國立台灣科技大學九十五學年度碩士班招生試題

系所組別： 機械工程系碩士班丙組

科　　目： 流體力學

Total score: 100

1. Answer the following questions:

(a)What is fully developed flow? Discuss the effects/functions of the pressure gradient in a laminar pipe flow before reaching fully developed flow and after reaching fully developed flow, respectively.(10%)

(b)The hydrostatic equation, $\nabla p = -\rho \mathbf{g}$, is a well-known equation to predict a pressure distribution in a static fluid. It is found that only pressure and weight of a fluid are considered in the hydrostatic equation. Why is there no shear stress in the hydrostatic equation? Could you explain the reason using a mathematical formula? (5%)

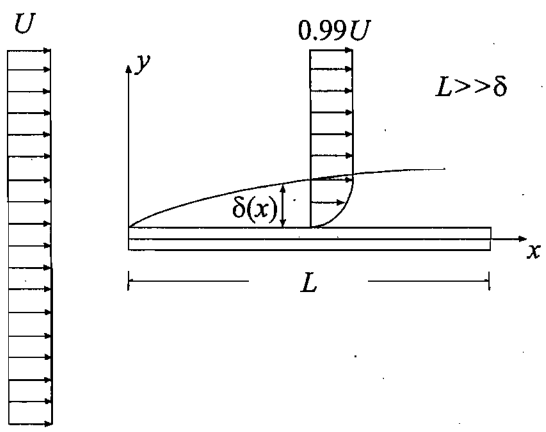
(c)Explain a distorted model in scale model experiments. Reynolds number and Froude number could be two dynamic coefficients to employ. (5%)

2. Consider the steady 2 dimensional incompressible flow over a flat plate as shown in Figure 1. It is known that a thin boundary layer will form on the flat plate when the far-field velocity U is large and the viscosity μ is small. In order to analyze this boundary layer, a boundary layer approximation proposed by Prandtl (1904) can be obtained as follows:

(a) Separate the flow into two regions: outer solution and inner solution. Can you briefly describe the essential differences between these two regions? (6%)

(b) Please perform an order-of-magnitude analysis to obtain the approximate equations for the boundary layer. Briefly describe the behaviors of the pressure variation inside the boundary layer. (7%)

(c) Describe briefly how you would deal with the pressure gradient term in the approximate equations. (7%)



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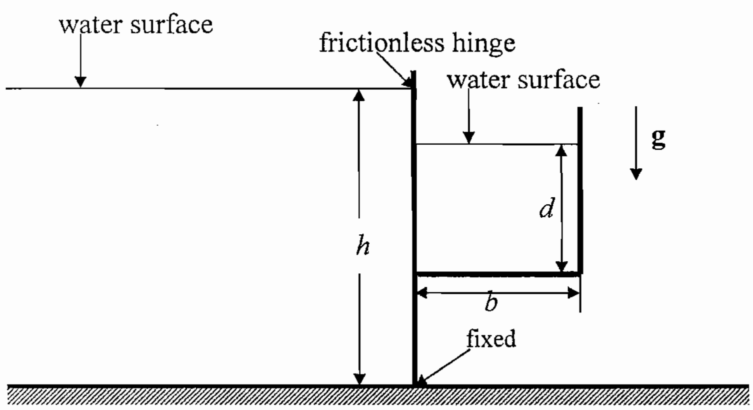
3. Determine the pressure drop per 100-m length of horizontal new 0.20-m-diameter cast iron water pipe ($\varepsilon = 0.25*10^{-3}$ m) when the average velocity is 1.6 m/s. The kinematic viscosity of water is $\nu = 1.12*10^{-6}$ m²/s. You are asked to find the friction coefficient through the Colebrook formula given below instead of Moody chart. (20%)

$$\frac{1}{\sqrt{f}} = -2.0\log\left(\frac{\varepsilon / D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$

4. A rectangular gate of width *w* and height *h* is placed in the vertical side wall of a tank containing water. The top of the gate is located at the surface of the water, and a rectangular container of width *w* and breadth *b* is attached to the gate, as shown in the figure. Find *d*, the depth of the water required to be put into the container so that the gate is just about to open, in terms of *h* and *b*. The top and sides of the tank and container are open to the atmosphere. Neglect the weight of the container. (20%)



5.(a) Consider a velocity field denoted as $\mathbf{u} = (3x^2 - 3y^2)\vec{i} - 6xy\vec{j}$. It is an irrotational flow. Could you prove it and tell us the physical meaning of an irrotational flow? (5%)

(b) Furthermore, please obtain the velocity potential and stream function of the velocity field. (5%)

(c) Please derive the pressure distribution using the velocity field. It is a two-dimensional flow field, so it is regarded as a horizontal flow. (5%)

(d) Tell us the assumptions of the theory of potential flow and derive the governing equations for velocity potential and stream function. Are those equations linear? (5%)