國立臺灣科技大學
八十七學年度碩士班招生考試試題

所　別：機械工程技術研究所　　組別：熱流組　　科目：流體力學
學程別：

Part I：簡答題 (30%)

Note: **(a) Briefly and clearly answer the following problems.**
(b) Each problem is 3 points.

1. Write out the equation for Newton's law of viscosity.

2. What is the kinematic viscosity? What is its dimension?

3. What is the definition for a continuum? In what situation the assumption of continuum will break down?

4. In what conditions that the statement "The normal stress is the same in all directions at a point in a fluid" will be true?

5. Give the definition for a streakline.

6. List all the assumptions about flow required in deriving the equation
$gz + v^2/2 + \int dp/\rho = const$.

7. Give two sets of arbitrary recombination of the Π parameters,
$$F\left(\frac{V_0}{\omega D}, \frac{\rho\omega D^2}{\mu}, \frac{c}{\omega D}\right) = 0.$$

8. When liquid is in laminar motion at constant depth and flowing down an inclined plate (y measured normal to surface), what boundary conditions should be specified at the free surface and the solid boundary respectively?

9. Give the definition of the displacement thickness. What physical meaning does it have?

10. Concisely describe the change of velocity at various sections of a converging-diverging nozzle operating at the design condition.

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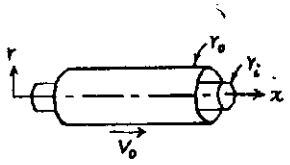
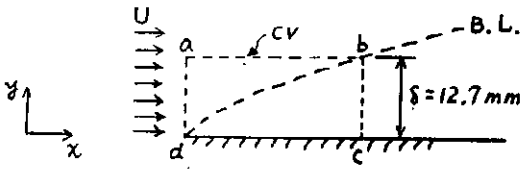
Part Ⅱ: 計算題 (70%)

Note: Show every step you make in the following problems.

1. Consider fully developed laminar flow in the annulus between two concentric pipes. The inner pipe is stationary, and the outer pipe moves in the x direction with speed V_0. Assume the axial pressure gradient is zero ($\partial p / \partial x = 0$).
   (a) Obtain a general expression for the shear stress, τ, as a function of the radius, r, in terms of a constant, C_1. **(7%)**
   (b) Obtain a general expression for the velocity profile, $V(r)$, in terms of two constants, C_1 and C_2. Evaluate C_1 and C_2. **(8%)**



2. Air at standard conditions flows over a thin flat plate *1 m* long and *0.3 m* wide. The flow is uniform at the leading edge of the plate. Assume the velocity profile in the boundary layer is parabolic, and the free stream velocity is *U = 2.7 m/sec*. Treat the flow as two-dimensional; assume that flow conditions are independent of *z*.
   (a) Using control volume *abcd*, shown by the dashed lines, compute the mass flow rate across surface *ab*. **(10%)**
   (b) Determine the magnitude and direction of the *x* component of force required to hold the plate stationary. **(10%)**



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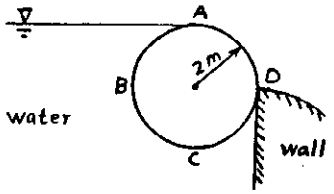
3. Air flows isentropically in a converging-diverging nozzle. At section 1 in the converging portion where the area is 1250 mm^2, the pressure is 600 kPa (abs), the temperature is 22 $^{\circ}C$, and the Mach number is 0.5.
   (a) Develop a general expression for the area ratio, A_2 / A_1, in terms of M_1 and M_2, where A_2, M_2 are conditions at some section 2. (10%)
   (b) Determine the area, A_2, in the diverging section where the Mach number is 2. (10%)

4. A cylindrical barrier holds water as shown. The contact between cylinder and wall is smooth. Considering a 1-m length of cylinder,
   (a) determine its weight. (7%)
   (b) determine the force exerted against the wall. (8%)



$\rho_{air} = 1.23 kg/m^3$

$\rho_{water} = 1000 kg/m^3$

For isentropic flow of an ideal gas,

$$pv^k = const.$$

$$\frac{T_0}{T} = 1 + \frac{k-1}{2} M^2$$

$$\frac{p_0}{p} = \left[1 + \frac{k-1}{2} M^2 \right]^{k/(k-1)}$$