國 立 清 華 大 學 命 題 紙

九十二學年度 動力機械工程學系 甲組 碩士班研究生招生考試
科目：熱流學(II) 科號：1301 共 2 頁 第 1 頁 *請在試卷【答案卷】內作答

QUESTION 1 (20%)
A 20,000 kg truck coasts down a steep mountain grade without brakes. The truck's ultimate steady-state speed is determined by a force balance between the weight, the rolling resistance, and the aerodynamic drag. Assume the rolling resistance for a truck on concrete is 0.012 of the weight. The grade has a slop of $\tan\theta = 0.07$. The front area of the truck is $10\,m^2$. The drag coefficient based on the front area is 0.76. Estimate the ultimate steady-state speed V.

QUESTION 2 (20%)
Answer following questions briefly. (5% each)
(a) Define the Vorticity and Circulation.
(b) Describe the no-slip condition in solving the Newtonian fluids. What would happen if the no-slip condition is no longer valid?
(c) Define the thermal contact resistance.
(d) Use the concept of shape factor to find the optimum geometry for fin cooling design.

QUESTION 3 (20%)
Consider a one-dimensional steady-state heat conduction problem with variable thermal conductivity. The surfaces at $x = x_1$ and $x = x_2$ are maintained at constant temperatures T_1 and T_2, respectively. The thermal conductivity of the slab is $k = k_1 + b(T - T_1)$, where both k_1 and b are constant.
(a) Find an analytical expression for the temperature distribution $T(x)$ if $b = 0$. (4%)
(b) Repeat your work in (a) in case $b \neq 0$. (10%)
(c) Plot schematic temperature distributions $T(x)$ for the cases of $b > 0$, $b = 0$, and $b < 0$ on the same figure. Discuss your finding. (6%)

QUESTION 4 (17%)
A laminar air flow with uniform velocity U_∞ and uniform temperature T_∞ flows over a flat solid surface that is maintained at a constant temperature T_s ($T_s > T_\infty$), as shown in Fig.
A. Neglect natural convection and temperature dependence of thermophysical properties.
(a) Draw schematically the thermal boundary layer along the surface length. (3%)
(b) Draw the steady-state temperature distribution in the air flow along the y-direction at $x = L$. (3%)
(c) If the free stream air velocity is increased to $4U_\infty$, compare the region of the thermal boundary layer and the steady-state temperature distribution with your answers in (a) and (b), respectively. (5%)
(d) Compare the heat transfer rates ($\dot{q}$) between the above two cases (i.e., the free stream air velocity being U_∞ and $4U_\infty$, respectively). Also describe physically how forced convection enhances heat transfer. (6%)

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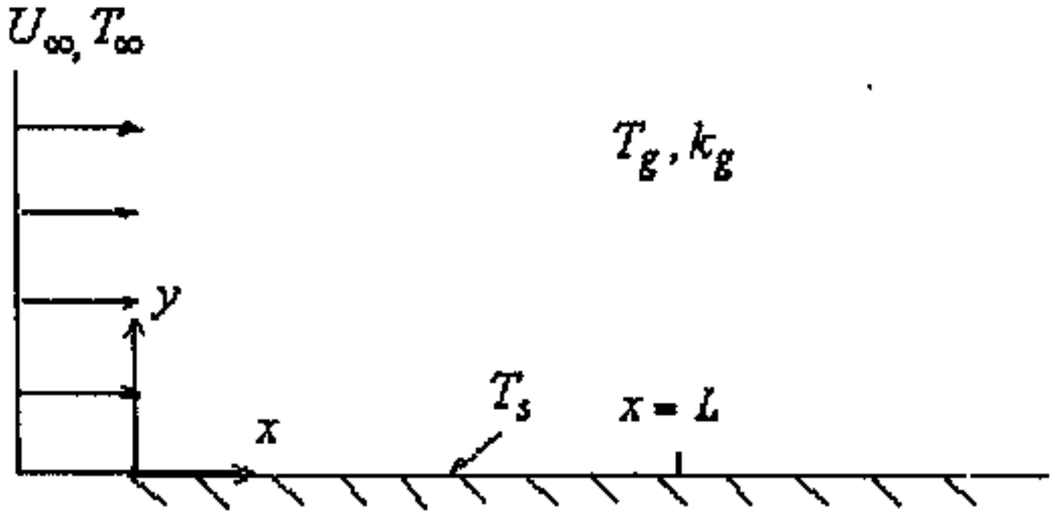

Fig. A

QUESTION 5 (23%)
Consider the same condition as in Fig. A.

(a) Express the local heat flux $\dot{q}''(x)$ on the surface in terms of the thermal conductivity of air k_g and the derivative of air temperature T_g. Also describe how the heat convection mechanism is related to heat conduction mechanism. (7%)

(b) How is the local heat convection coefficient $h(x)$ defined in this situation? Also draw the curve of $h(x)$ roughly, with explanation for its trend. (6%)

(c) How is the nondimensional local Nusselt number $Nu(x)$ correlated with $h(x)$? Also describe the usage of $Nu(x)$. (5%)

(d) For the present situation, write the expression of $Nu(x)$ in terms of some proper nondimensional parameters. (5%)

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