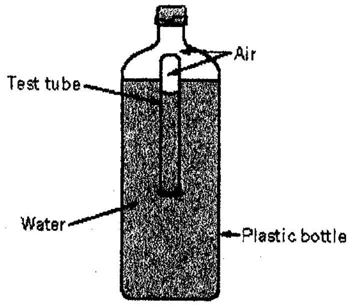
國立中央大學九十二學年度碩士班考試入學招生試題卷　　共 2 頁 第 1 頁

系所別：機械工程學系　丙組　科目：流體力學　流體力學

1. Consider the flow (density= ρ , viscosity= μ) behavior in a long pipe (length=L, diameter=D) and on a long flat plate (length=L, width=W). We know that the dimensionless parameter (Reynolds number, Re) is a criterion by which the state of the flow may be determined.
   (a) Please define Re for the pipe and the flat plate, respectively? (6%)
   (b) Describe the characteristics of the pipe flow based on Re. (4%)
   (c) Plot and describe the evolution of the velocity profile along the pipe (from the inlet to the fully developed condition). (5%)

2. 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. What will happen to the test tube if we slight squeeze the plastic bottle? Explain it. (10%)



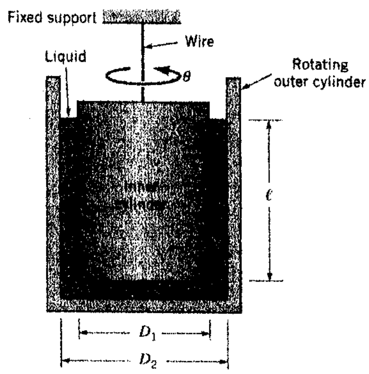
3. Given the following reference values: V (reference velocity), p (reference pressure), ρ (reference density), L (reference length), μ (reference viscosity), τ (reference time).
   (a) Find the following force terms in terms of above values: F_{Il}=inertial (local) force, F_{Ic}=inertial (convective) force, Fp=pressure force, F_v=viscous force. (4%)
   (b) Define (expression and its name) the ratio of three terms: F_{Il}/F_{Ic} , F_p/F_{Ic} , F_{Ic}/F_v (6%)

4. (a) Explain the difference between a solid and a liquid. (2%)
   (b) Given the definition of the Newtonian fluid. (2%)
   (c) Why is the incompressible fluid has large values of the bulk modulus (Ev=- $dp/(dV/V)$)? (3%)
   (d) When can a completely immersed body be said to be in a stable equilibrium position? (3%)

5. A rotating cylinder viscometer shown in the figure is used to measure the viscosity, μ, of liquids by relating the angle of twist, θ, of the inner cylinder to the angular velocity, ω, of the outer cylinder. Assume that

$$\theta = f(\omega, \mu, K, D_1, D_2, \ell)$$

where K depends on the suspending wire properties and has the dimensions FL. The following data were obtained in a series of test for which μ=0.01 lb・s/ft^2, K=10 lb・ft, ℓ =1 ft, and D_1 and D_2 were constant. Determine from these data, with the aid of dimensional analysis, the relationship between θ, ω, and μ. (20%)



θ (rad)	0.89	1.50	2.51	3.05	4.28	5.52
ω (rad/s)	0.30	0.5	0.82	1.05	1.42	1.86

注意：背面有試題

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6. Consider a simple one-dimensional laminar molecular diffusion process. In it, there are three fundamental transport processes, namely the mass, the momentum, and the heat transfer. (total 20 %)

(a) Please choose the corresponding law in the following answers for each of three transport processes (mass, momentum, heat) and write down the answers in order.
(1) Laplace's law; (2) Fourier's law; (3) Fick's law; (4) Thermodynamic first law; (5) Newton's second law. (2 %)

(b) Please write down the relation between the mass flux (J_{AY}) and the concentration (C) along the y direction for the mass diffusion process. (2 %)

(c) Write down the relation between the momentum flux or shearing stress (τ_{xy}) and the velocity (u) along the y direction for the momentum diffusion process. (2 %)

(d) Write down the relation between the heat flux (q_y) and the temperature (T) along the y direction for the heat diffusion process. (2 %)

(e) What is the unit of the mass diffusivity, D? (1 %)
(1) 1/s; (2) cm/s; (3) cm/s^2; (4) cm^2/s; (5) cm^2/s^2.

(f) What is the unit of the kinematic viscosity, ν? (1 %)
(1) 1/s; (2) cm/s; (3) cm/s^2; (4) cm^2/s; (5) cm^2/s^2.

(g) Is the kinematic viscosity the same as the momentum diffusivity? Please just answer YES or NO. (1 %)

(h) What is the unit of the thermal diffusivity, α? (1 %)
(1) 1/s; (2) cm/s; (3) cm/s^2; (4) cm^2/s; (5) cm^2/s^2.

(i) The simple molecular diffusion equation may be written as

$$\frac{\partial A}{\partial t} = MD\frac{\partial^2 A}{\partial x_i \partial x_i},$$

where A could be the temperature (T) or the velocity (u) or the concentration (C) and MD is the corresponding molecular diffusivity. Use the dimensional analysis on the above diffusion equation to estimate: Approximately how long will a bottle of the perfume just opened inside a room take to diffuse itself into the room of 5 m width? Assume that the air molecular diffusivity $MD=\alpha=2 \times 10^{-5}$ m^2 /s and the buoyancy effect is negligible. (4 %)

(j) Same as above, but there is a fan in the room to generate turbulence, such that the characteristic eddy size can be greatly reduced. Take the average eddy size of 1 cm and re-estimate the diffusion time for this turbulent case using the dimensional analysis on the above diffusion equation. (4 %)

7. Please define the following boundary layer parameters: (a) The boundary layer thickness (δ); (b) the displacement thickness (δ^*); (c) the momentum thickness (Θ); (d) the wall shear stress (τ_ω); (e) the skin friction coefficient. (5 %)

8. A spherical tank of volume 1 m^3 contains air at p=1000 kPa (absolute) and T=15 °C. At t=0, air starts to escape through a valve of an area $A=10^{-4}$ m^2 on the tank. If the air leaves the valve with a speed of u=300 m/s, what is the rate of change of the air density in the tank at t=0? Assume that the air density ρ is equal to 6 kg/m^3 at t=0 and the flow is uniform across the area of the valve. Is this flow incompressible or compressible? Explain your answer. (10 %)