（總分爲 100 分）

1. Following Ergun equation has been widely employed for describing packed columns

$$\left(\frac{(P_0 - P_L)\rho}{G_0^2}\right)\left(\frac{D_P}{L}\right)\left(\frac{\varepsilon^3}{1-\varepsilon}\right) = 150\left(\frac{1-\varepsilon}{D_P G_0 / \mu}\right) + 1.75$$

Write down the physical meanings and the units of the symbols appeared in this equation: D_P , G_0 , L , P_0 , P_L , ε , μ ,and ρ . Please follow the order shown above.(16%)

2. Consider the turbulent flow of air at $30\,m/s$, 1 *atm* and $20\,°C$ over a flat plate $1\,m$ long, with the air containing a low concentration of water vapor. Find the mass transfer coefficient h_L . Assume $\rho = 1.18 \times 10^{-3}\,g/cm^3$, $\mu/\rho = 0.157 cm^2/s$, $D_{AB} = 0.220 cm^2/s$, and $Sh = 0.036\,Re^{4/5} Sc^{1/3}$. (15%)

3. There is an electric wire of circular cross section with radius R and the rate of heat production per unit volume is S_e . We assume here that the steady state is applicable and the thermal conduction as well as the heat source resulting from electrical dissipation need be considered. The surface of the wire is maintained at temperature T_0 . Please derive the radial temperature distribution expression within the wire, $T = T(r)$, starting from shell energy balance. (19%)
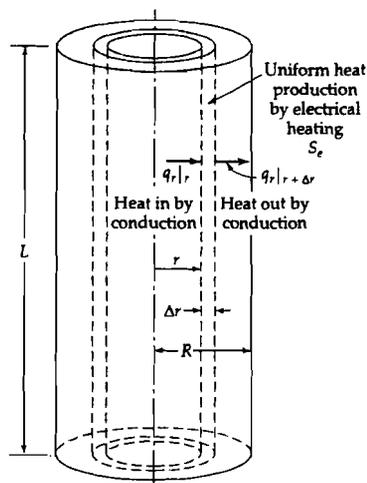
4. The duct from a heater has an inside diameter of 114.3 mm with ceramic walls 6.4 mm thick. The average k=1.52 W/m·K. Outside this wall, an insulation of rock wool 102 mm thick is installed. The thermal conductivity of the rock wool is $k=0.046+1.56\times10^{-4}$ T/°C (W/m·K). The inside surface temperature of the ceramic is $T_1=588.7$ K, and the outside surface temperature of the insulation is $T_3=311$ K. Please estimate the heat loss for 1.5 m of duct and the interface temperature T_2 between the ceramic and the insulation. (20%)

5. Consider a capillary flowmeter as shown in the following figure. Please determine (a) average velocity; (b) the volume flow rate. (15%)

Density of flow fluid: ρ_1

Density of fluid in flowmeter: ρ_2
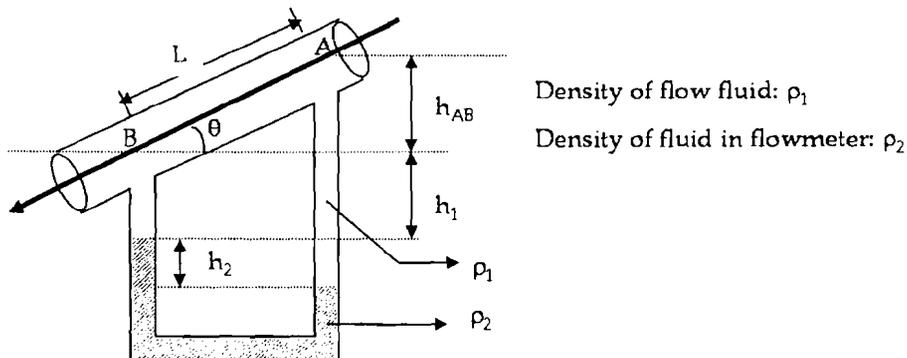
6. An open tank travels along x-direction at a velocity v_c. A jet of area A_j exhausts fluid of density ρ at a velocity v_j relative to the car. At the same time, the tank collects fluid from an overhead sprinkler which directs fluid downward with velocity v_s. Assume that the sprinkler flow is uniform over an area, A_c. Please determine the net force of the fluid on the tank car. (15%)