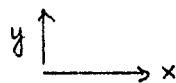1. (8%) Dimensional analysis 的用途是什麼？你覺得這個方法美中不足的是什麼？

2. (10%) 分別簡述 Venturi meter 與 Pitot tube 的原理，並比較其差異，請分別繪出簡圖說明之。

3. (15%) Evaluate the exact solution δ , C_{fx} , and C_{fL} for the laminar boundary layer over a flat plate, using the following velocity profile

$$\upsilon_x = a \cdot sin(by)$$

[Note]

1. von Kármán momentum integral expression is given by

$$\frac{\tau_o}{\rho} = (\frac{d}{dx}\upsilon_\infty)\int_0^\delta (\upsilon_\infty - \upsilon_x)\,dy + \frac{d}{dx}\int_0^\delta \upsilon_x(\upsilon_\infty - \upsilon_x)\,dy$$

2. $C_{fx} = \dfrac{\tau_o}{\rho\upsilon_\infty^2 / 2}$

3. δ: boundary layer thickness,
   C_{fx}: local skin friction coefficient,
   C_{fL}: mean skin friction coefficient
   L: the length of this flat plate

   τ_o : shear stress at the surface of the plate
   ρ : density of the fluid flow
 υ_∞ : υ_x at $y \to \infty$

Follow the procedures to solve this problem,

1) What is the simplified form of the von Kármán equation for this case.

2) List the boundary conditions of this problem.

3) Obtain δ in terms of R_{ex} of υ_x

4) Obtain C_{fx} and C_{fL}.

541021

4. 請討論並比較熱交換器兩種分析方法, the log-mean temperature difference method and the effectiveness-number of transfer units method, 的適用時機。 (4 %)

5. Heat is being generated uniformly by a chemical reaction in a long cylinder of radius R. The heat is assumed to flow radially by conduction and the rate of heat generated per unit volume is $\dot{q}$. The thermal conductivity k will be considered constant. The walls of the cylinder are cooled so that the wall temperature is held at T_W. Please derive the expression for the temperature profile T(r), where r is distance from the center. (8 %)

6. 根據報導,由於口蹄疫的流行,民眾除了需注意所選購的豬肉是否經過檢驗合格外,在烹調過程應將豬肉加熱至 80°C 以上。為了解烹調豬排時,其內部溫度隨時間變化的情形,現在將一塊豬排視為一個平板,並將問題簡化成下列的熱傳問題: unsteady-state heat conduction in a flat plate with negligible surface resistance. The plate is initially at a uniform temperature T_0, and at time t = 0 the surfaces at x = +L and x = -L are suddenly increased to temperature T_s. Please write down the governing equation, initial condition, and boundary conditions, and use the method of separation of variables to obtain a general solution (product solution) for this problem. You don't have to apply the initial and boundary conditions to solve for the constants in the general solution. (10 %)

7. A kerosene stream (150 kg/hr) is to be used to remove nicotine from a water stream containing 0.01 g nicotine/g water and flowing at a rate of 100 kg/hr. The equilibrium relationship between aqueous and kerosene phases is given by $Y = X$, where Y is the mass ratio of nicotine to kerosene; X is the mass ratio of nicotine to water. Calculate the percentage removal of nicotine from the water stream in

(1) a single ideal stage (3 %)

(2) two-stage cascades in crossflow pattern (equal amounts of kerosene are fed to the two stages). (5 %)

(3) two-stage cascades in countercurrent pattern. (5 %)

(4) two-stage cascades in cocurrent pattern. (5 %)

8. Consider a gas scrubbing unit as shown in the figure. Air containing a water-soluble vapor is flowing up and water is flowing down in the experimental column. The water flow in the 0.07 cm-thick film is 3 cm/sec, the column diameter is 10 cm, and the air is essentially well mixed right up to the interface. The diffusion coefficient in water of the absorbed vapor is 1.8×10^{-5} cm²/sec. How long a column is needed to reach a gas concentration in water that is 10% of saturation ? (15%)
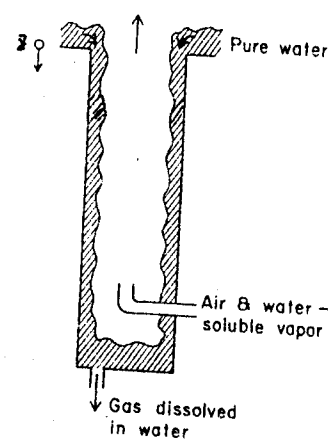
(The mass transfer correlation in falling films is $\dfrac{k\delta}{D} = 0.69 \left(\dfrac{z v^0}{D}\right)^{\frac{1}{2}}$

where k: mass transfer coefficient, D: diffusion coefficient

z: position along film, v^0: average film velocity)

9. 簡答下列各題

(1) 請以題(8)的 gas scrubbing column 為例，畫一示意圖來解釋 Film Theory 和 Penetration Theory 的差異。(6%)

(2) 在設計一個蒸餾塔時，請以圖形表示進料板的可能範圍？若為理想板，則最佳進料板之位置為何？若為非理想板，則進料板之位置應如何決定？(6%)