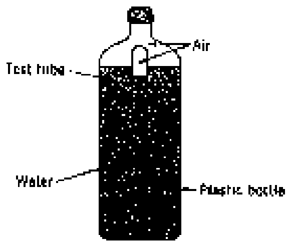
國立中央大學九十一學年度碩士班研究生入學試題卷

所別：機械工程學系 丙組　科目：流體力學　共 2 頁 第 1 頁

1. (8 %) Explain the following terms.

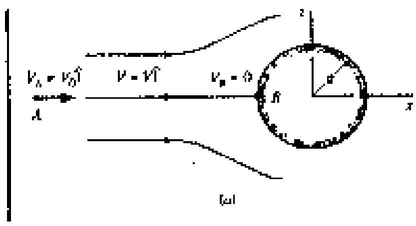
(a) dynamic viscosity, (b) pressure gradient, (c) inviscid flow, (d) continuum fluid.

2. (10 %) An inverted test tube partially filled with air floats in a plastic water-filled bottle. The amount of air in the tube has been adjusted so that it just floats. The bottle cap is securely fastened. A slight squeezing of the plastic bottle will causes the test tube to sink to the bottom of the bottle. Explain this phenomenon.



3. (15 %) Consider the one-dimensional, inviscid, incompressible, steady flow along the horizontal A-B in front of the sphere ($R=a$). The velocity distribution is given as

$$V = V_0(1+a/x), \qquad V_0 = \text{constant}$$



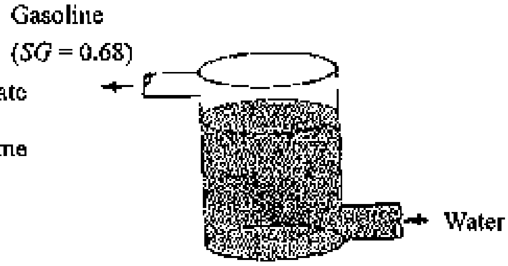
(a) Write out the equation of motion along the A-B line for this flow field. (2 %)

(b) Find the pressure distribution along the streamline from point A far in front of the sphere ($x_A=-\infty$ and $V_A=V_0$) to point B on the sphere ($x_B=-a$ and $V_B=0$). (10 %)

(c) Verify the Bernoulli equation along the streamline A-B. (3 %)

4. (15 %) A potential function is given as $\varphi = r^{-1/2}\cos(\theta/2)$. Please find: (a) the radial velocity; (b) the tangential velocity; and (c) the corresponding stream function.

5. (12 %) Water enters a rigid, sealed, cylindrical tank at a steady rate of 150 liters/hr and forces gasoline ($SG = 0.68$) out. What is the time rate of change of mass of gasoline (in kg/sec) contained in the tank.



6. (6 %) Please explain the flowing dimensionless groups (including the interpretation in terms of forces): (a) Reynolds number; (b) Froud number and (c) Euler number.

注意：背面有試題

7. (24 %) Please answer the following questions briefly:

(a) What is the fully developed flow in a circular pipe? (2 %)

(b) What are the boundary layer thickness (δ), the displacement thickness (δ^*), the momentum thickness (Θ), the wall shear stress (τ_w), and the skin friction coefficient (C_f). (5 %)

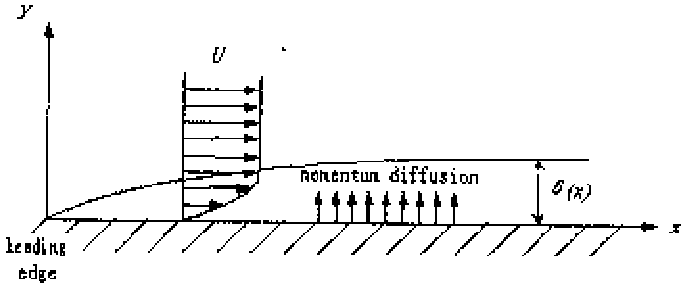
(c) What are the units of the kinematic viscosity (ν) and the dynamic viscosity (μ)? (2 %)

(d) The incompressible Navier-Stokes equations are

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

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

Consider a steady, two-dimensional, incompressible, laminar boundary layer flow, as sketched below. U, x, and $\delta(x)$ are the mean velocity, the distance away from the leading edge, and the boundary layer thickness as a function of x respectively, where $\delta \ll x$.



(a) Write down the appropriate momentum equations for this flow. (6 %)

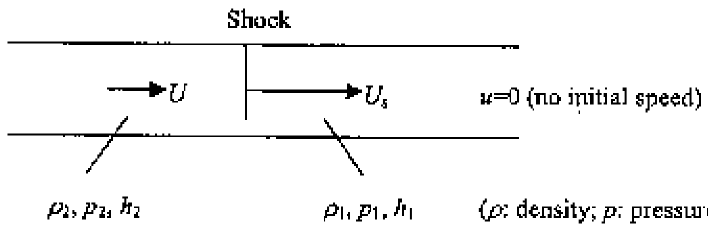
(b) The growth of the boundary layer (δ) is due to the momentum diffusion that may be dominated by the kinematic viscosity (ν) and a characteristic time scale (t). What is δ in terms of ν and t? (2 %)

(c) What is t in terms of U and x? (2 %)

(d) What is δ in terms of ν, U and x? (2 %)

(e) What is δ in terms of the Reynolds number (Re) and x? (3 %)

8. (10 %) Consider a normal shock wave propagating through a tube with speed U_s, as sketched and indicated as below where U is the speed behind the shock. Please write down the appropriate mass, momentum and energy equations. (Hint: Make the propagating shock stationary and apply the conservation concept by treating the shock as a discontinuity.)



(ρ: density; p: pressure; h: enthalpy)

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