國立清華大學 102 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(2704)

1. 解釋名詞 (30%)

- Largrangian Method
- Eulerian Method
- Streamline, Pathline, Streakline
- (a)What is the Bernoulli equation?

  (b) 應用 Bernoulli equation 的假設為何?

  (c)以 pressure 的觀點解釋 Bernoulli equation 內每一項

  (d)以 head 的觀點解釋 Bernoulli equation 內每一項
- Fully developed and developing
- Major loss and Minor loss
- boundary layer thickness and momentum thickness

2. 利用 dimensional analysis 將 Two dimensional N-S Eqs (如 Eq. (1))簡化成 Boundary layer Eqs (如 Eq. (2))並找出 boundary layer thickness 與 Re 的關係 (20 %)

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2} \qquad (2)$$

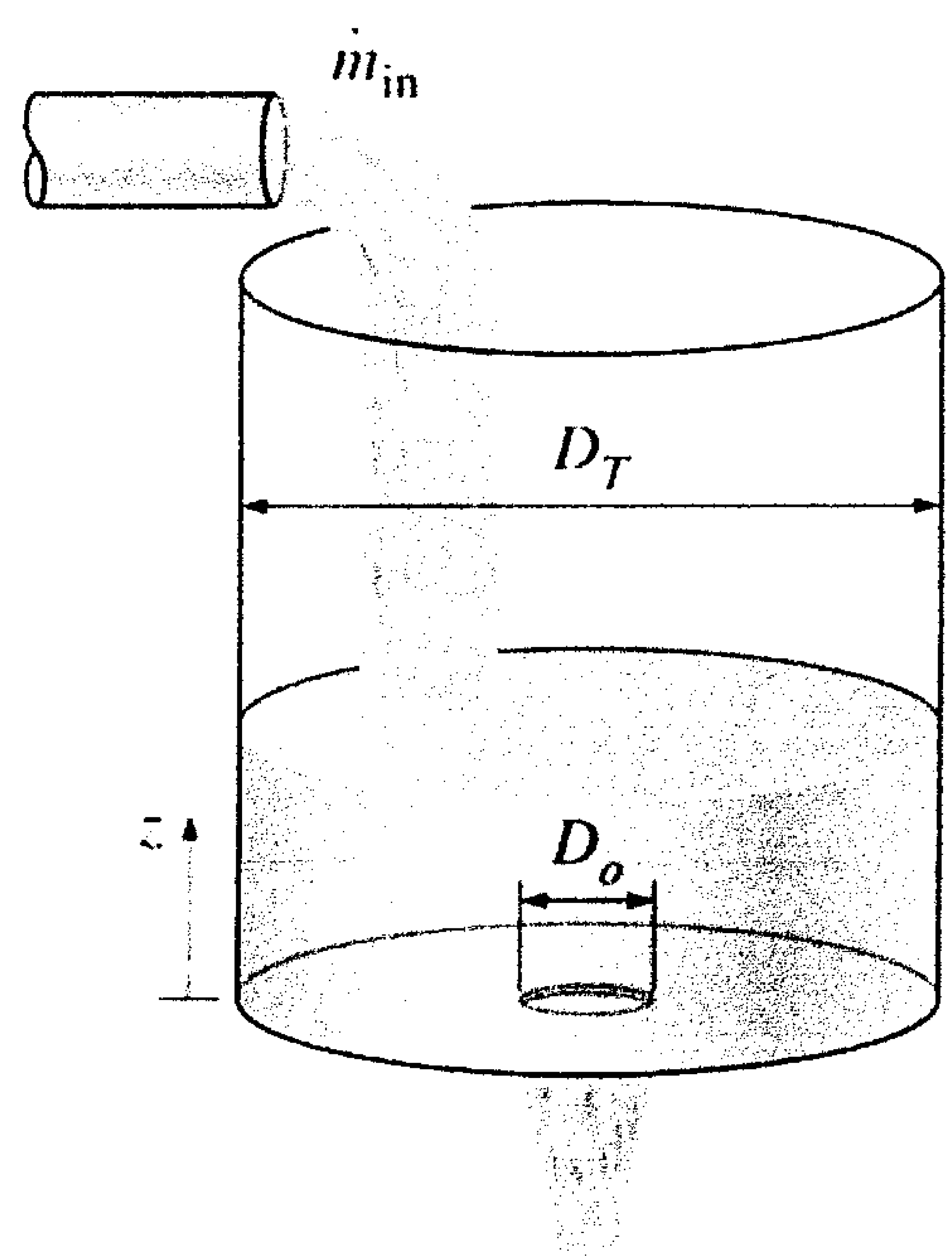
3. (20 %)

Water enters a tank of diameter D_T steadily at a mass flow rate of $\dot{m}_{in}$. An orifice at the bottom with diameter D_o allows water to escape. If the tank is initially empty, (a) determine the maximum height h_{max} that the water will reach in the tank; (b) obtain a relation for water height z as a function of time t.

