國立臺灣科技大學
九十二學年度碩士班招生考試試題
系所組別：機械工程系碩士班丙組
科　目： 流體力學

總分100分

1. Please answer the following questions:
   a. What's the Newton's viscosity law? (5%)
   b. What's the physical meaning of vorticity? (5%)
   c. There are some assumptions for the potential flow theory. Please indicate these assumptions and why we need them for the potential flow theory. (5%)
   d. When fluids enter a pipe from a tank, the flow region is divided into the potential core (inviscid core) and the boundary layer before the flow is fully developed. Explain the difference between the potential core and the boundary layer. (5%)
   e. There exists a boundary layer above the surface of a plate when a uniform flow past the flat plate. The boundary layer is laminar at the beginning of the surface. It becomes turbulent after a certain distance. Please explain the difference of momentum transfer between a laminar boundary layer and a turbulent boundary layer according to their velocity profiles. (5%)
   f. The total drag for a flow past an obstacle is divided into the form drag and the friction drag. In general, a turbulent flow causes larger friction , so the surface of a car is very smooth to avoid to trigger turbulence in the flow. A gulf ball, however, is not smooth. There are many dimples on the surface of a gulf ball. Please explain why a gulf ball designer put lots of dimples on a gulf ball according to form drag and friction drag. (5%)
   g. In the chaos theory, there is the famous butterfly effect that claims that beating wings up and down of a butterfly in New York could cause a storm in Beijing. It is because the disturbance induced by the butterfly is amplified by the nonlinear atmospheric system. Hence the small disturbance becomes a disaster after a long distance. Could you indicate the same physical phenomenon in piping flows described in every textbook of fluid mechanics? (5%)

2. Consider a closed-loop wind tunnel shown in Figure1. A fan is installed to general a uniform flow in the tunnel. The cross section of the tunnel is a square of 0.5m*0.5m. There is energy loss when air flows through channels and corners. Here are information regarding energy loss in channels and corners. The friction factor, *f*, is 0.02 for all of channels. The *K* factor for each corner is 0.2 Please determine the required power of the fan if the averaged velocity at the test section is 10m/s. (air density is 1.204kg/m^3) (15%)

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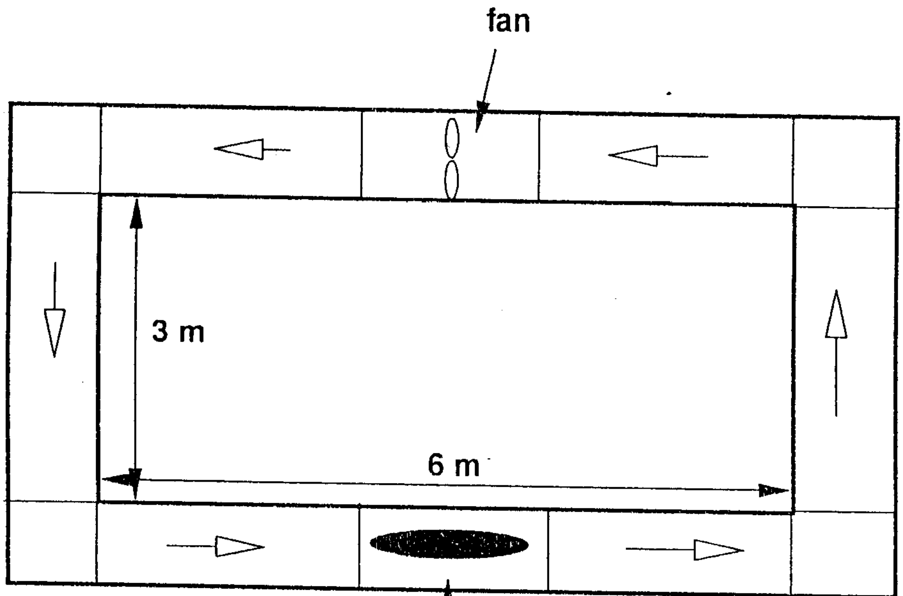

