九十學年度 動机 系（所）甲(熱流) 組碩士班研究生招生考試
熱流學(II) 科號 1301 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

(1) Please define and answer the following,

(a) Boundary layer displacement thickness δ^* and momentum thickness Θ. (6 %)

(b) Please show that within the flat plate boundary layer, the drag is related to the momentum thickness by the expression, $D = \rho b U^2 \Theta$ where D, ρ, b and U are the drag, density, depth of the flat plate and velocity outside the boundary layer, respectively. Please list also the assumptions made. (10%)

(c) Please indicate that the above equation is valid for laminar or turbulent flows or both. Why ? (4%)

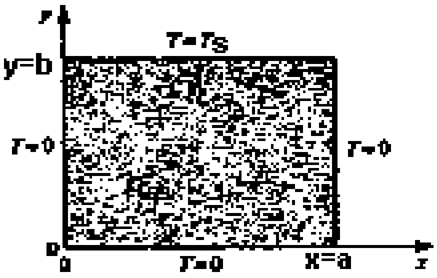
(2) The figure below depicts a thin rectangular plate with negligible heat loss from its surface. Temperature variations across the plate in the z direction are assumed to be zero and the thermal conductivity is assumed to be constant.

(a) Please establish the governing equation to find the temperature distribution T (x,y). (5%)

(b) What are the boundary conditions? (5%)

(c) What is the analytical solution for T (x,y) ? (5%)

(d) If a=b=4 cm, T_s= 100 °C, please make a 4x4 grid and describe how to solve the numerical solutions for T (x, y) ? Please check if the numerical solutions are same as the analytical solutions. (5%)



(3) The figure below shows an example of cooling of an electronics package. The heat sink is a rectangular plate with 70 cm wide and 40 cm high (vertical). The plate temperature must not exceed 340 K. The air at 300 K is blown upward over the plate at 1 m/s. If the air properties are $k=0.0281$ W/m.K, $\nu=17.44\ m^2/s$, and Prandtl Number $Pr= 0.69$, please calculate the following items:

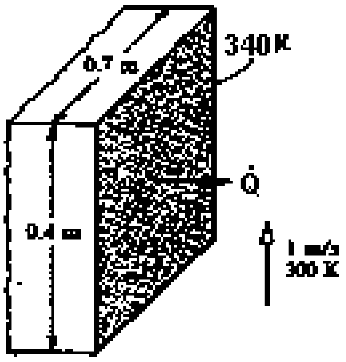
(a) Reynolds number Re, (4%)

(b) Nusselt number, Nu, for forced convection, (4%)

(c) Grashof number, Gr, for natural convection, (4%)

(d) Rayleigh number, Ra. (4%)

(e) If the average Nusselt number for this mixed forced and natural convection is 97.1, estimate the power dissipated by convective heat transfer. (4%)



(4)

(a) Derive the expression for the net radiation exchange between convex object (surface 1 with area A_1, emissivity ε_1 and temperature T_1) and a large cavity (surface 2 with area A_2, emissivity ε_2 and temperature T_2) which encloses the object. (13%)

(b) If the $A_2/A_1 >> 1$, how the expression obtained above can be simplified? Notice that some of the properties of surface 2 are eliminated in such a situation and the large cavity may be considered as a blackbody surface. Give physical explanation for this. (7%)

(5) Consider the thermal entry region for a tube flow subjected to constant surface heat flux.

(a) If the flow entering the tube is laminar and has uniform velocity and temperature profiles, as shown in the figure below, draw the temperature distribution T(r) at three different sections along x: one is in the middle of the tube entrance and the entry length (i.e., the section where fully developed flow for both thermal and velocity profiles is reached); one is right at the entry length; and the other beyond the entry length. (5%)

(b) If the entering flow already is laminar and has a uniform temperature profile but a fully developed velocity profile, will the Nusselt number Nu_D in the entry region be larger or smaller than for flow condition (a)? Explain your answer. (5%)

(c) If the entering flow is turbulent and has uniform velocity and temperature profiles, will the entry length be longer or shorter than flow condition (a)? Explain your answer. Both flow conditions have an identical Reynolds number Re_D. (4%)

(d) Schematically compare the distributions of Nu_D along x for flow conditions (a), (b), and (c). (6%)