91 學年度 國立成功大學碩士班招生考試 工程科學系所 熱傳學(專班乙組)試題

I. Explain the following terms: (20%)

(1) Fourier's law of heat conduction
(2) The thermal boundary layer
(3) Natural convection
(4) Steady-state
(5) Thermal resistance

II. Answer the following questions: (20%)

1. What's physical meaning of Pr? How does it relate to the momentum and thermal boundary layer thicknesses?
2. What's the physical meaning of Biot number?
3. What is the Boussineq approximation?
4. In an exmperiment, if you want a surface to be at a constant temperature, how would you do?

III. For a one-dimensional problem of heat conduction, derive the expression of the energy equation in steady-state condition. To derive this equation, consider a small control volume as shown in Fig. 3 and the temperature is only function of y, i.e., T = T(y). (15%)

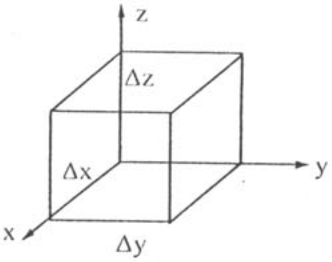

Fig. 3

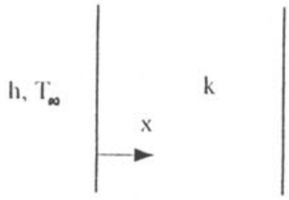

Fig. 4

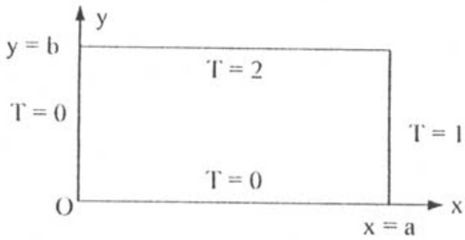

Fig. 5

IV. The temperature distribution of a 1-D steady-state problem (as shown in Fig. 4) is $T = a + bx + cx^2$. At x = 0, there is a convective boundary condition. Derive the expression of h, which is the convective heat transfer coefficient. T_∞ is the ambient temperature, and k is the thermal conductivity. (10%)

V. Consider a steady-state heat conduction problem in a rectangular plate. Its boundary conditions are shown in Fig.5. Find the temperature solution of the plate. (20%)

VI. Ethylene glycol is to be cooled from 60 °C to 40 °C in a 3.0-cm-diameter tube. The tube wall temperature is maintained constant at 20 °C. The glycol enters the tube with a velocity of 10 m/s. Calculate the length of tube necessary to accomplish this cooling. (15%)

$$Nu_d = 0.027\,Re_d^{0.8}\,Pr^{1/3}(\nu/\nu_w)^{0.14}$$

All properties are evaluated at the average bulk-temperature (i.e., at 50 °C), except ν_w which is evaluated at the wall temperature.

T, °C	ρ, kg/m	cp, kJ/kg°C	ν, m²/s	k, W/m°C	Pr
0	1,130.75	2.294	57.53×10^{-6}	0.242	615
20	1,116.65	2.382	19.18×10^{-6}	0.249	204
40	1,101.43	2.474	8.69×10^{-6}	0.256	93
60	1,087.66	2.562	4.75×10^{-6}	0.260	51
80	1,077.56	2.650	2.98×10^{-6}	0.261	32.4

Hint: $q = \dot{m}C_p\Delta T_b = h(\pi DL)[T_w - (T_b)_{average}]$, $\dot{m} = \rho V(\pi D^2/4)$, $Re_D = VD/\nu$.