Please write down all the critical steps in your answer. You can answer your questions in English or in Chinese
(請寫出重要計算步驟。可以用英文或中文作答)

Problem 1 (20 points)

A proposed three-dimensional incompressible flow field has the following vector form:

$$\mathbf{V} = Kx\mathbf{i} + Ky\mathbf{j} + Kz\mathbf{k}$$

(a) Determine if this field is valid solution to continuity and Navier-Stokes

(b) If $\mathbf{g} = -g\mathbf{k}$, find the pressure field p(x, y, z)

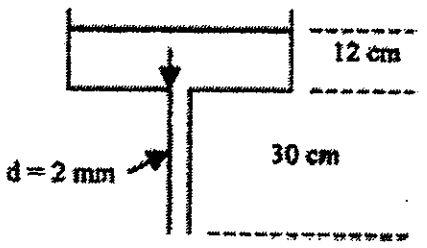
Problem 2 (20points)

The wall shear stress τ_w in a boundary layer is assumed to be a function of stream velocity U, boundary layer thickness δ, local turbulence velocity u', density ρ, and local pressure gradient dp/dx. Using (ρ, U, δ) as repeating variables, rewrite this relationship as a dimensionless function

Hint: $\tau_w \equiv ML^{-1}T^{-2}$, $dp/dx \equiv ML^{-2}T^{-2}$

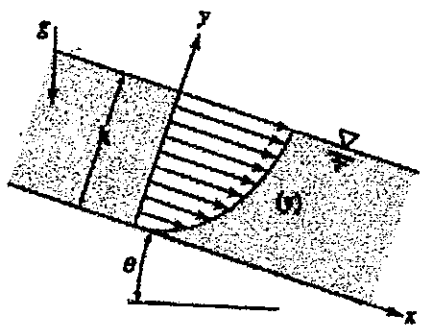
Problem 3 (20points)

To determine the viscosity of a liquid of specific gravity 0.95, you fill, to a depth of 12 cm, a large container which drains through a 30-cm-long vertical tube attached to the bottom. The tube diameter is 2 mm, and the rate of draining is found to be 1.9 cm^3/s. What is your estimate of the fluid viscosity? Is the tube flow laminar?



Problem 4 (20points)

A constant-thickness film of viscous liquid flows in laminar motion down a plate inclined at angle θ, as in figure. The velocity profile is: $u = Cy(2h - y); v = 0; w = 0$



(a) Find the constant C in terms of the specific weight and viscosity and the angle θ.

(b) Find the volume flux Q per unit width in terms of these parameters.

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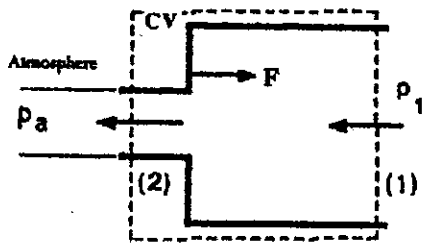
Problem 5 (20points)

A liquid of density ρ flows through the sudden contraction in figure and exits to the atmosphere. Assume uniform conditions (P_1, V_1, D_1) at section 1 and (P_2, V_2, D_2) at section 2. Find an expression for the force F exerted by the fluid on the contraction.



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