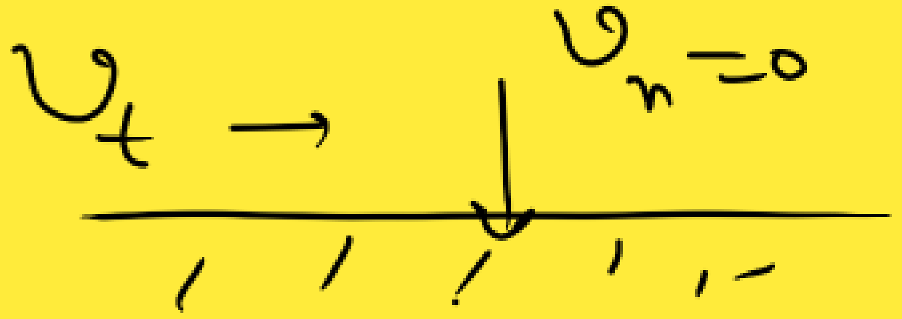
Solid surface

$v_1 = v_2 = 0$ ← opposite

$\tau_1 = \tau_2 = \tau_{max}$ → $\mu \frac{dU_2}{dx} = max$

Free



$\frac{d\tau}{dx} = 0$

velocity $= 0$

$f = f_{max, min}$

$\frac{df}{dx} = 0$

mass

Energy

Mom

Problem Analysis

Shell balance approach

Differential Method →

modified version

general eqn.

equation approach

$\frac{\partial}{\partial t} = 0$ ⇐ Steady state

Transient ⇒ $\frac{\partial}{\partial t} \neq 0$

{ Shell Momentum balance }

B.Tech →

$a_1 \frac{d^2y}{dx^2} + a_2 \frac{dy}{dx} + a_3 y = a_4$

NAG

IMSL

MATLAB

Steady state shell Momentum balance eqⁿ

$$\left(\text{Rate of Momentum in}\right) - \left(\text{Rate of Momentum out}\right) + \left(\text{Sum of forces Acting on shell}\right) = 0$$

body forces

$$\frac{d}{dt}(mv) = F$$

$$\text{flux} = \frac{F}{A}$$

micro

Molecular level → flux: τ × Area (Contact)

