1. A fluid flows at a velocity V through a horizontal pipe of diameter D. An orifice plate containing a hole of diameter d is placed in the pipe. It is desired to investigate the pressure drop, Δp, across the plate. Assume that

$$\Delta p = f(D, d, \rho, V)$$

where ρ is the fluid density. Determine a suitable set of pi terms. (15%)

2. A soft drink with the properties of 10 ℃ water ($\rho = 999.7\ kg/m^3$, $\nu = 1.307 \times 10^{-6}$) is sucked through a 4-mm-diameter, 0.25-m-long straw at a rate of 4 cm^3/s. Is the flow at the outlet of the straw laminar ? Is it fully developed ? Explain. (15%)

3. Please define major head loss and minor head loss. (5%)

4 State the conditions under which prototype behavior can be predicted from model tests.. (7%)

5. For fully-developed flow in a pipe determine the wall shear stress and the shear stress variation in the flow in terms of the pressure gradient. (8%)

(背面仍有題目,請繼續作答)

6. 回答下列問題（請完整地將答案寫在答案紙上，否則不予計分）
(10 %)

(a) The continuity equation

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

is valid for ------------------

(b) If for a flow, a stream function ψ exists and satisfies the Laplace equation, then the flow is---------------

(c) In two-dimensional flow the equation of a streamline is given as------

(d) If a stream function ψ exists it implies that the potential function also exists. True or False

(e) In a steady flow, streamline, streakline and pathline can be different from each other. True or False

7. The stream function ψ for uniform flow past a circular cylinder of radius a in a polar coordinate is given by

$$\psi = U_\infty\left(1-\frac{a^2}{r^2}\right) r\sin\theta$$

where U_∞ is the free stream velocity parallel to the horizontal axis. Determine the velocity on the cylinder at $\theta = 90^\circ$ (10%)

8. By using velocity triangles for flow upstream (1) and downstream (2) of a turbomachine rotor, prove that the shaft work in per unit mass flowing through the rotor is

$$W_{shaft} = \frac{V_2^2 - V_1^2 + U_2^2 - U_1^2 + W_1^2 - W_2^2}{2}$$

where V = absolute flow velocity magnitude, W = relative flow velocity magnitude, and U = blade speed (12%)

9. An infinitely long, solid, vertical cylinder of radius R is located in an infinite mass of an incompressible fluids. Start with the Navier-Stokes equation in the θ direction and derive an expression for the velocity distribution for the steady flow case in which the cylinder is rotating about a fixed axis with a constant angular velocity ω. You need not consider body forces. Assume that the flow is axisymmetric and the fluid is at rest at infinity. (18%)

Navier-Stokes equation in θ direction is given as

$$\rho\left(\frac{\partial v_\theta}{\partial t} + v_r\frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{v_r v_\theta}{r} + v_z\frac{\partial v_\theta}{\partial z}\right)$$

$$= -\frac{1}{r}\frac{\partial p}{\partial \theta} + \rho g_\theta + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_\theta}{\partial r}\right) - \frac{v_\theta}{r^2} + \frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2} + \frac{2}{r^2}\frac{\partial v_r}{\partial \theta} + \frac{\partial^2 v_\theta}{\partial z^2}\right]$$