所別：化學工程與材料工程學系碩士班 一般生 科目：輸送現象與單元操作
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This exam has two pages and four questions with a total score of 100%. State all your assumptions, units, derivations and steps clearly. Circle and number your final answers.

1. (25%) Momentum Transfer

A cylindrical rod of radius R_1 moves axially with a constant velocity, V, through a fluid inside a horizontal cylindrical tube of inner radius R_2 and length L. There is also a pressure gradient imposed on the Newtonian fluid in the annulus. Derive the momentum balance equation and use the appropriate boundary conditions to find the velocity distribution of the fluid in the annulus under steady-state, fully developed laminar-flow conditions.

2. (25%) Heat Transfer

(a) (5%) What is the physical meaning of the Prandtl number? Does the value of the Prandtl number depend on the type of flow or the flow geometry?
(b) (5%) Explain how the fins enhance heat transfer from a surface. Also, explain how the addition of fins may actually decrease heat transfer from a surface.
(c) (5%) Consider a hot boiled egg in a spacecraft that is filled with air at atmospheric pressure and temperature at all times. Will the egg cool faster or slower when the spacecraft is in space instead on the ground? Explain.
(d) (5%) Show that the volume expansion coefficient of an ideal gas is $\beta=1/T$, where T is the absolute temperature.
(e) (5%) Consider two fluids, one with large coefficient of volume expansion and the other with a small one. In what fluid will a hot surface initiate stronger natural convection currents? Why? Assume the viscosity of the fluids to be the same.

注意：背面有試題

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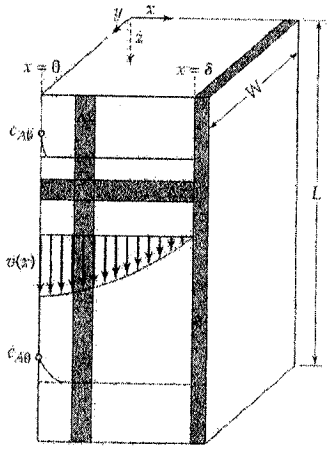
3. (25%) Mass Transfer

Consider the absorption of gas A by a laminar falling film of liquid B as shown in the figure. Gas A is only slightly soluble in B and the diffusion takes place so slowly in the liquid film that A will not "penetrate" very far into the film – that is, the penetration distance is small in comparison with the film thickness, δ. The velocity profile can be expressed by



$$v_z(x) = v_{max}\left[1-\left(\frac{x}{\delta}\right)^2\right]$$

The solubility of A in B is C_{A0} and the diffusivity of A in B is D_{AB}. Find the concentration profile, C_A.

4. (25%) Unit Operations

A binary system contains components A and B with liquid and vapor in equilibrium at a given pressure, P. Component A is more volatile than component B. Let the amounts of liquid and vapor be n(l) and n(g), and their sum be n. Assume that the overall mole fraction of component A in the system, the mole fraction of component A in the liquid phase and the mole fraction of component A in the vapor phase be z_A, x_A and y_A respectively.

(a) (5%) Derive the lever rule.
(b) (5%) Draw a temperature-composition diagram at P of this binary system. Label all axes, points, areas and curves.
(c) (5%) Derive the feed line of a flash distillation where the concentration of the feed be x_F, in mole fraction of the more volatile component and f be the molal fraction of the feed that is vaporized and withdrawn continuously as vapor.
(d) (5%) Relate the lever rule in Part (a) with the feed line in Part (c) mathematically.
(e) (5%) Explain how to construct an equilibrium curve for distillation on an x-y plot from the tie lines in Part (b) and why the equilibrium curve is above the diagonal line y = x.