系所組別：水利及海洋工程學系甲、乙組

考試科目：流體力學 考試日期：0222，節次：2

※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Consider the 2D steady viscous flows of streamline patterns around a vertical plate in the experiment, as illustrated in **Fig 1a** (for **flow 1**) and **Fig 1b** (for **flow2**) below. We mark four points **A, B, C, D** on the plate, two far-away points **E, F** and four surrounding regions **I, II, III, IV** in **Fig 1c**. Let **U**=approaching flow velocity, **L**=plate length, **t**=plate thickness, μ=fluid viscosity, ρ=fluid density. Please answer briefly:

(A) Define the best flow Reynolds number (**Re**); What are flow directions possible in Figs 1a and 1b? Which is larger in **Re** between two flows? (5%)

(B) In **Fig 1a**, the pattern is one of the Hele-Shaw flow. Why are the streamlines of this viscous flow similar to a potential flow of inviscid fluid? Explain. (5%)

(C) In **Fig 1b**, what are the special flow features found at points B, D? What are points A & C called? Also, what is name of flow regions III and IV? Is this flow laminar or turbulent, why? (5%)

(D) In Fig 1a, discuss the variation of velocity, acceleration (in both magnitude and direction) and pressure both along the streamline **EA** (5%) and along the nearest streamline turning around point B (5%);

(E) Compare the drag and lift forces of two flows? What are these two forces coming from? (5%)

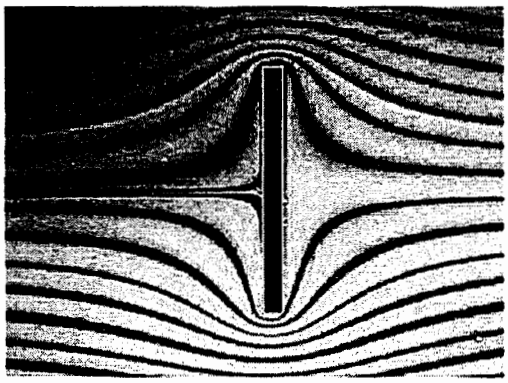

Fig 1a. Streamlines of flow 1

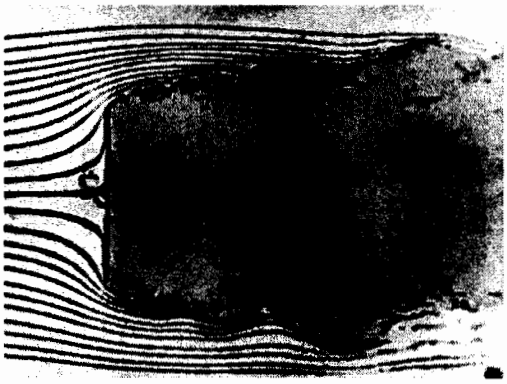

Fig 1b. Streamlines of flow 2

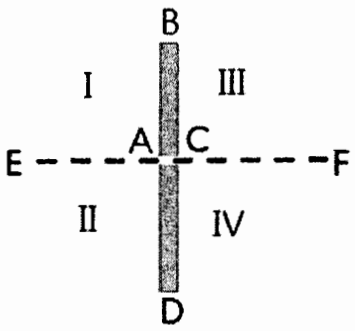

Fig 1c. Notations

2. As shown in **Fig 2a**, a pipe system of diameter **D** and total length **L** (friction factor ***f***) with overall minor loss coefficient K_L connecting two large tanks of constant levels z_1, z_2 ($< z_1$).

(A) Determine the flowrate **Q** in pipe; (5%)

(B) Sketch the **HGL** and **EL** from tank A to tank B; (5%)

(C) For engineering practice, the friction factor ***f*** is determined from the Moody chart (as **Fig 2b**). Describe how the values of abscissa affect the value of ***f*** at various flow features; (5%) What condition(s) of the pipe is considered as hydraulically smooth? (2%) What condition(s) of the flow as wholly turbulent? (3%)

(D) When flow in the pipe becomes fully developed, compare the flow velocity across the pipe section between lamina and turbulent flow; (5%) What is the pressure varied along the pipe? (3%) What the shear stress on the wall (2%)

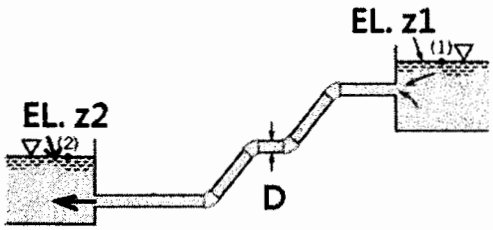

Fig 2a. Pipe system and two large tanks.

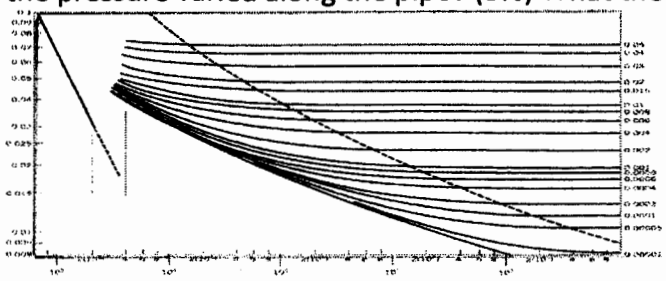

Fig 2b. Moody chart (a reminding without showing information)

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3. Discuss how a sphere in uniform motion is affected by its translation velocity, rotation speed and wall roughness. (15%) (Hint: consider the effects on the drag and lift and various flow regimes, like laminar/turbulent flow and flow separation, etc.)

4. **Newton's second law** states that the nonzero net force is equal to the time variation of momentum of a particle. For a fluid particle of constant density (ρ=constant), the forces exerting on the particle are due to pressure (p), fluid viscous stress ($\bar{\bar{\tau}}$) and gravity (g=gravitational acceleration) while the momentum change is describe due to the variation of velocity ($\vec{V}$) at a fixed location (x, y, z) and time (t) **by Eulerian viewpoint**. According to these given properties of fluid and flow and express the variation in space by ∇, write down the vector forms of Newton's second law (per unit volume) term by term for: (A) the pressure force, (B) the viscous force, (C) the gravity force, (D) the accelerations (splitting the acceleration in parts of time and space variations.) (10%)

5. In a tank of cross-area **A** filled with a liquid of specific weight γ_1, we put a solid block of volume **V** and specific weight γ_2 to raise the fluid level Δh, as shown in **Fig 5**.

(A) Expressed Δh by given quantities. (10%)

(B) How much does the weight of the tank increase. (5%)

(C) If he tank is accelerated horizontally without the block, what is the acceleration required to equate the water height to Δh on the right side of tank wall? (5%)

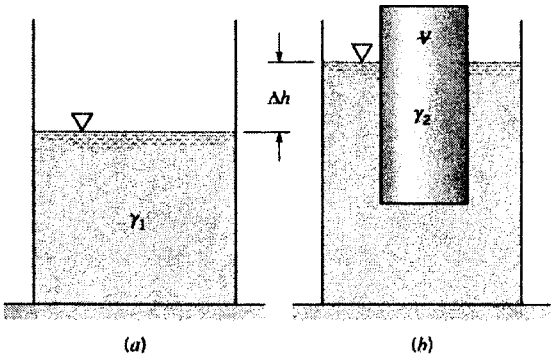

Fig 5. fluid tank and a solid block