所別：化學工程與材料工程學系碩士班 不分組 科目：輸送現象與單元操作

1. (10%) Friction factor

For flow through conduits of various shapes, what factor(s) influence the friction factor? Give the answer for both laminar and turbulent flow.

2. (20%) Annular flow with inner cylinder moving axially

A cylindrical rod of diameter κR moves axially with velocity v_0 along the axis of a cylindrical cavity of radius R as seen in the figure. The pressure at both ends of the cavity is the same, so the fluid moves through the annular region solely because of the rod motion. Find the velocity distribution in the narrow annular region.

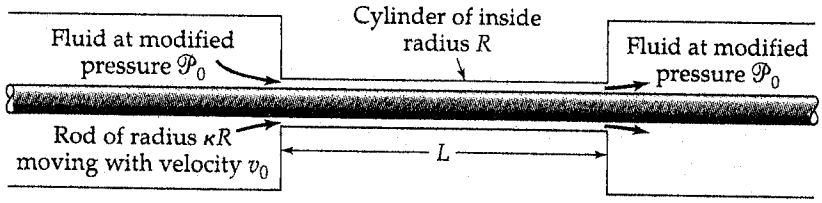

Fig. Annular flow with the inner cylinder moving axially.

3. (20%)

A plane wall of thickness 0.1 m and thermal conductivity 25 W/m K having uniform volumetric heat generation of $0.3\times10^6 W/m^3$ is insulated in one side (the inner surface), while the other side (the outer surface) is exposed to a fluid at $92^\circ C$. The convection heat transfer coefficient between the wall and the fluid is 500 $W/m^2\cdot K$.

(a) Determine the temperature at the outer surface of the wall.

(b) Solving the proper conservation equation and boundary conditions to determine the temperature at the inner surface of the wall.

4. (15%)

Steam condensing on the outer surface of a thin-walled circular tube of 50-mm diameter and 6-m length maintains a uniform surface temperature of $100^\circ C$. Water flows through the tube at a rate of $\dot{m} = 0.25 kg/s$, and its inlet and outlet temperatures are $T_{m,i} = 15^\circ C$ and $T_{m,o} = 57^\circ C$. Outer surface convection resistance and tube wall conduction resistance are negligible. (Heat capacity for water at $36^\circ C$ is 4178 J/kg K)

(a) Determine the total heat transfer rate of this tube.

(b) Determine the log mean temperature difference of this system.

(c) What is the average convection coefficient associated with the water flow?

注意：背面有試題

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5.(15%) Molar flux N_A

Consider a binary mixture of A and B with the average velocity **v**. The velocity and concentration of component i are $\mathbf{v}_i$ and c_i, respectively. Here i = A or B.

(a) (3%) What are the definitions of the average velocity (**v**) and the molar flux of A ($\mathbf{J}_A$)?

(b) (10%) Derive the molar flux, $N_A = -D\nabla c_A + x_A(N_A+N_B)$ and explain the physical meaning of the two terms. What form do you use for $\mathbf{J}_A$?

(c) (2%) Under what condition the second term can be neglected?

6. (20%) Concentration boundary layer theory

As the fluid passes a solid plate, the substance A is dissolved with a saturated concentration c_0 at $y = 0$. Assume the thickness of the momentum boundary layer is much smaller than that of the concentration boundary layer. Therefore, we can consider the fluid flowing with a uniform velocity U inside the concentration boundary layer $0 < y < \delta(x)$. Outside the boundary layer, the concentration of A is essentially zero, $c = 0$ for $y > \delta(x)$. The diffusivity of A is D.

(a) (5%) Write down the partial differential equation (pde) for the mass balance of A and explain the meaning of each term.

(b) (5%) Assume a linear concentration profile $c(x,y) = p + q\,(y/\delta)$ as $0 < y < \delta(x)$ and $c = 0$ otherwise. Determine the unknown constants p and q by the boundary conditions.

(c) (5%) Integrate the pde with respect to y from 0 to δ. Note that $\partial c/\partial y$ is discontinuous at $y = \delta$ and we adopt $\partial c/\partial y = 0$. You should obtain an ordinary differential equation for $\delta(x)$. Assume $\delta(x=0)=0$.

(d) (5%) Obtain $\delta(x)$ and the mass transfer coefficient $k(x)$ defined by $N_y(x) = k(x)(c_0-0)$.