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。可以英文或中文作答。)

Problem 1 (20 points)

Assuming that the drag force (D) experienced by an object moving through a fluid is a function of its projected area (A) in the direction of motion, its velocity (V), and density (ρ) and dynamic viscosity (μ) of the fluid, develop dimensionless groupings that describe the problem.

Problem 2 (20 points)

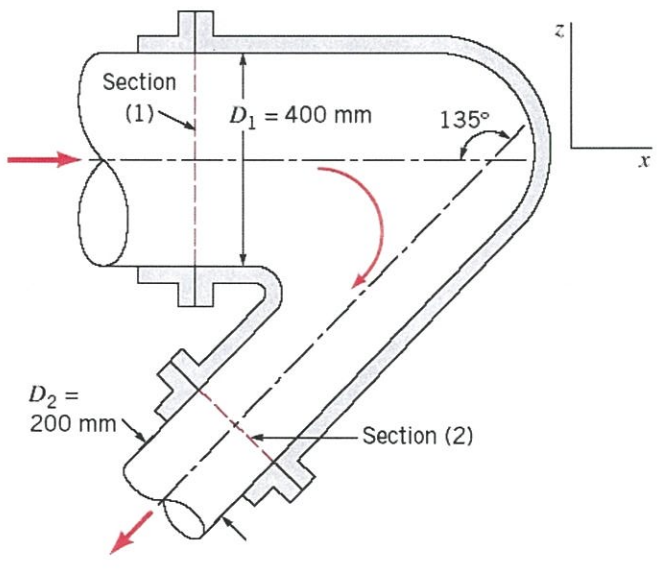
Consider a flow field given by

$$\vec{V} = \begin{pmatrix} 5yt \\ -5xt \\ 3xy \end{pmatrix}$$

(1) Is this a steady or unsteady flow? **(6 points)**
(2) Could this be an incompressible fluid? **(6 points)**
(3) Is the flow field rotational or irrotational? If rotational, calculate the components of vorticity. **(8 points)**

Problem 3 (20 points)

A converging elbow turns water through an angle of 135° in a vertical plane. The flow cross section diameter is 400 mm at the elbow inlet, section (1), and 200 mm at the elbow outlet, section (2). The elbow flow passage volume is 0.2 m^3 between sections (1) and (2). The water volume flowrate is 0.5m^3/s and the elbow inlet and outlet pressures are 200 kpa and 100 kpa. The elbow mass is 15 kg. Calculate the horizontal (x direction) and vertical (z direction) anchoring forces required to hold the elbow in place.



Problem 4 (10 points)

In the modeling of particle movement in flows, we may have to use the Shields parameter τ_c^* to determine whether a particle is subject to incipient motion.

$$\tau_c^* = \frac{\rho u^{*2}}{RgD}$$

where ρ is the fluid density, u* is the shear velocity [L/T], D is the particle diameter, R is the ratio of density difference (i.e., density of particle minus water density) to particle density, and g is gravitational constant. Determine the dimension of τ_c^*.

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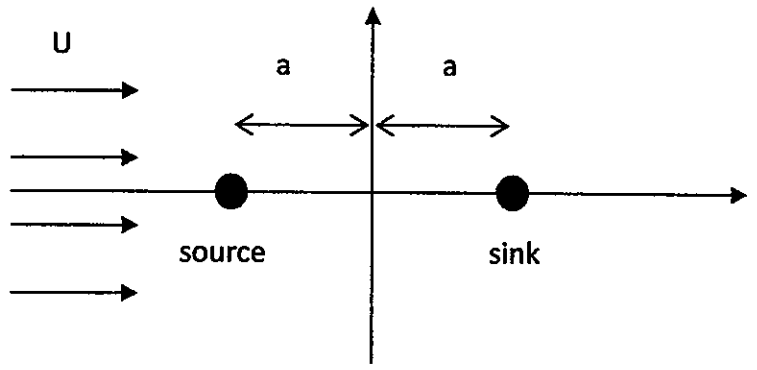
Problem 5 (30 points)

Consider the flow field created by a superposition of a uniform flow with speed *U* in the positive x-direction, a positive source of strength *q* located at $x = -a$, and a negative source (i.e., sink) of the same strength located at $x = a$.

(1) Find the complex potential, and potential function. **(10 points)**

(2) Verify that $x = \pm\left[a^2 + \frac{aq}{\pi U}\right]^{1/2}$, $y = 0$ are stagnation points. Hint: $\frac{1}{x+a} - \frac{1}{x-1} = -\frac{2a}{x^2-a^2}$. **(10 points)**

(3) Find the pressure at point $x = 0$ and $y = 0$. Neglect gravity effects and assume that the pressure at a large distance is P_∞. **(10 points)**



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