系所組別： 奈米科技暨微系統工程研究所

考試科目： 流體力學

考試日期：0219，節次：2

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. Please answer the following questions:

(a) Explain what is the so-called Newtonian fluid? (5%)

(b) Explain the physical meaning of each terms of the Reynolds transport theorem. Give all the possible physical quantities of N and associated quantities η (5%)

$$\left.\frac{dN}{dt}\right]_{\text{system}} = \frac{\partial}{\partial t}\int_{control\_volume}\eta\rho dV + \int_{control\_surface}\eta\rho\vec{V}\cdot d\vec{A}$$

(c) Explain the physical meaning of $\nabla\times\vec{V}$ and $\nabla\cdot\vec{V}$ where $\vec{V}$ is the velocity of a fluid motion described in Eulerian view $\vec{V}=\vec{V}(x,y,z,t)$ (5%)

(d) An observer standing on a boat which travels with a velocity $\vec{V}_b = u_b\vec{i} + v_b\vec{j}$ across a river flowing at the velocity $\vec{V} = u\vec{i} + v\vec{j}$. What is the time rate of change of the vorticity the observer see for the river? (5%)

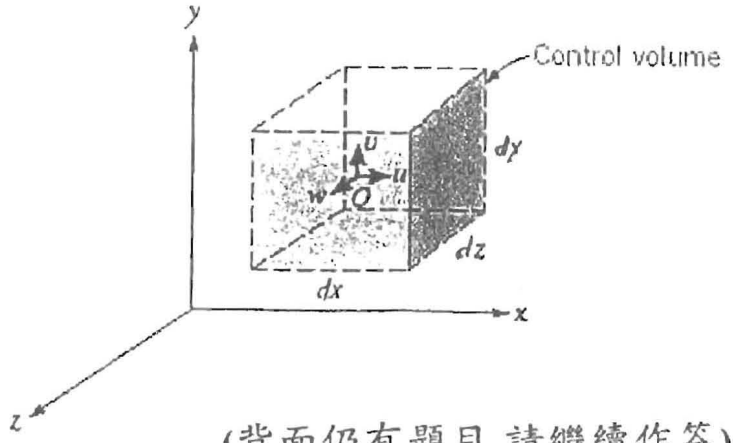
2. The air resistance (drag force) on a ball with mass M in free flight is given by $F_D=KV^2$, where K is a constant. If the ball is dropped from rest $y=y_o$ above the ground,

(a) Please express the velocity field of the ball by using Euler coordinate. (10%)

(b) From velocity of the ball in Euler coordinate found in (a), find out the acceleration of ball at $y=0.5\ y_o$ (5%)

(c) Find out the terminal speed of the ball? (5%)

3. Derive the continuity equation from mass conservation principles using an infinitesimal control volume of rectangular shape and having dimensions with dimensions (dx, dy, dz), as shown in Figure below. Identify the net mass flow rate through each surface of this element as well as the rate at which the mass of the element is increasing. The resulting equation should be expressed in terms of the cartesian coordinates (x, y, z, t), the cartesian velocity components (u, v, w) and the fluid density ρ. (20%)



(背面仍有題目,請繼續作答)

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4. (a) Consider the following equations, find the dimensionless group in terms of the dimensionless procedure. (10%)

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

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p_\infty}{\partial x}+\frac{\mu}{\rho}\frac{\partial^2 u}{\partial y^2}$$

(b) The pressure drop, △P, for steady, incompressible viscous flow through a straight horizontal pipe depends on the pipe length L, the average velocity V, the fluid viscosity, μ, the pipe diameter D, the fluid density ρ and the average "roughness" height e. Apply dimensional analysis and determine a set of nondimensionless groups that can used to correlate data. (10%)

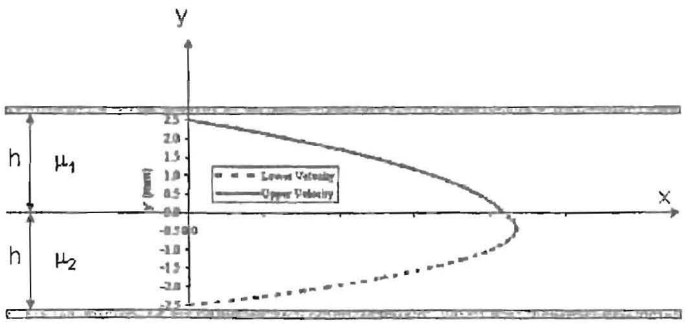
5. Two immiscible fluids are contained between infinite parallel plates. The plates are separated by distance 2h, and the two fluid layers are of equal thickness h=2.5mm. The dynamic viscosity of the upper fluid is twice that of the lower fluid, which is μ_2=0.5 N • s/m^2. If the plates are stationary and the applied pressure gradient is -1000 N/m^2/m, find the following answers:

(a) What are the simplified governing equations? (5%)

(b) What are the boundary conditions? (5%)

(c) Find the velocity at the interface? (5%)

(d) What is the maximum velocity of the flow? (5%)



Hint: The Navier-Stokes equations and continuity equation are

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=-\frac{\partial p}{\partial x}+\rho g+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right) \qquad \text{(a)}$$

$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right) \qquad \text{(b)}$$

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad \text{(c)}$$