Convective level → (flux) → ((vol. conc. of Mom.) v_z) × Area

vol. conc. of Mom. → $\rho v \times v_z$

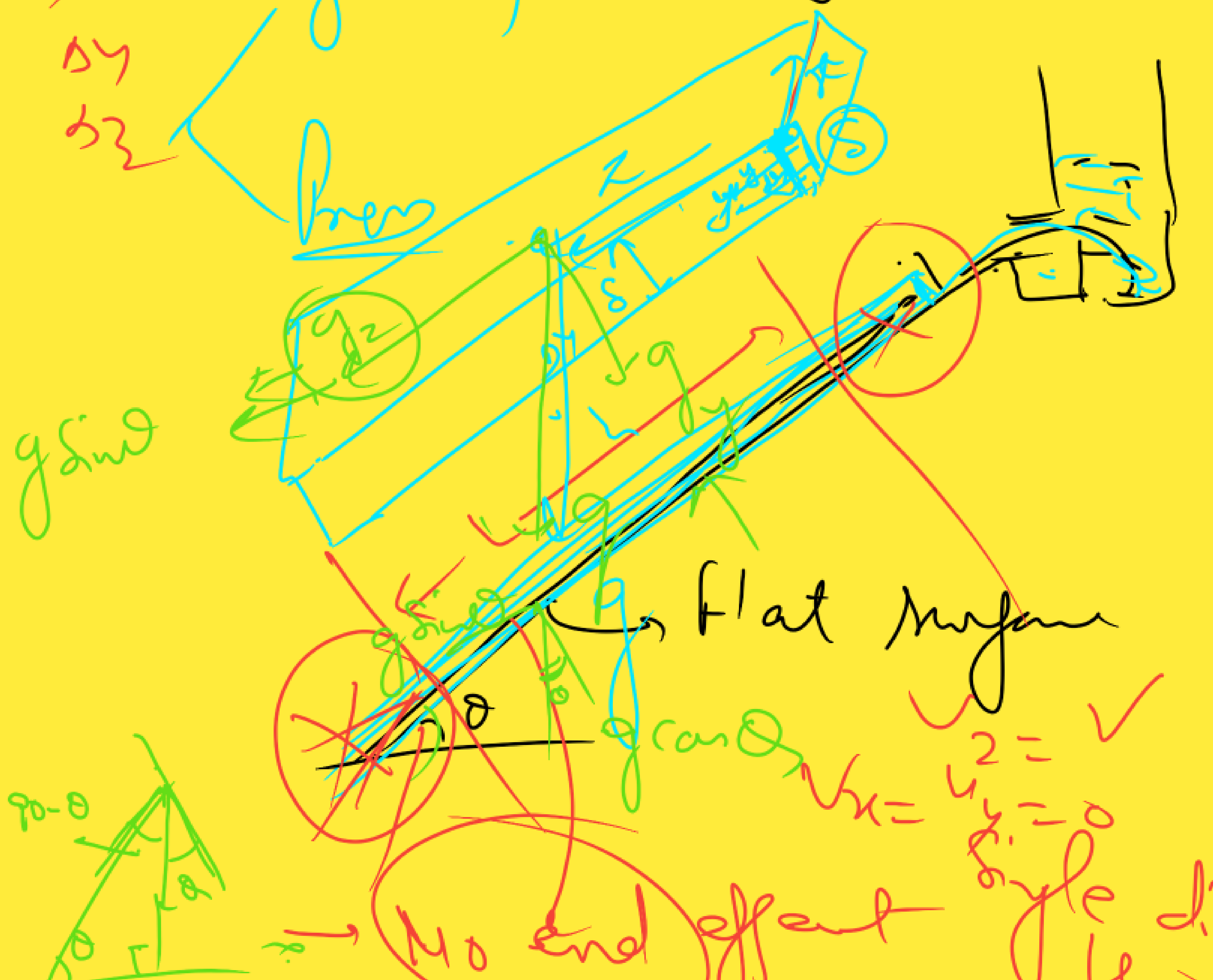
Area → CS

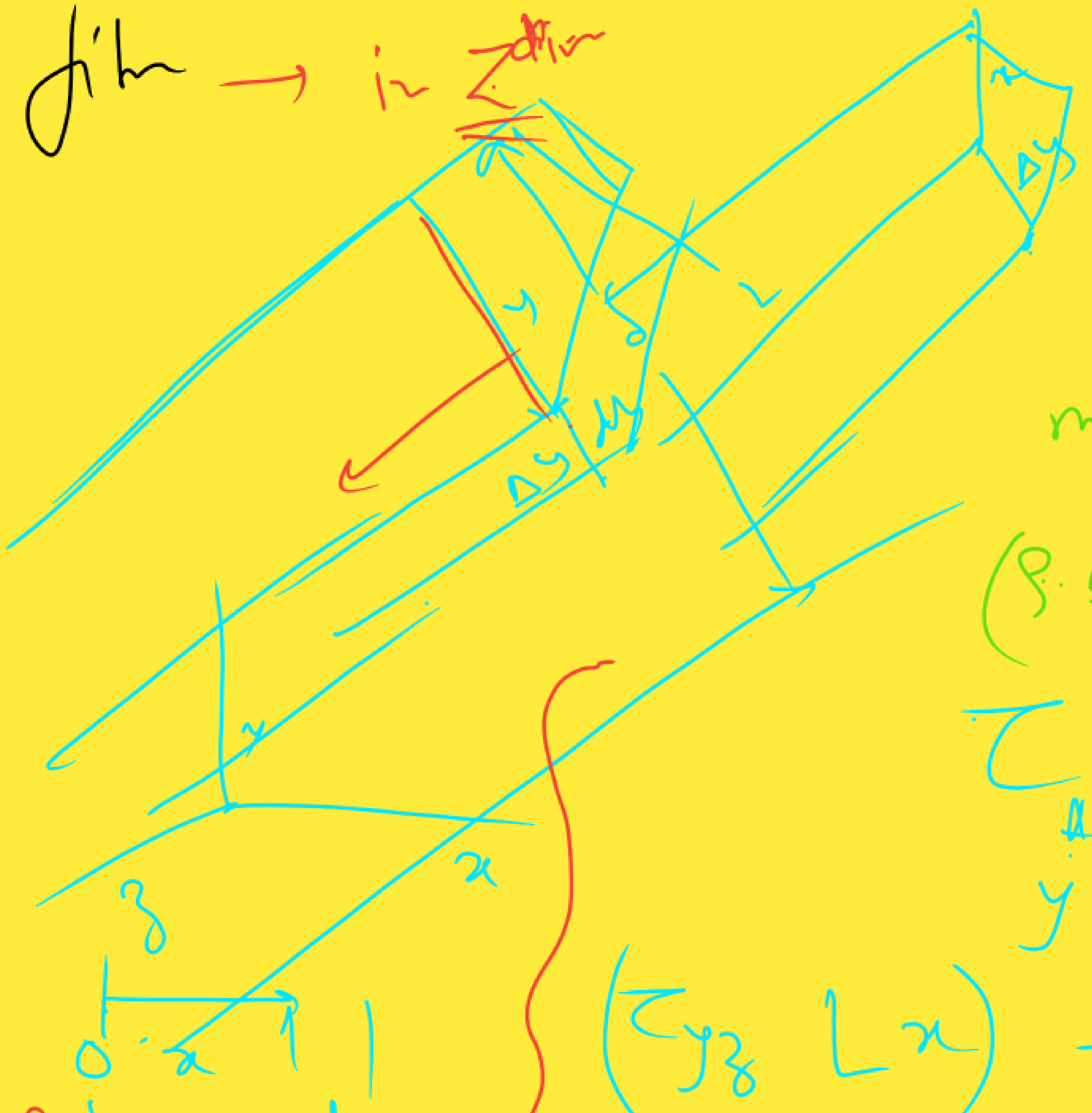
Macro

→ gravity = mg

Press

flow of a falling film → in z dir





- No end effect
- FDF
- Laminar flow

$V_x = V_y = 0$, V_z ✓

single dirn flow

origin

