

國立清華大學 102 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班乙組

考試科目（代碼）：流體力學(2603)

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*請在【答案卷、卡】作答

1. 解釋名詞 (30%)

- Lagrangian 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 %)

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

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

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

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

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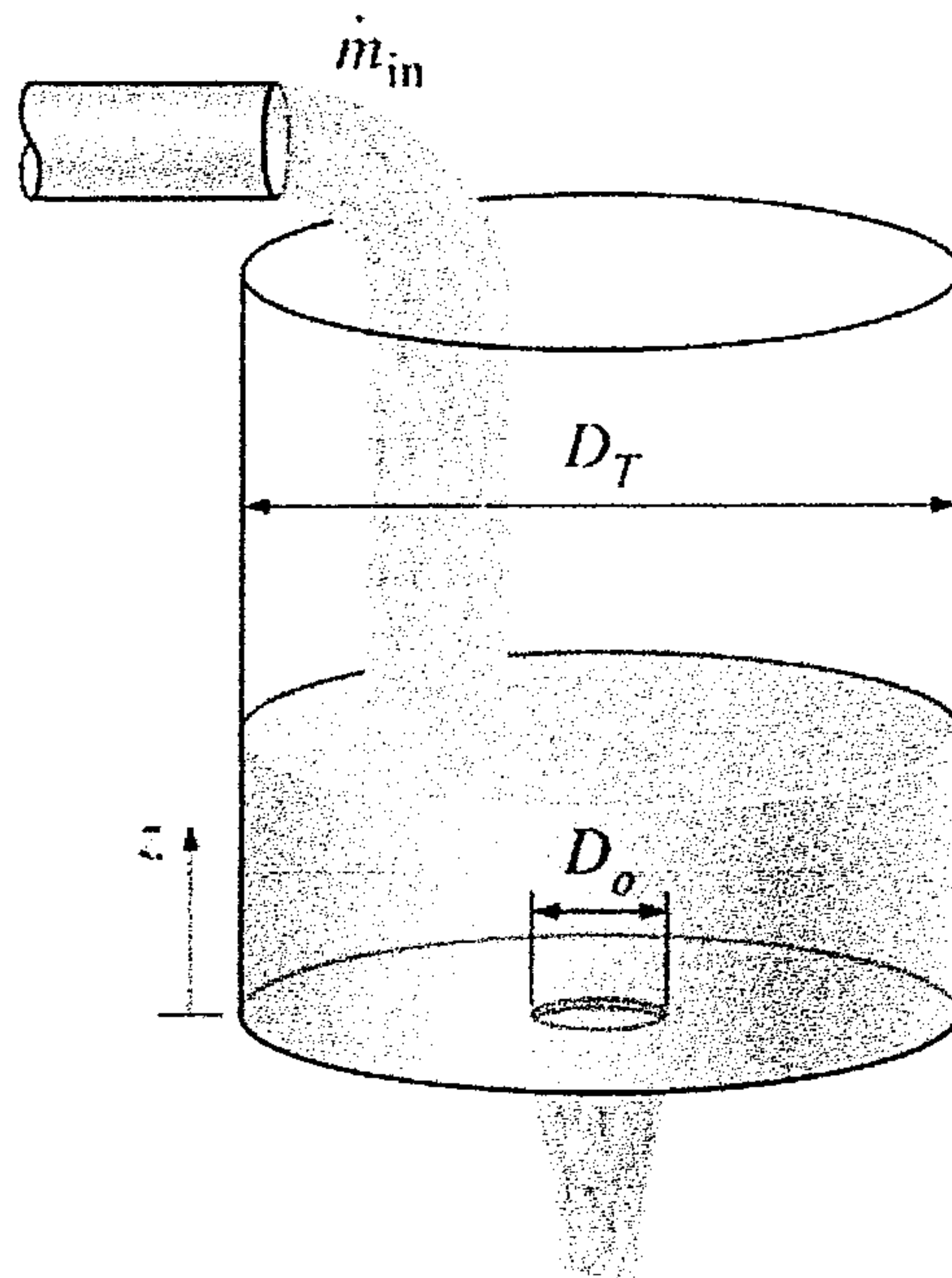
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3. (20 %)

