國立清華大學 106 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 乙組(0527)

考試科目（代碼）：熱傳學 (2704)

1. (a) Please describe the Fourier's law of heat conduction and Newton's law of cooling, respectively. (5 %)

   (b) Please describe the lumped capacitance model and the criterion for its validity. (5%)

   (c) What is the criterion for an internal flow in a circular tube to become turbulent ?(5 %)

   (d) Show that, for an ideal gas, the volumetric thermal expansion coefficient (β) at a given temperature (T) is equal to 1/T. (5 %)

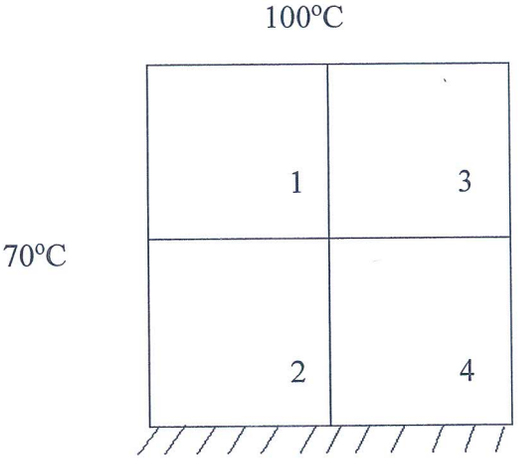
   Hint:β is defined as:

$$\beta = -\frac{1}{\rho}\left(\frac{\partial \rho}{\partial T}\right)_P$$

   Where ρ is the density and p is the pressure.

2. A plane wall is a composite of two materials, A and B. The wall of material A has uniform heat generation of g, thermal conductivity of k_a, thickness of L_a. The wall of material B has no heat generation and its thermal conductivity is k_b and thickness is L_b. The inner surface of material A is adiabatic, while the outer surface of material B is cooled by a fluid at T_o with a heat transfer coefficient h. Obtain the temperature distribution in the material A and determine its maximum temperature. (20%)

3. Consider two-dimensional, steady-state conduction in a square cross section with prescribed boundary conditions as shown, using a finite difference method based on the conservation of energy to determine the temperatures at nodes 1, 2, 3, and 4.(20%)



4. Water at 20℃ enters a circular channel of diameter 1cm with a mass flow rate of 0.1 kg/s. The tube is uniformly heated with a heat flux of 10^4 W/m^2. The tube length is such that the water temperature at the exit is 60℃. Determine

(a) the length of the tube (10%)

(b) the maximum channel surface temperature (10%)

The water properties at 40℃ are:

ρ =992 kg/m^3 ; Cp=4.179×10^3 J/kgK

k_f =0.631W/mK ; μ =6.539×10^{-4} kg/ms.

Hint：Nu_D=4.36 if the flow is laminar

Nu_D=0.023$Re_D^{0.8}$ $Pr^{0.4}$ if the flow is turbulent

5. A horizontal, high pressure steam pipe of 10 cm outside diameter passes through a large room whose wall and air temperatures are 30℃. The pipe with thermal insulation has an outside surface temperature of 124℃ and an emissivity of ε = 0.90. Estimate the heat loss due to natural convection of air and thermal radiation per unit length. (20%)

Hint: (1)The Stefan- Boltzman constant is 5.67×10^{-8} W/m^{2}K^4

(2)You may use the Churchill and Chu's correlation to evaluate the heat transfer coefficient due to natural convection from a long horizontal cylinder:

$$\overline{Nu}_D = \left\{0.60 + \frac{0.387\, Ra_D^{1/6}}{[1 + (0.559/Pr)^{9/16}]^{8/27}}\right\}^2 \qquad Ra_D \lesssim 10^{12}$$

The air properties at T_f =350 K are given as: k_f= 0.030 W/mK, ν_f =20.9×10^{-6}m^2/s, α_f =29.9×10^{-6}m^2/s