flow dirn → +ve axis

Pressure →

$P_z|_{z=0} \, \Delta y \, x$

$- P_z \, \Delta y \, x|_{z=L}$

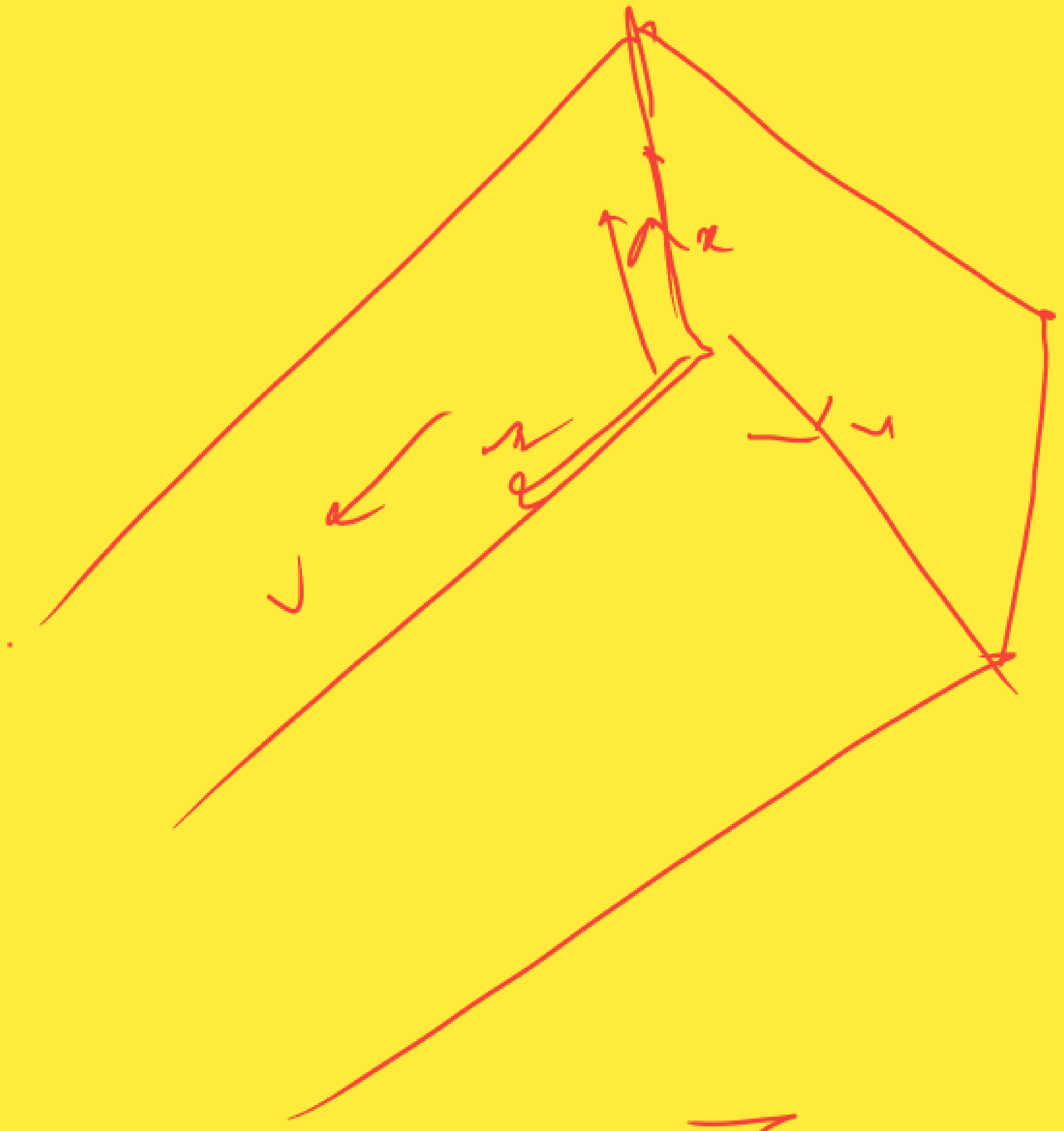
mg_z

$(\rho \, \Delta y \, x \, L) \, g_z$

τ_{yz}, ΔF

$$(\tau_{yz} L x)_{in} - (\tau_{yz} L x)_{out}$$

$$(\rho V_z) V_z \, x \, \Delta y|_{z=0} - (\rho V_z) V_z|_{z=L}$$



$\tau_{yx} \ \Delta y x$

$\tau_{xy} \ \Delta y L$