熱 流 學 (II)

共 5 題，每題 20%。

QUESTION 1 (20%)
Answer the following questions briefly:
(a) Draw the pressure distribution along a horizontal pipe from the entrance region to the fully developed region. (5%)
(b) Define the boundary layer thickness δ, displacement thickness δ^*, and the momentum thickness θ.
(c) For a flow past a cylinder, draw the pressure distribution along the surface of the cylinder, in case the flow is (i) inviscid, (ii) laminar, and (iii) turbulent.
(d) The drag of a cylinder subjected to an inviscid flow is zero. For a viscous flow, do you expect the drag to reduce to zero if the viscosity is reduced to approaching zero, but not zero? Why? (5%)

QUESTION 2 (20%)
For a fully developed flow inside an inclined straight pipe (θ degree relative to the horizontal plane) with diameter D and length L, show that
(a) The pressure drop and wall shear stress are related by (10%)

$$\Delta p - \rho g L \sin\theta = 4 L \tau_w / D$$

(b) If the flow is laminar, the velocity profile can be written as (10%)

$$u(r) = \frac{(\Delta p - \rho g L \sin\theta) D^2}{16 \mu L}\left[1 - (\frac{2r}{D})^2\right]$$

where r is the radial coordinate.

QUESTION 3 (20%)
Consider a heat conduction problem in a slab of thickness L. The thermal conductivity k, specific heat c_p, and density ρ of the slab are all constant. Let a periodically varying heat flux $q_0 \cos(\omega t)$ be applied on one face ($x = 0$), while a heat convection (with heat transfer coefficient h) into an environment at a constant temperature T_∞ be maintained on the other surface ($x = L$).
(a) Use a lumped-system analysis to obtain the governing equation for the temperature. (10%)
(b) What is the temperature as the time approaches infinite? (10%)

QUESTION 4 (20%)

Consider a hydrodynamically fully developed laminar flow in a parallel-plate duct. The distance between the two plates is H. For $x<0$, both plates are insulated such that the fluid is at a uniform temperature T_L (axial conduction is negligible). For $x\geq 0$, the upper plate ($y=H$) is maintained at a temperature T_H ($T_H > T_L$), while the lower plate ($y=0$) is still insulated. Please draw sketches of

(a) the bulk temperature $T_b(x)$, and (10%)

(b) the temperature profile $T(y)$ at various locations of x. (10%)

QUESTION 5 (20%)

(a) Describe (i) *specular reflection* and (ii) *diffuse reflection* from surfaces. (10%)

(b) What are the *transparent* and *black* boundary conditions for thermal radiation? (10%)