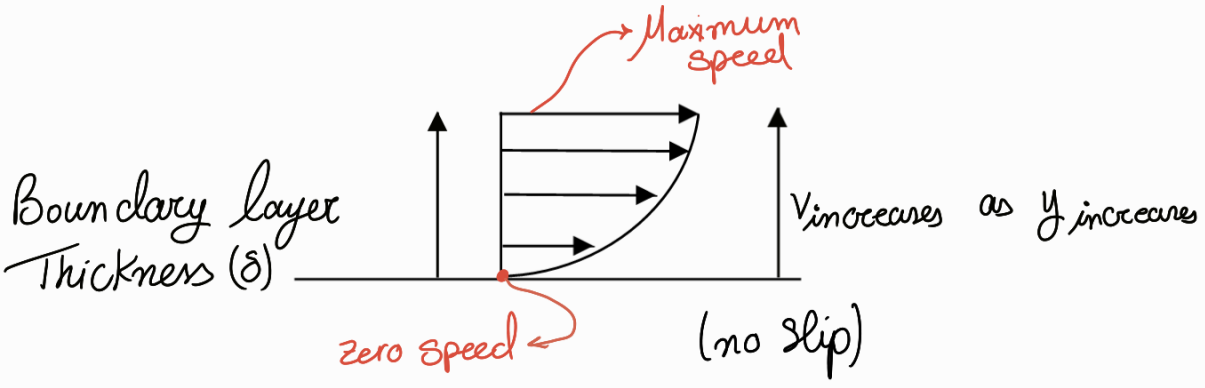
Experiment 6
Boundary layer

- When a fluid flows over a solid surface there is no slip at the surface



Boundary layer thickness: thickness where velocity reaches 0.99 of the free stream velocity

- Displacement thickness (δ^*): y distance needed to be added to compensate for the loss in the mass flow rate of fluid due to formation of boundary layer

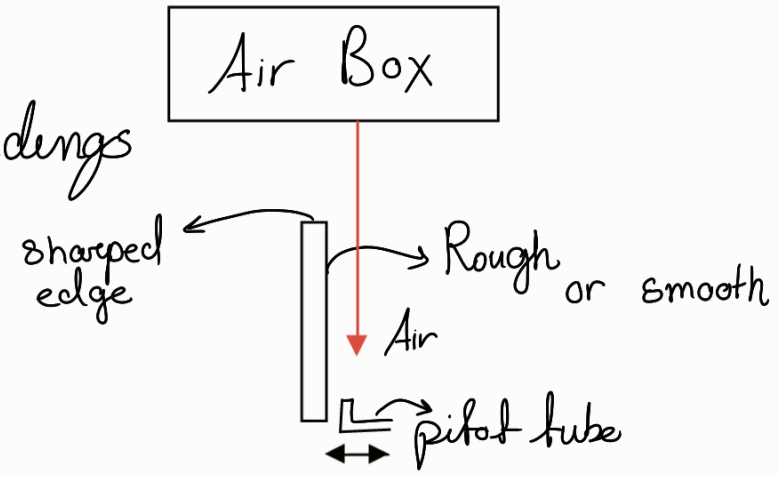
- Momentum thickness: a measure of how much distance the velocity of the fluid should be displaced to compensate for the momentum losses caused by the formation of boundary layer

- Skin Friction coefficient: a representation of the skin friction on the plate surface
- Shape factor H: ratio between displacement thickness & momentum thickness

Apparatus

Manometer: 2 pressure Readings

Fan opening is maximum



Calculations

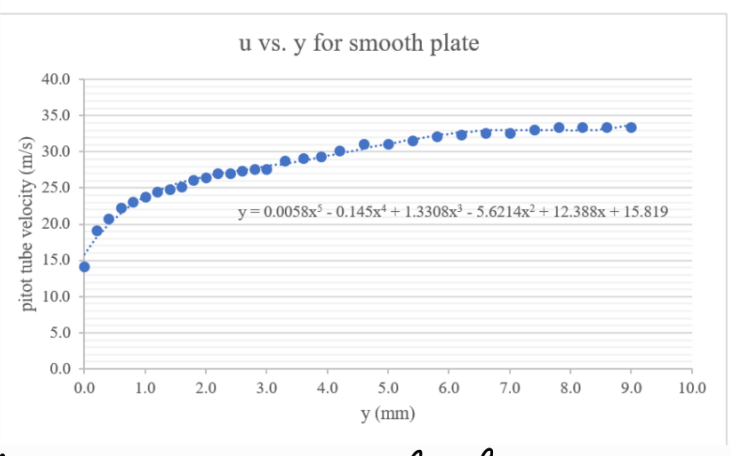
- pascal = 100 x mbar
- Dynamic pressure: $P_d = \frac{1}{2}\rho u^2$

  u (free stream velocity) $= \sqrt{\frac{2P_d}{\rho}}$ → 1st P from air Box

  u (Speed at distance y) $= \sqrt{\frac{2P_d}{\rho}}$ → from pitot tube readings
- Displacement- Thickness: $\delta^* = \int_0^\infty \left(1 - \frac{u}{U}\right) dy$
- Momentum thickness: $\Theta = \int_0^\infty \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$
- Skin friction factor: $C_f = \frac{\tau_w}{\frac{1}{2}\rho U^2}$ → Shear Stress
- Shear stress $\tau_w = \mu \frac{du}{dy}\Big|_{y=0}$
- Shape factor $H = \frac{\delta^*}{\Theta}$
- Reynolds number $Re = \frac{\rho U L}{\mu}$

Discussion of Results

- The fluid velocity increases as y increases
  → as y increases, the molecular interaction between fluid particles and the surface decreases until it almost becomes zero at which $u = 0.99\,U$



$U_{Rough} < U_{smooth}$ since there is more molecular collisions

- θ for rough surfaces > Smooth Surfaces
- S^* for rough surfaces > Smooth Surfaces
- C_f for rough surfaces > Smooth Surfaces since there is higher friction
- H for rough surfaces > Smooth Surfaces

Objectives

To study the velocity profile of both smooth and rough surfaces, compare between them, calculate the boundary layer characteristics and understand how surface roughness can affect flow nature.