國立臺北科技大學 101 學年度碩士班招生考試

系所組別：1432 能源與冷凍空調工程系碩士班丙組

第二節　流體力學　試題（選考）

注意事項：

1. 本試題共 5 題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

一、The venturi meter shown in Fig. 1 carries water at 60 °C (The specific weight γ= 9.65 kN/m^3). The specific gravity of the gage fluid in the manometer is 1.25. Calculate the velocity of flow at section A and the volume flow rate of water. (20%)

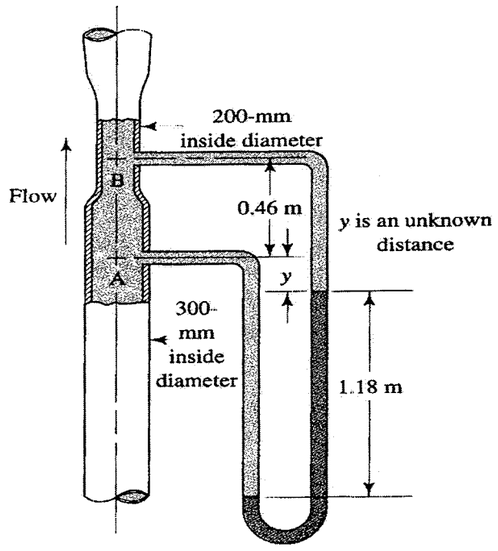

Fig. 1

二、As shown in Fig. 2, take a reference frame in which the air is moving and the propeller is stationary. Labels, *a* and *b*, represent upstream and downstream sections of the propeller, respectively. The effect of the propeller is to accelerate the fluid velocity from the upstream value V_1 at section 1 to the downstream value V_2 ($>V_1$) at section 2. Assuming incompressibility,

1. show that thrust developed by the propeller is given by (10%)

$$F=\frac{\rho A}{2}\left(V_2^2-V_1^2\right)$$

where A is the projected area of the propeller and ρ is the air density.

2. show that the velocity of the fluid at the plane of the propeller, V, is the average value of V_1 and V_2. That is, (10%)

$$V=\left(V_1+V_2\right)/2$$

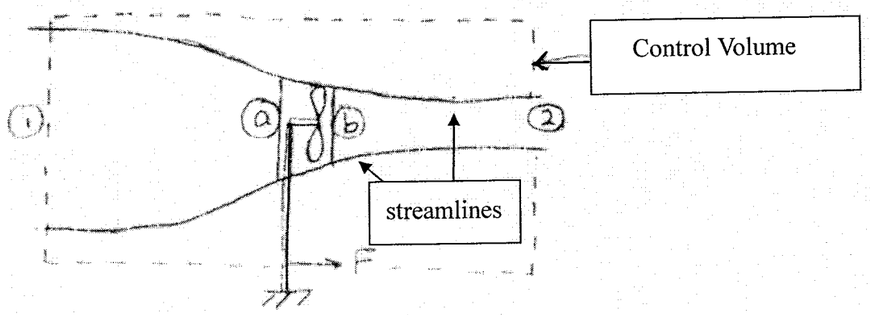

Fig. 2

三、Consider the laminar flow of a fluid layer falling down a plane inclined at an angle α with the horizontal, as depicted in Fig. 3. The coordinates along the inclined surface and normal to the inclined surface are defined as x and y, respectively. The direction of the gravitational acceleration, g, is normal to the horizontal. The symbol, g_x, represents the component of g along the x direction. Neglect the air resistance at the free surface. If h is the thickness of the layer in the stage of fully developed flow, please

1. determine the velocity distribution, u. (10%)
2. find the volume flow rate per unit width. (4%)
3. find the frictional stress on the wall. (4%)
4. plot the distribution of shear stress between the bottom wall and free surface. (2%)

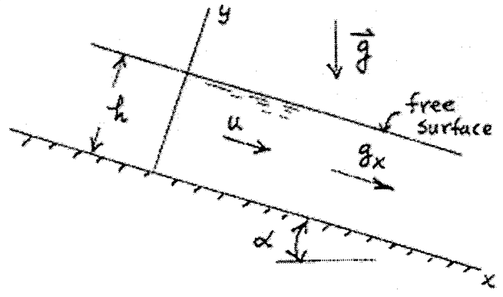

Fig. 3

注意：背面尚有試題

四、Consider a differential control volume of boundary layer flow, as shown in Fig. 4. This control volume is located at a distance x downstream from the leading edge of the plate per unit width. Use the conservation of mass and momentum to derive

1. mass flow rate passing through surface bc is $-\frac{\partial}{\partial x}\left(\int_0^{\delta}\rho u dy\right)dx$. (5%)

2. the x-component momentum equation for the indicated control volume is

$$\delta\frac{dp}{dx}+\tau=U\frac{\partial}{\partial x}\int_0^{\delta}\rho u dy-\frac{\partial}{\partial x}\int_0^{\delta}\rho u^2 dy \qquad (15\%)$$

where δ is the boundary layer thickness growing with the x coordinate, p is the pressure, τ is the wall shear stress acting on the CV, u is the velocity distribution within boundary layer and U is the velocity of free stream.

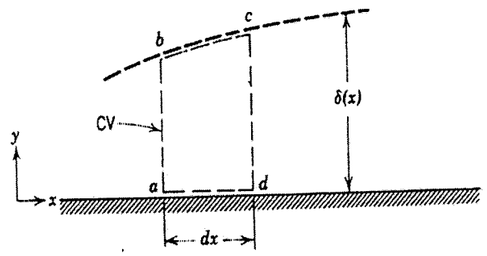

Fig. 4

五、Consider a two-dimensional incompressible laminar boundary-layer flow over a flat plate, as shown in Fig. 4. The velocity of free stream, U, is a constant and the velocity boundary thickness is δ. If the pressure gradient can be neglected,

1. show that the integrated boundary-layer equation, as shown in 四-2, can be written as

$$\frac{d}{dx}\int_0^{\delta}u(U-u)dy=\frac{\tau}{\rho} \qquad (3\%)$$

2. Let the velocity profile within the boundary layer be

$$\frac{u}{U}=a+b\frac{y}{\delta}+c\left(\frac{y}{\delta}\right)^2+d\left(\frac{y}{\delta}\right)^3$$

Please find the constants a, b, c and d. (6%)

3. Find the boundary layer thickness, $\frac{\delta(x)}{x}$, is function of local Reynolds number. (8%)

4. Find wall shear stress τ. (3%)