國立清華大學 103 學年度碩士班考試入學試題

系所班組別：工程與系統科學系 乙組

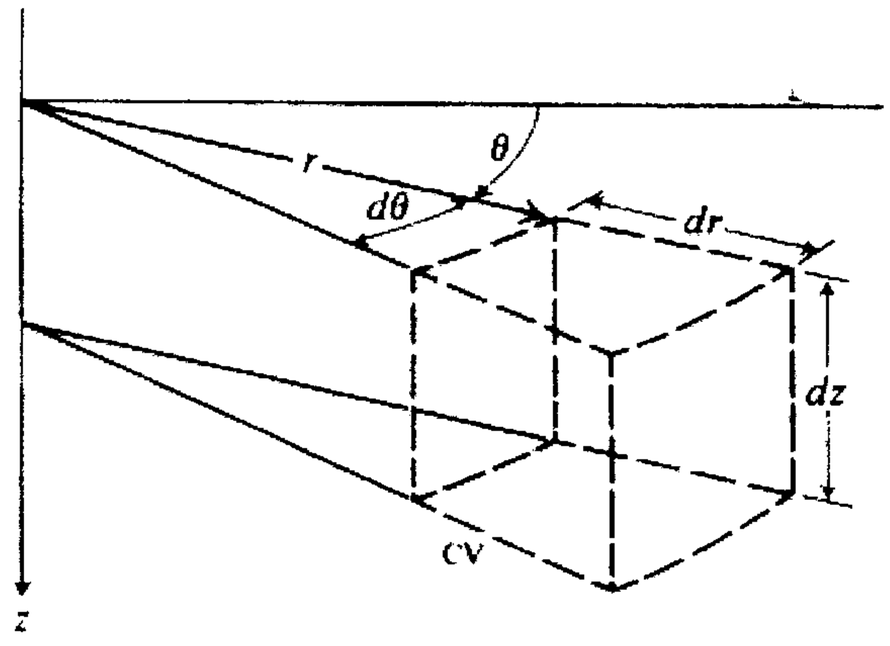
考試科目（代碼）：流體力學(2703)

1. (15 %)

試畫出 Moody chart(儘量詳細)，並解釋圖上每一個參數以及 Moody chart 的用途

2. (30 %)

利用控制體積法(control volume method)，試推導圓柱座標(cylindrical coordinates)型式的 Navier-Stokes equation。(σ is the normal stress and τ is the shear stress)



[Hint]

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

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

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

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

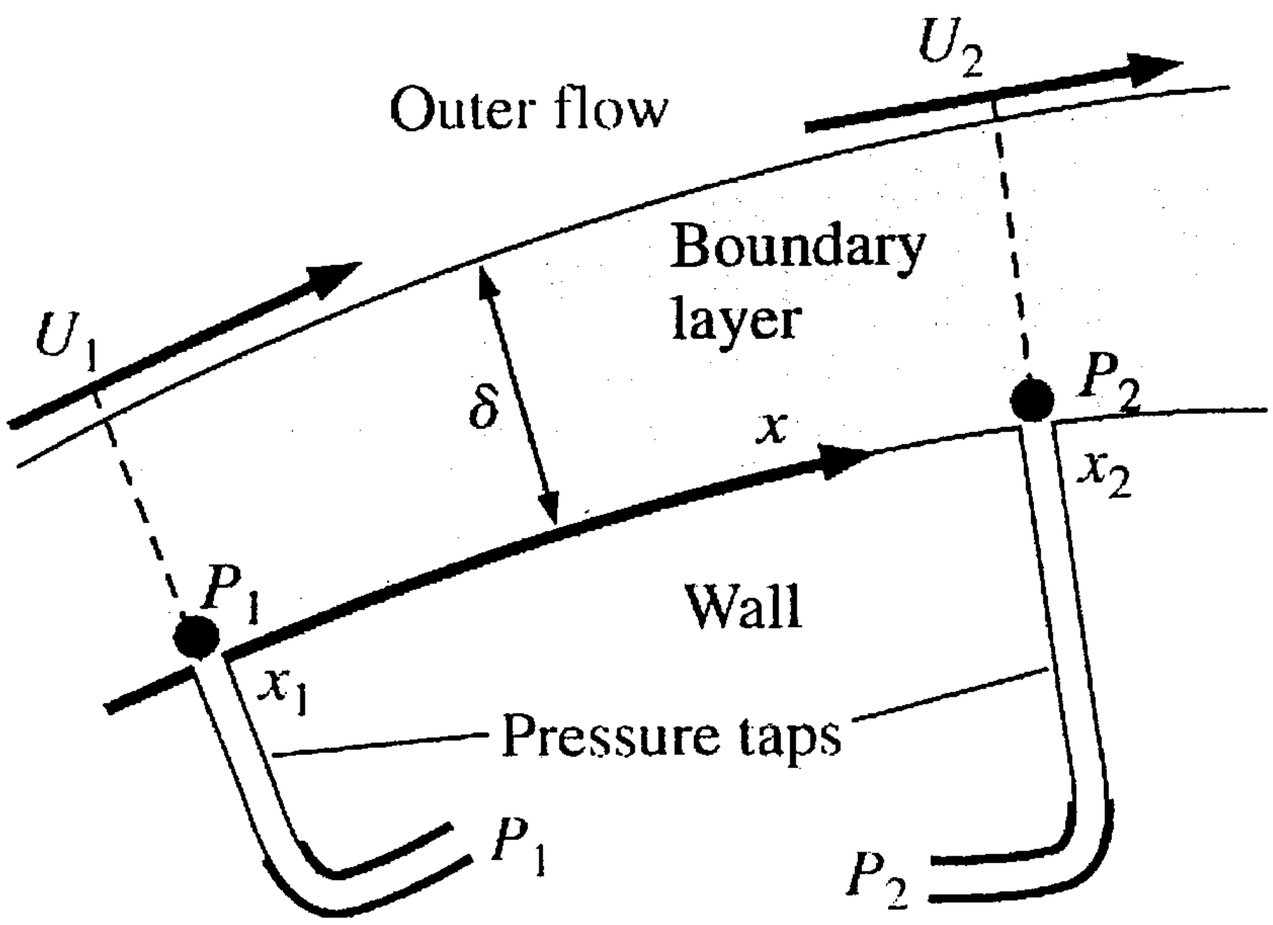
$$\tau_{\theta z} = \tau_{z\theta} = \mu\left(\frac{\partial v_\theta}{\partial z} + \frac{1}{r}\frac{\partial v_z}{\partial \theta}\right)$$

