國立中正大學八十九學年度碩士班招生考試試題

系所別：化學工程學系　　科　目：輸送現象與單元操作

1. Explain the following terms and problems. **(10 points)**
   (a) Stokes' viscosity relation
   (b) Boundary layer theory
   (c) Bernoullis equation
   (d) inviscid flow
   (e) Physical meaning of gradient

2. In Reynolds' experiment, below a value for Reynolds number of 2300, the flow is laminar. The flow exhibits irregular motions when Reynolds number is larger than 2300. Explain why the flow field becomes more and more complex as the Reynolds number increases. **(10 points)**

3. What is the viscosity? How do you measure viscosity of fluid by experiments without a viscometer? **(10 points)**

4. For flow parallel to a flat surface, the governing equations are **(20 points)**

$$v_x \frac{\partial v_x}{\partial x} + v_y \frac{\partial v_x}{\partial y} = \frac{\mu}{\rho} \frac{\partial^2 v_x}{\partial y^2} \qquad (1)$$

$$\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} = 0$$

with boundary conditions $v_x = v_y = 0$ at $y = 0$, and $v_x = v_\infty$ at $y = \infty$. (2)

(a) This problem can be solved by introducing the following relations

$$\eta(x,y) = \frac{y}{2}\left(\frac{\rho v_\infty}{\mu x}\right)^{1/2} \quad \text{and} \quad f(\eta) = \frac{\psi(x,y)}{(\mu x v_\infty/\rho)^{1/2}}, \qquad (3)$$

where $\psi(x,y)$ is the stream function. Show that the system equations (1) and (2) can be transformed into an ODE by equations (3). Solve the velocity profiles.

(b) If the boundary condition $v_x = v_\infty$ at $y = \infty$ changes to $v_x = v_\infty$ at $y = 1$, can you still apply the scaling equations (3) to obtain an ODE? Why?

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5. A fluid with temperature T_o and velocity v_o, steadily flows through a tube with radius R, as shown in Figure A. The wall temperature of the tube is kept at T_w (where $T_w < T_o$). The heat convection is the dominant heat transfer as the fluid flows through the tube. The flow pattern in the tube is plug flow and the tube is not too long or the temperature difference is not too severe. Use ρ as liquid density, C_p as specific heat, h as heat transfer coefficient between wall and fluid, and k as thermal conductivity.

(i) Based on above information, please list all ***assumptions*** (e.g., velocity profile, properties vs. temperature, etc.) 至少六項。(10 points)

(ii) Please sketch a *differential volume element* (or a control volume of plug flow) as clear as you can and write down the *energy balance* of this differential volume element based on general conservation law (**Rate in – Rate out + Rate of Generation = Rate of Accumulation**). Take this equation to limits, and yield the sought-after differential equation. (15 points)

(iii) Write down boundary conditions and solve for this equation. (10 points)

(iv) If the flow velocity profile is $v_z = 2v_o[1-(r/R)^2]$, please re-do (ii) and (iii) (15 points)

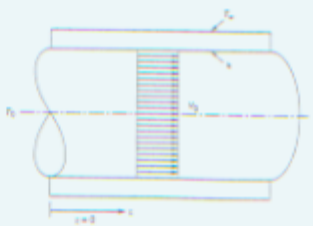

Figure A.