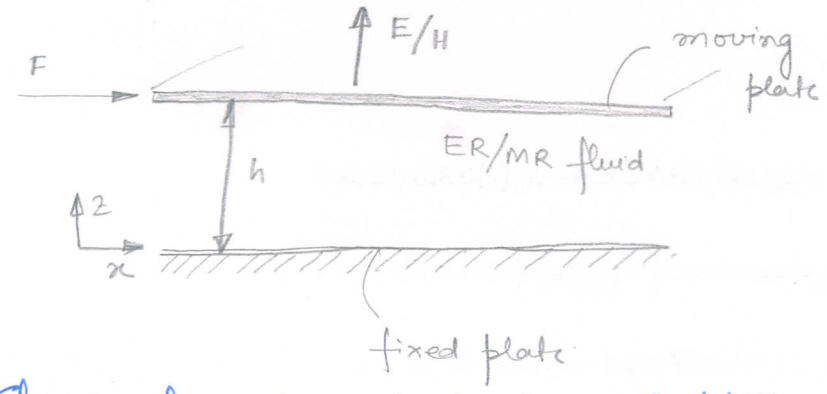
Assignment 6



Shear stress is constant along the depth and is given as

$$\tau_{xz} = \frac{F}{A} = \tau$$

A = area of the plate in contact with the fluid

F = force applied to the moving plate

Bingham plastic model:

$$\tau_{xz} = \tau_y + \eta \dot{\gamma} \rightarrow \text{strain rate}$$

(τ_y: yield stress; η: viscosity)

$$\dot{\gamma} = \frac{\tau - \tau_y}{\eta}$$

$$\Rightarrow \frac{du}{dz} = \frac{\tau - \tau_y}{\eta} \qquad u \rightarrow \text{velocity}$$

$$\Rightarrow \frac{du}{dz} = \frac{p - \tau_y}{\eta}$$

$$\Rightarrow u(z) = \frac{p - \tau_y}{\eta} z + \underbrace{C}_{=0}$$

(zero velocity at the fixed plate $h = 0$)

$$dQ = u(z)\, dz\, b$$

$$Q = \int_0^h \frac{b}{\eta}(p - \tau_y) z\, dz = \frac{b}{\eta}(p - \tau_y)\frac{z^2}{2}\Big|_0^h = \frac{bh^2}{2\eta}(p - \tau_y)$$

$$= \frac{bh^2}{2\eta}\left(\frac{F}{A} - \tau_y\right)$$