Assumptions: a. The orifice has a smooth entrance

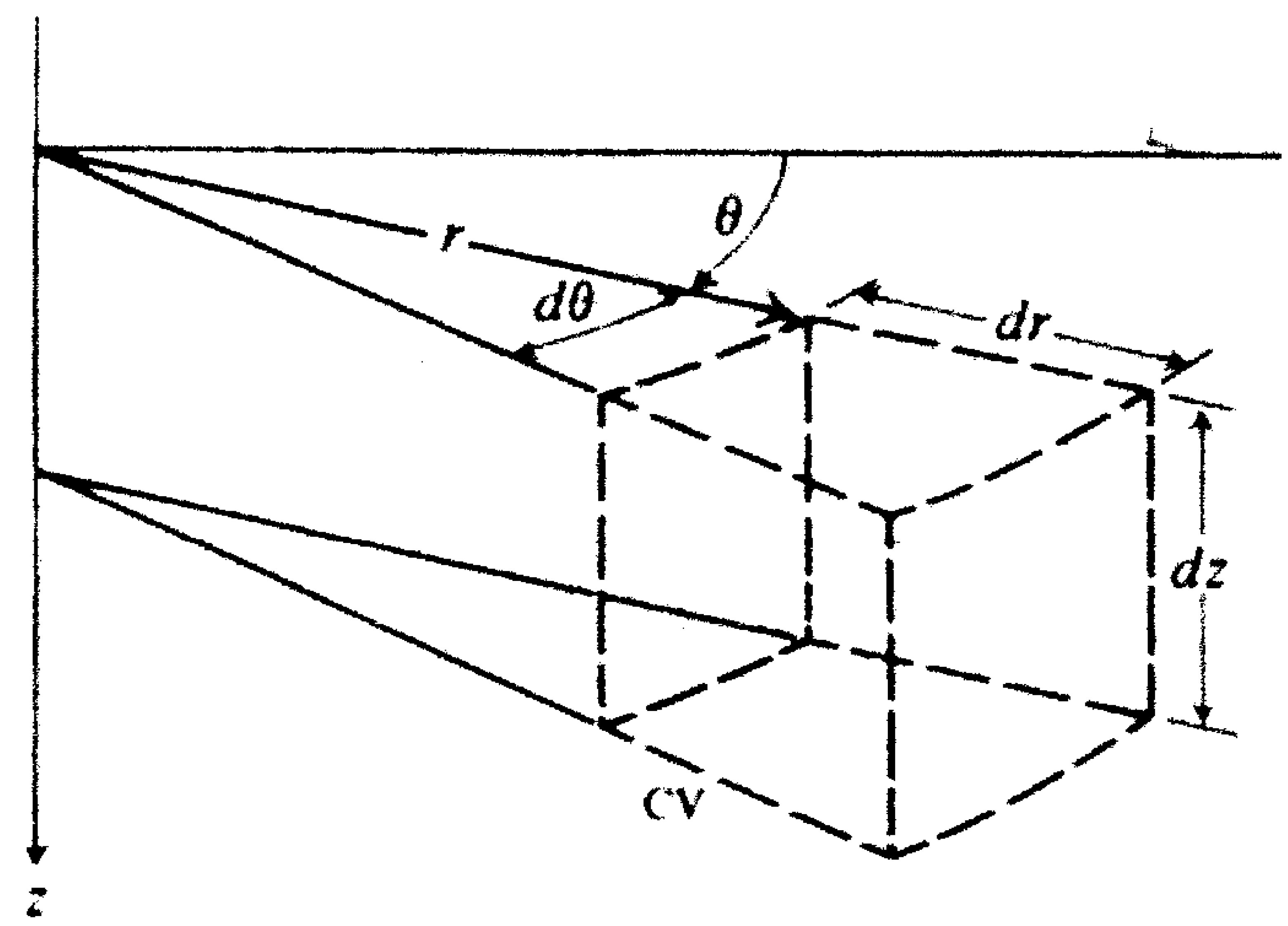
b. All of the frictional losses are negligible

c. $D_T >> D_o$



4. 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]

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

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

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

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

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

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