所別：機械工程學系碩士班 丙組(熱流)(一般生)　科目：流體力學及熱傳學　共 2 頁 第 1 頁
本科考試可使用計算器，廠牌、功能不拘　＊請在答案卷（卡）內作答

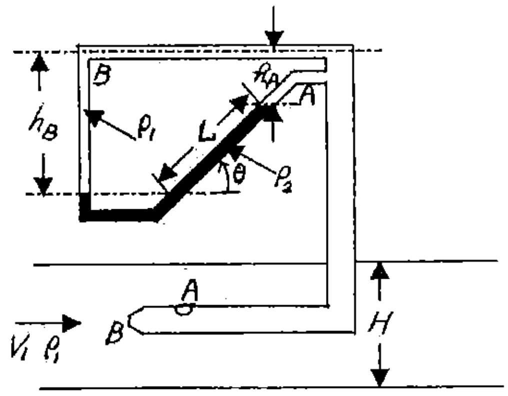
參考用

流體力學 (50 分)

1. What is the total (substantial or material) derivative $D\vec{v}/Dt$ of a steady-state velocity field represented by the following velocity vector? (5%)

$$\vec{v}(x,y,z) = -2x\vec{i} + -2y\vec{j} + 6z\vec{k}$$

2. A pitot tube is installed inside a square channel to measure the incompressible flow, and it is attached with an inclined-tube manometer. The corresponding values for the pitot tube and channel are given as: $\rho_1 = 1.2$ kg/m^3, $\rho_2 = 1{,}000$ kg/m^3, $h_A = 10$ cm, $h_B = 40$ cm, $L = 50$ cm, $H = 50$ cm, $g = 9.8$ m/s^2. (20%)



(a) What do you name the pressure at point A (p_A) and point B (p_B) of the pitot tube? (2%)
(b) Derive the pressure difference ($p_A - p_B$) in terms of ρ_1, ρ_2, h_A, h_B, L, g. (6%)
(c) Compute the speed of the channel (V_1). (4%)
(d) Compute the volume flow rate of the channel. (3%)
(e) Write out the complete relation between speed and the pressure for this channel flow? Briefly explain this equation and what terms have you neglected in this equation? (5%)

3. Please answer the following questions.
(a) The Navier-Stokes equations (in x-direction) is: (7%)

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right) = -\frac{\partial p}{\partial x} + \rho g_x + \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right)$$

Please explain **physical meaning** of each term.

(b) If a smooth tube is 0.1 mm diameter delivering 0.1mm/s water. Please provide the simplified the N-S equation and explain the simplified reason. (8%)

4. An incompressible fluid oscillates harmonically ($V=V_0\sin\omega t$, where V is velocity and ω is the frequency) with frequency of 10 rad/s in a 10 cm diameter pipe. A 1/4 model is used to determine the pressure drop per unit length, ΔP_l. .The similarity model determine by Buckingham Pi theorem is:

$$\frac{D\Delta P_l}{\rho V_0^2} = \phi\left(\frac{V_0 t}{D}, \omega t, \frac{\rho V_0 D}{\mu}\right)$$

Where D is pipe diameter, μ is viscosity and ρ is density
Please determine the frequency should model operate. (10%)

注意：背面有試題

熱傳學 (50 分)

1. A plane wall has the variable thermal conductivity that depends on temperature, and can be expressed as $k(T)=k_1+\alpha(T-T_1)$. The surfaces of the wall are maintained at temperature T_1 at $x = 0$, T_2 at $x = L$, and $T_2 > T_1$. Explain and plot the steady-state temperature profile $T(x)$ across the wall for (a) $\alpha > 0$, (b) $\alpha = 0$, and (c) $\alpha < 0$. (6%)

2. A truncated cone of axial length L has the variable cross-sectional area. The bottom surface is maintained at temperature T_b, the top surface is well insulated, and the other surface is cooled by thermal radiation to the surroundings of temperature T_∞. (7%)
(a) Obtain the steady-state equation for the temperature of the cone. Assume temperature is uniform over any cross sections of the cone.
(b) Write down the boundary conditions for the equation.

3. A hot potato is put into a pot of cold water. Assume the heat exchange is only between the potato and water, and the potato and water have uniform temperatures. (12%)
(a) Derive the equations that describe the time-dependent temperature change for the potato and the water, respectively.
(b) Explain if the internal energy change of the potato will be equal to that of the water?
(c) Explain if the temperature change of the potato will be equal to that of the water?
(d) Will the temperature change of the potato in the first minute be larger, smaller or equal to that in the second minute? Why?
(e) Explain under what condition the uniform temperature assumption for the potato is acceptable?

4. The friction coefficient of a certain fluid inside a special tube has been tested as $c_f = 0.032Re^{-0.1}$. If the Reynolds analogy can be applied for this condition, what is the Nusselt number for this flow at Reynolds number equals to 40,000? (10%)

5. Please define and explain the fully developed conditions for velocity and temperature. (7%)

6. What are the values of a, b c and d for flow over a flat plate? Where δ, x, c_{fx} and h_x are the boundary layer thickness, flow distance, local friction coefficient and local heat transfer coefficient respectively. (8%)

Laminar	$\delta \sim x^a$	$c_{fx} \sim x^{-0.5}$	$h_x \sim x^c$
Turbulent	$\delta \sim x^{-0.2}$	$c_{fx} \sim x^b$	$h_x \sim x^d$

參考用

注意：背面有試題