國　立　清　華　大　學　命　題　紙

96 學年度＿＿＿＿＿生命科學院＿＿＿＿＿系（所）＿＿＿丙＿＿＿組碩士班入學考試

科目＿輸送現象及單元操作＿科目代碼＿0404＿共＿2＿頁第＿1＿＿頁 *請在【答案卷卡】內作答

1. Briefly explain the following questions:

(a) Would $D\rho/Dt$ generally be zero for a steady state flow? (5%)

(b) Can one use the Navier-Stokes equation to describe the flow of molten steel of constant density and viscosity? (5%)

(c) What are the four variables to be obtained by solving the equations of continuity and motion for flow of Newtonian fluids of constant density and viscosity? (5%)

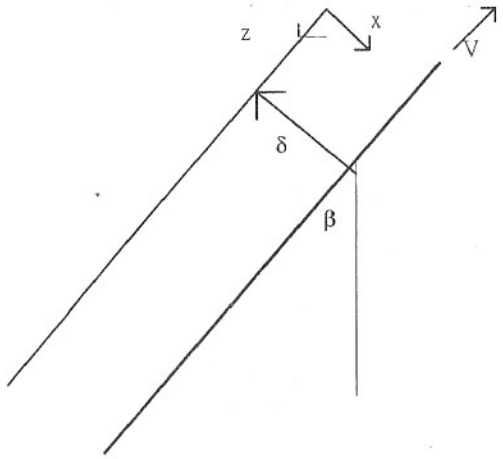
(d) Is eddy viscosity a physical property of fluids? (5%)

2. Consider a Newtonian fluid (viscosity μ and density ρ) flows down an inclined plate. The plate is pulled upward with a constant velocity V. Consider a control volume of $L \times W \times \delta$.

(a) Derive the shear stress and velocity distributions. (10 %)

(b) At the condition of zero Q, find the relation between δ and V. (5 %)

(c) Sketch the distribution of shear stress and velocity. (5 %)



(d) Find the force exerted by the fluid on the plate. (5 %)

3. (a) Prove $\underline{\underline{\delta}} : \nabla \underline{v} = \nabla \cdot \underline{v}$. (5 %)

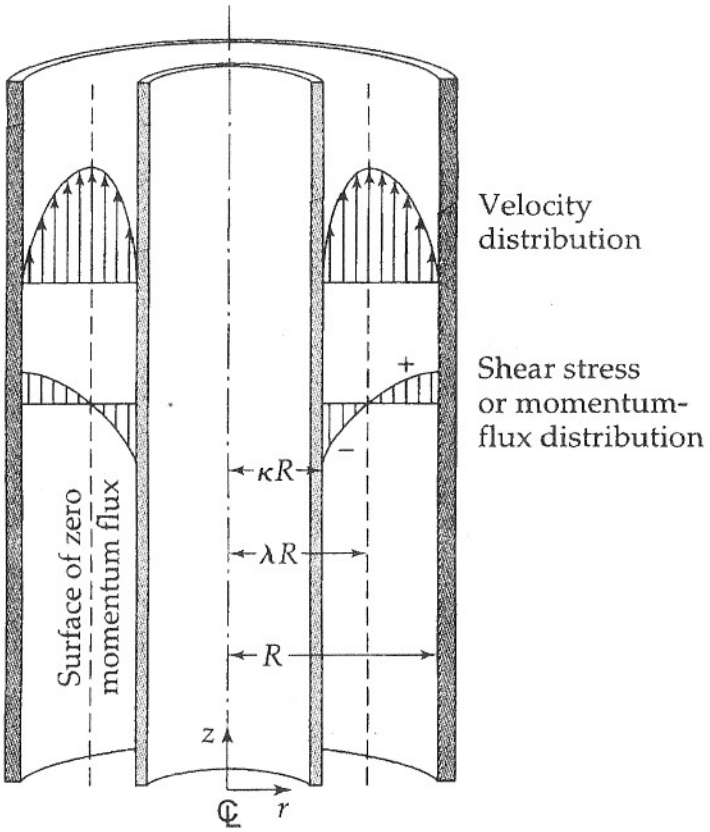
(b) Derive the expression for $\nabla \cdot \underline{v}$ in cylindrical coordinates. (10 %)

[Note: $\nabla = \underline{\delta}_r \frac{\partial}{\partial r} + \underline{\delta}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \underline{\delta}_z \frac{\partial}{\partial z}$; $\frac{\partial \underline{\delta}_r}{\partial \theta} = \underline{\delta}_\theta$; $\frac{\partial \underline{\delta}_\theta}{\partial \theta} = -\underline{\delta}_r$]

4. Consider the steady state axial flow of an incompressible Newtonian fluid in an annular region between two coaxial cylinders of radii kR and R as shown below. The fluid is flowing upward in the tube. Let $P=p+\rho gz$ being the modified pressure. Consider a control volume of a tube of length L.

(a) Derive the momentum flux and velocity distributions. (15 %)

(b) At what location will the velocity reaches a maximum and at what location will the momentum flux becomes zero. Are the two locations the same? Explain why they are or are not the same. (5 %)



5. If one wants to determine the viscosity of Hg at 20 °C ($\rho = 13.5 g/cm^3$, $\mu = 1.547 cp$) by measuring the terminal velocity of a steel ball ($\rho_s = 7.75 g/cm^3$) in a large expanse of Hg. What is the largest radius of the ball that can be used in this experiment?

(Hint: Stokes' law is good only for $Re<0.1$) (20 %)