國立雲林科技大學 107 學年度 碩士班招生考試試題
系所：化材系
科目：單元操作與輸送現象

1. A wall is composed of three kinds of bricks (shown as following). The indoor air is at the temperature of 80°F with heat transfer coefficient of 2.0 Btu/hr-ft^2-°F. The outdoor air is at the temperature of 105°F with heat transfer coefficient of 6.0 Btu/hr-ft^2-°F. The thickness (in) and thermal conductivity (k, Btu/hr-ft-°F) of the bricks are given in the figure. (20%)
   (a) Please calculate the heat transfer rate per unit area (Btu/hr-ft^2) through the wall.
   (b) Please determine the temperature at the indoor surface of the wall.

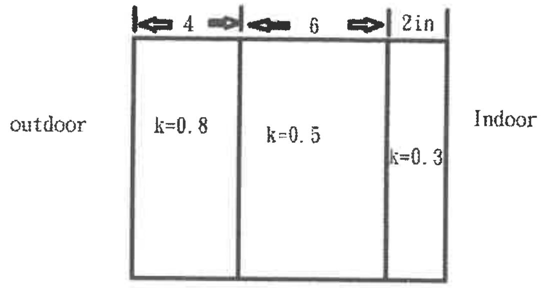

Figure 1.

2. A cylindrical tube is composed of two materials (shown as following). A fluid at the temperature of T_i flows through the inner tube with heat transfer coefficient of h_i. On the other hand, another fluid at the temperature of T_o flows over the outer tube with heat transfer coefficient of h_o. The heat transfer is assumed in the radial direction. Please derive the overall heat transfer coefficient. (20%)

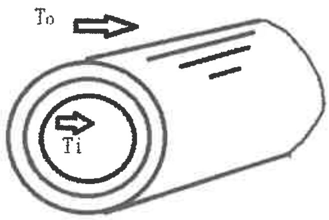

Figure 2.

3. Answer the followings in the fractioning process. (16%)
   (a) The physical meaning of operation line and equilibrium line in the McCabe-Thiele method for distillation.
   (b) If the overall efficiency is 75% and the numbers of ideal plates are 16, what is the number of real plates in the fractioning tower?
   (c) What are the situations when the q values are 0 and 1?
   (d) What is the situation when the minimum reflux ratio occurs?

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4. According to the film theory (referring to Figure 3), prove that the Sherwood number $Sh = \frac{k_c \delta}{D_{AB}} = 1$ where k_c is the mass transfer coefficient, δ is the film thickness, and D_{AB} is the diffusivity of gas A in liquid B. (20%)

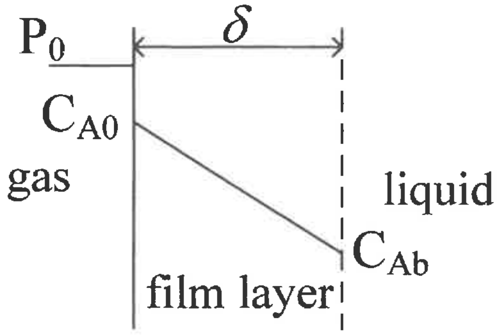

Figure 3.

5. Consider a pressure-driven fully-developed laminar flow of an incompressible Newtonian fluid of density ρ and viscosity μ in a horizontal tube of diameter D and length L, referring to Figure 4. (24%)

(a) Derive the average fluid velocity, $\langle v_z \rangle$, in terms of a function of pressure drop Δp across the tube **by using the shell momentum balance method**.

(b) Prove that the Fanning friction factor $f_F = \frac{16}{\mathrm{Re}}$, where $\mathrm{Re} = \frac{\rho \langle v_z \rangle D}{\mu}$.

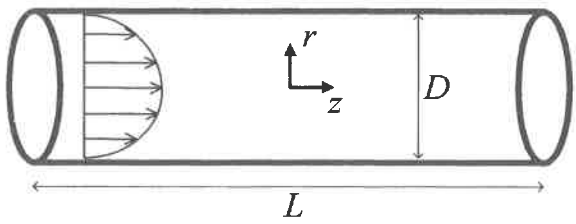

Figure 4.