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:**
- The orifice has a smooth entrance
 - All of the frictional losses are negligible
 - $D_T \gg D_o$



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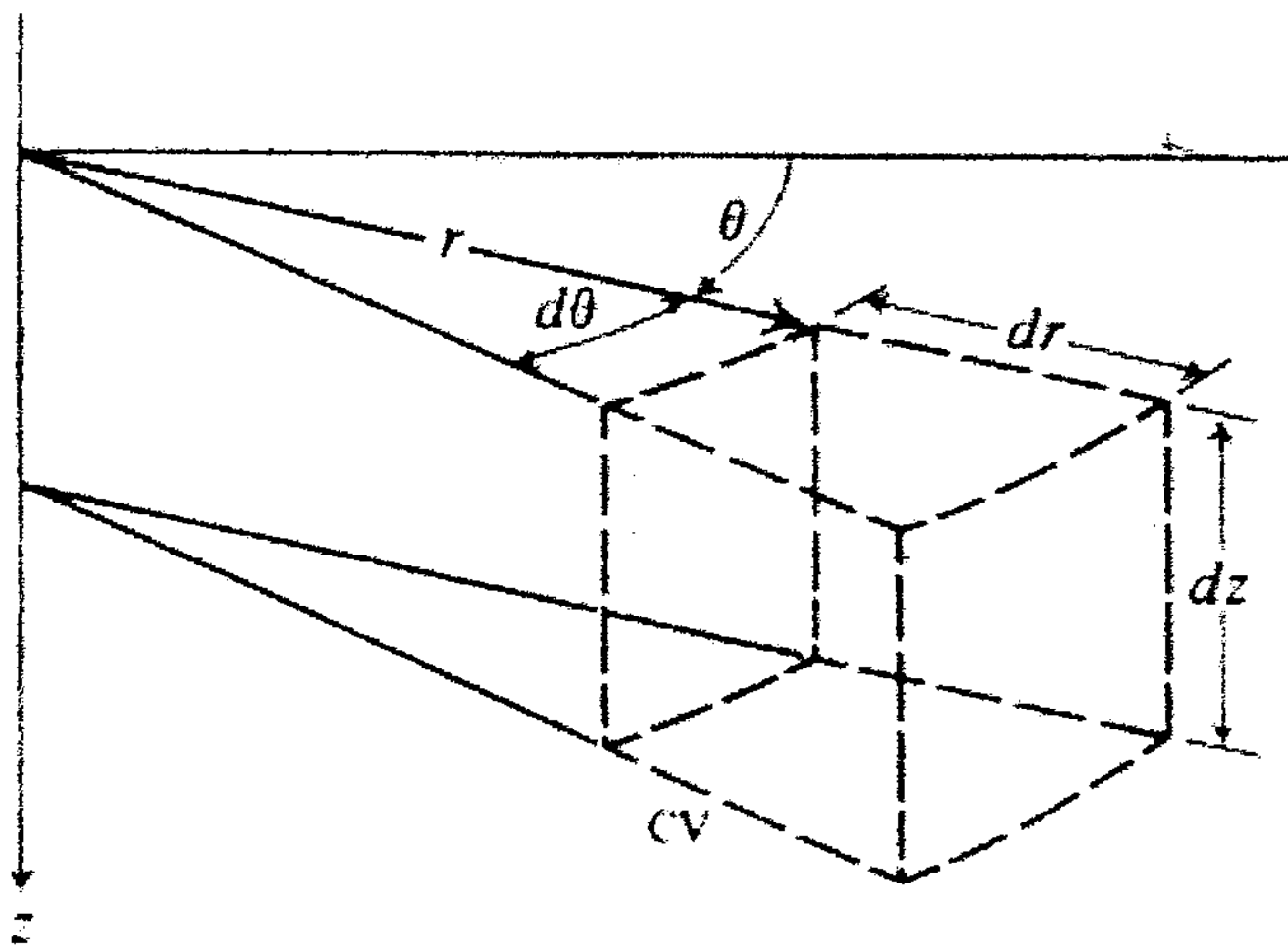
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4. 30 %

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 $r d\theta, dr, dz$. (σ is the normal stress and τ is the shear stress)



[Hint]

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

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

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

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

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

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