國立成功大學

115學年度碩士班招生考試試題

編　號：111

系　所：生物醫學工程學系

科　目：流體力學

日　期：0203

節　次：第 2 節

注　意：1.可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

1. (a) Define Reynolds number, Peclet number, and Mach number. (6%)
   (b) Indicate what factors may change surface tension? (4%)
   (c) Define Streamline, Streakline, and Pathline. (6%)

2. Given the Navier-Stokes equation along the z-axis in a circular tube.

$$\rho\left(\frac{\partial u_z}{\partial t}+u_r\frac{\partial u_z}{\partial r}+\frac{u_\theta}{r}\frac{\partial u_z}{\partial \theta}+u_z\frac{\partial u_z}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 u_z}{\partial \theta^2}+\frac{\partial^2 u_z}{\partial z^2}\right]+\rho g_z$$

(a) **Use assumptions**: steady, incompressible, axisymmetric, fully developed, no body forces, only axial velocity u_z=$u_z(r)$ to derive an ODE form. Two boundary conditions are no slip and maximum velocity at the centerline. (10%)
(b) Integrate the above ODE form with the radius r from 0 to R and the angle θ from 0 to 2π to obtain an **expression for the flowrate.** (10%)

3. The flow rotation is defined as the average rotation of two mutually perpendicular faces of a fluid element. The rotationality can be expressed in terms of velocity:

$$\vec{\omega}=\vec{\nabla}\times\vec{V}$$

(a) In **straight streamlines**, explain the situations of rotational and irrotational flows separately. (5%)
(b) In **concentric streamlines**, explain the situations of rotational and irrotational flows separately. (5%)
(c) Given a stream function $\psi=(xy^3-X^3y)$ m²/s, determine the **rationality of the flow.** (10%)
(d) For the answer derived in (c), explain if Bernoulli's equation can be applied in the flow and why. (3%)

4. Water flows steadily from a tank mounted on a cart as shown in Fig.1. After the water jet leaves the nozzle of the tank, it falls and strikes a vane attached to another cart. The cart's wheels are frictionless and the fluid is inviscid. (a) Determine the speed of the water leaving the tank, V_1, and the water speed leaving the cart, V_2. (9%) (b) Determine the tension in rope *A* (6%) and (c) the tension in rope *B*. (6%) (Notice: A **Control Volume** must be drawn!)

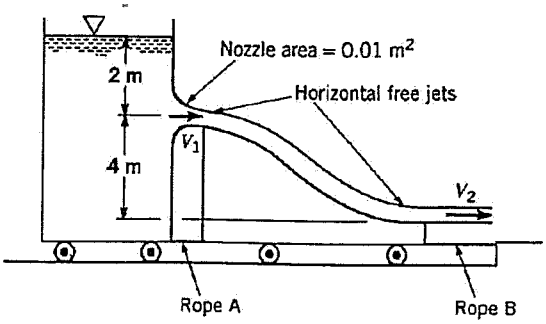

Fig.1

5. The drag, $\mathscr{D}$, on a sphere located in a pipe through which a fluid is flowing is to be determined experimentally (see Fig.2). Assume that the drag is a function of the sphere diameter, d, the pipe diameter, D, the fluid velocity, V, and the fluid density, ρ.

(a) Show **all the dimensionless terms** based on the Buckingham Pi theorem. (12%)

(b) Some experiments using water indicate that for d = 0.51 cm, D = 1.27 cm, and V = 0.61 m/s, the drag is 6.67×10^{-3} N. **Estimate the drag** $\mathscr{D}$ on a 0.24-m sphere located in an **unknown diameter** pipe through which water is flowing with a velocity of 1.82 m/s. Assume one of the Pi terms associated with the geometric similarity is maintained. (8%)

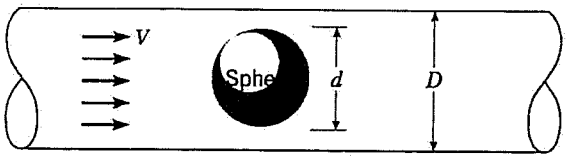

Fig.2