Figure 1

3. Consider fluids flowing between two parallel incline solid wall shown in Figure. The upper solid wall moves at a constant velocity u_o. The depth between two walls is h. No pressure gradient exists in the flow. The viscosity of fluids is μ. Please give the solutions of velocity profile of fluids, the volume flow rate and the shear stress on the still wall. (20%)

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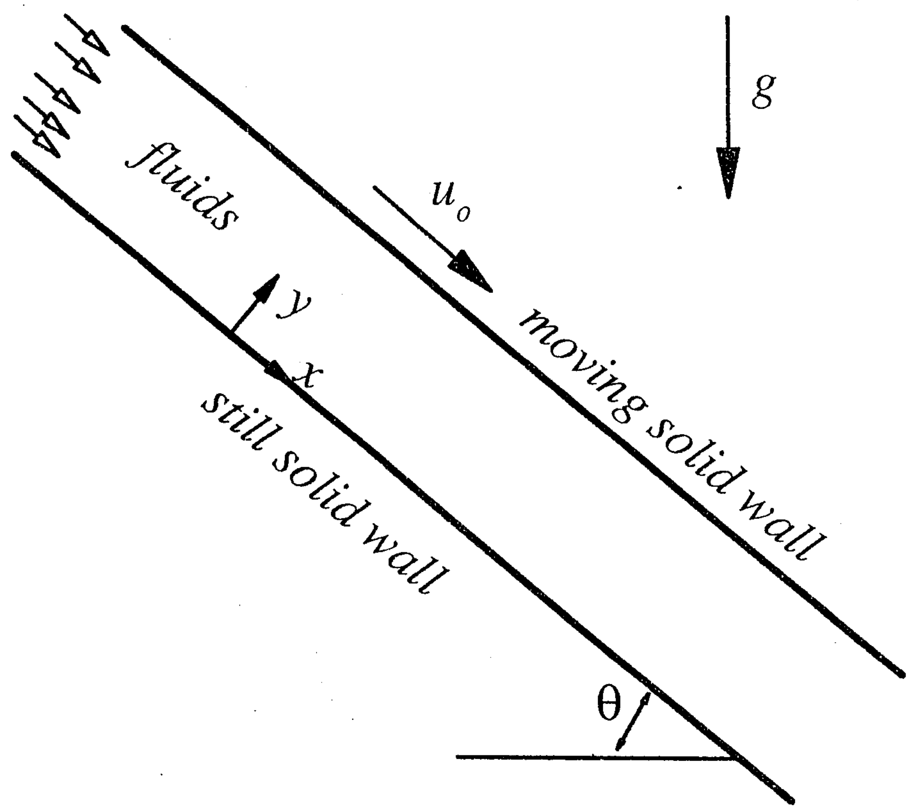

Figure 2

4. Consider the velocity field $\vec{u} = (2x^2 - 2y^2)\vec{i} + (-4xy)\vec{j}$. Please determine the stream function and vorticity Is this flow field irrotational? If it is an irrotational flow, please find its potential function. (10%)

5. For the turbulent boundary layer above a flat plate, the velocity profile is denoted as

$$\frac{u}{U} = \left(\frac{y}{\delta}\right)^{\frac{1}{7}}, \qquad 0 < y < \delta$$

where U is the inlet velocity, y is the distance above the plate, δ is the boundary layer thickness. In addition, $\frac{\delta}{x} = \frac{0.382}{Re_x^{\frac{1}{5}}}$. Please determine the displacement thickness, δ^*/x, momentum thickness, θ/x, and the shear stress, τ_w.(Hint:

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$\tau_w = \rho U \frac{d\theta}{dx}$) (20%)

2-D continuity equation for an incompressible fluid

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$$

2-D Navier Stokes equations

x-dir

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+g_x+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

y-dir.

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+g_y+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$