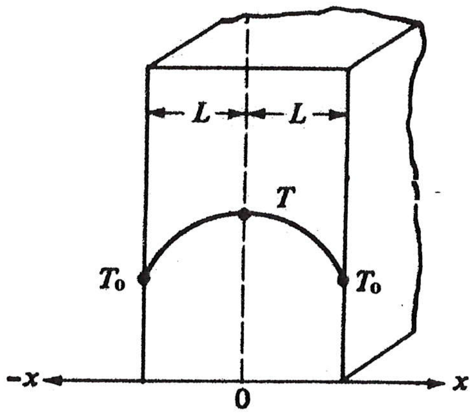
國立雲林科技大學 112 學年度
碩士班招生考試試題
系所：化材系
科目：單元操作與輸送現象

1. A thick-walled pipe of stainless steel having a $k = 21.51$ W/(m·K) with dimensions of 2.54 cm ID and 5.08 cm OD is covered with a 2.54 cm layer of asbestos (石棉) insulation, $k = 0.24$ W/(m·K). The inside wall temperature of the pipe is 800 K and the outside surface of the insulation is at 300 K. (a) Find the heat loss per unit meter length of pipe (b) the temperature at the interface between the metal and the insulation. (20%)

2. A plane wall is shown as following with internal heat generation Q per unit volume at steady state. Thermal energy is conducted only in x direction. The other walls in y, z directions are assumed to be insulated. The temperature of wall at x = L and x = −L is To. The thermal conductivity of the plane wall is k. Please derive temperature profile in the x direction T(x) as a function of x, Q, k, L, and T_0 within the plane wall. (20%)



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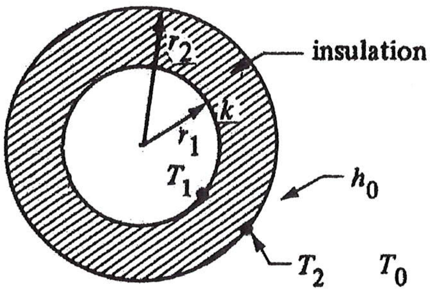
3. A cylinder, with high thermal conductivity and thin wall thickness, is insulated by a layer of insulation with thickness of (r_2−r_1), of which thermal conductivity is k. The inner temperature of the insulation is T_1 at r_1. The outer surface of the insulation at T_2 (r_2) is exposed to an environment at T_0, wherein convective heat transfer occurs with coefficient of h_0. Find the critical thickness of the insulation for the maximum heat transfer rate. (10%)



4. Please explain the physical meaning of the following dimensionless numbers: (12%)
   (a) Reynolds number
   (b) Biot number
   (c) Froude number
   (d) Schmidt number

5. For a binary mixture, find the concentration profile C_A, if A and B components are transported under equimolar counterdiffusion condition along z axis without chemical reaction. The system is controlled at constant temperature and pressure. It is known that the concentrations of A are C_{A1} and C_{A2} at z = z_1 and z = z_2, respectively. (18%)

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6. For a steady-state and laminar flow of a fluid along z axis in a vertical tube (radius R and length L), find the expressions for modified pressure $P(z)$ and velocity profile $v_z(r)$ by using the following equations. Suppose the liquid flows downward under the influence of a pressure difference and gravity. The viscosity and density of fluid can be regarded to be constant in the system. (20%)

$$\rho\left(\frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta}+v_z\frac{\partial v_r}{\partial z}-\frac{v_\theta^2}{r}\right)=-\frac{\partial p}{\partial r}+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_r)\right)+\frac{1}{r^2}\frac{\partial^2 v_r}{\partial \theta^2}+\frac{\partial^2 v_r}{\partial z^2}-\frac{2}{r^2}\frac{\partial v_\theta}{\partial \theta}\right]+\rho g_r$$

$$\rho\left(\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+v_z\frac{\partial v_\theta}{\partial z}+\frac{v_r v_\theta}{r}\right)=-\frac{1}{r}\frac{\partial p}{\partial \theta}+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_\theta)\right)+\frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2}+\frac{\partial^2 v_\theta}{\partial z^2}+\frac{2}{r^2}\frac{\partial v_r}{\partial \theta}\right]+\rho g_\theta$$

$$\rho\left(\frac{\partial v_z}{\partial t}+v_r\frac{\partial v_z}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta}+v_z\frac{\partial v_z}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2}+\frac{\partial^2 v_z}{\partial z^2}\right]+\rho g_z$$