國立清華大學 107 學年度碩士班考試入學試題

系所班組別：核子工程與科學研究所 甲組(工程組)

考試科目（代碼）：流體力學 (3003004)

 *請在【答案卷】作答

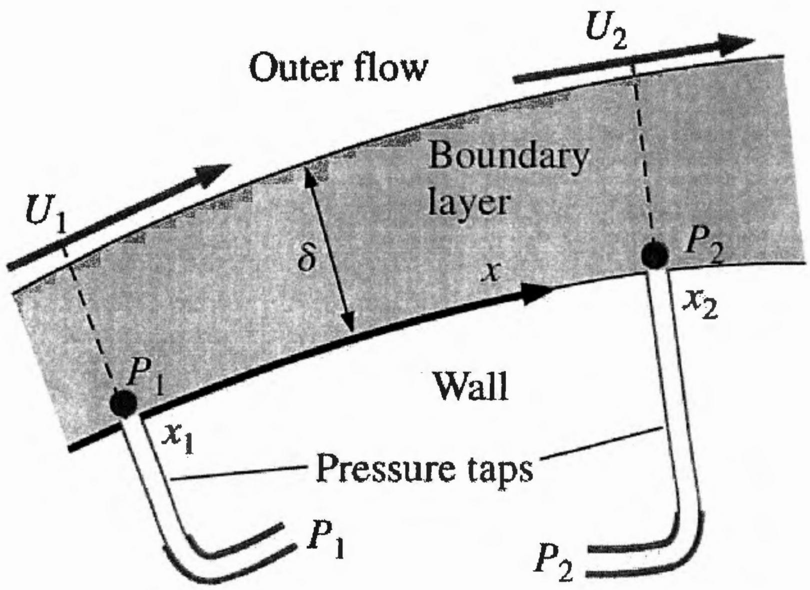
1. 解釋名詞 (30%)

- 寫出 the Bernoulli equation 與應用 Bernoulli equation 的假設為何?
- 用圖形解釋 Developing flow, Entrance region 以及 Fully developed flow
- 說明 Reynolds Transport Theorem
- 解釋 Major loss and Minor loss
- 描繪 Moody Diagram

2. (20%)

Static pressure P is measured at two locations along the wall of a laminar boundary layer (as shown in the following figure). The measured pressures are P_1 and P_2, and the distance between the taps is small compared to the characteristic body dimension ($\triangle x = x_2 - x_1 << L$). The outer flow velocity above the boundary layer at point 1 is U_1. The fluid density and viscosity are ρ and μ, respectively. Generate an approximate expression for U_2, the outer flow velocity above the boundary layer at point 2, in terms of P_1, P_2, $\triangle x$, U_1, ρ and μ.

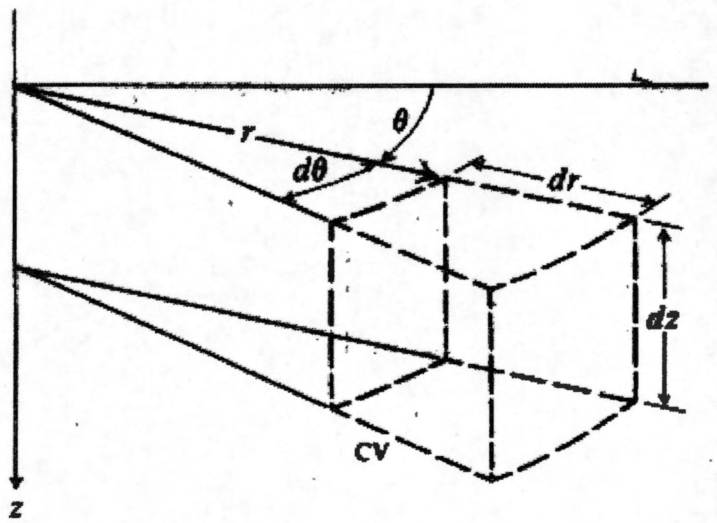
Hint: You can solve this problem from the one-dimensional Euler's equation above the boundary layer



3. (30 %)

Develop the differential equation for conservation of linear momentum (i.e. Navier-Stokes equation) in cylindrical coordinates by applying the control volume method to an infinitesimal control volume of dimensions $rd\theta, dr, dz$.

(σ is the normal stress and τ is the shear stress)



[Hint]

$$\sigma_{rr} = -p + 2\mu \frac{\partial v_r}{\partial r}$$

$$\sigma_{\theta\theta} = -p + 2\mu \left(\frac{1}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{v_r}{r} \right)$$

$$\sigma_{zz} = -p + 2\mu \frac{\partial v_z}{\partial z}$$

$$\tau_{r\theta} = \tau_{\theta r} = \mu \left(r\frac{\partial}{\partial r}\left(\frac{v_\theta}{r}\right) + \frac{1}{r}\frac{\partial v_r}{\partial \theta} \right)$$

$$\tau_{\theta z} = \tau_{z\theta} = \mu \left(\frac{\partial v_\theta}{\partial z} + \frac{1}{r}\frac{\partial v_z}{\partial \theta} \right)$$

$$\tau_{rz} = \tau_{zr} = \mu \left(\frac{\partial v_r}{\partial z} + \frac{\partial v_z}{\partial r} \right)$$

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4. (20 %)

Experiments are being designed to measure the horizontal force F on a nozzle, as shown in the following figure. $F = fn(V_1, \Delta P, \rho, \mu, A_1, A_2, L)$ $\Delta P = P_1 - P_2$. Determine the functional relationship between the horizontal force F and the independent variables using dimensional analysis.