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

3. (15%)

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 ($\triangle x=x_2-x_1 \ll L$). 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

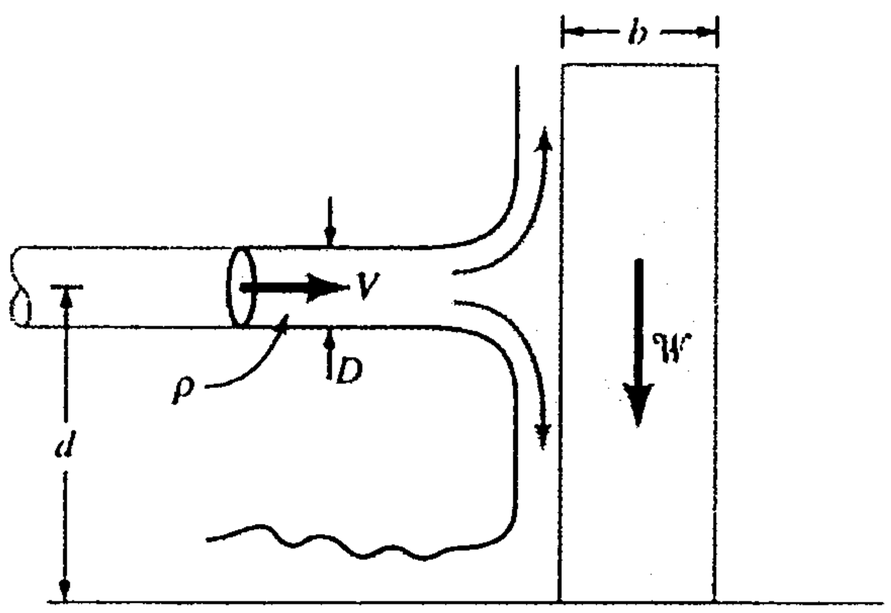


4. (20%)

As shown in the following figure, a jet of liquid directed against a block can tip over the block. Assume that the velocity, V, needed to tip over the block is a function of the fluid density, ρ, the diameter of the jet, D, the weight of the block, W, the width of the block, b, and the diameter, d, between the jet and the bottom of the block.

(a) Determine a set of dimensionless parameters for this problem.

(b) Use the momentum equation to determine an equation for V in terms of the other variables.



5. (20%)

A laminar boundary layer velocity profile is approximately by

$\frac{u}{U} = \left[2 - \left(\frac{y}{\delta}\right)\right]\left(\frac{y}{\delta}\right)$ for $y \le \delta$, and

$\frac{u}{U} = 1$ for $y > \delta$

(a) Show that this profile satisfies the appropriate boundary conditions for the boundary layer;

(b) Use the momentum integral equation to determine the boundary thickness, δ