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

(30%) (1) Explain/answer the following questions: ((a) to (h): 3 % each, (i): 6%).

(a) What's the major difference between solid and fluid motion?

(b) What is continuum assumption in fluid mechanics?

(c) Why fluid has viscosity? What is the so-called "no-slip" condition?

(d) What is Newtonian Fluid?

(e) What is vorticity and circulation in fluid mechanics? What is their relation?

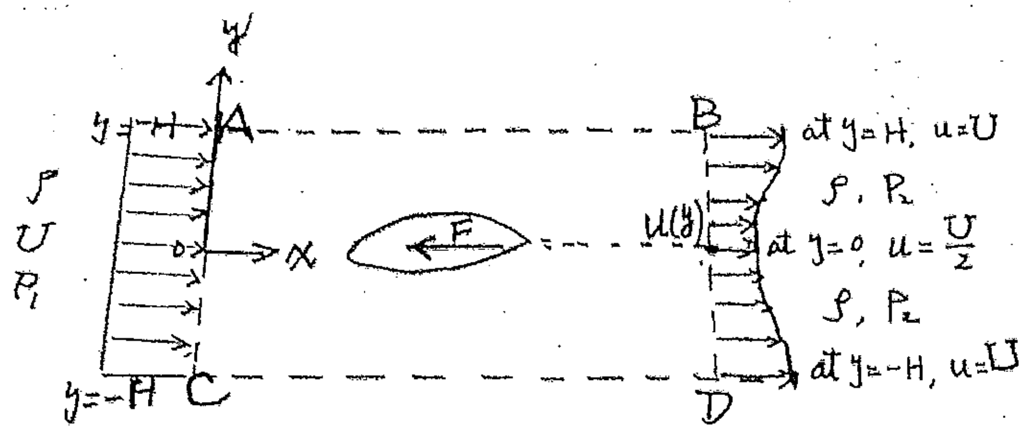
(f) List three kinds of condition that can make static fluids to move becoming flow.

(g) Explain why surface tension may exist between air and liquid interface.

(h) Explain streamline, path line and streak line. What condition will make the three lines be the same?

(i) In a flow field we can draw streamlines and define stream functions. For a 2-D **incompressible irrotational** flow, we can also define a potential function. Explain the physical meaning for the values difference between two stream functions. Prove that the associated potential lines are orthogonal to the streamlines. (6%)

(25%) (2) A submarine is cruising under the sea. Assume the flow field is steady-state, two-dimensional and incompressible. A control volume is chosen as shown below:



The submarine is located and fixed in the center of the control volume and the flow field is symmetric with respect to y=0. The in-flow has uniform velocity U, density ρ and pressure P_1. The out-flow has uniform pressure P_2, a parabola velocity profile with 0.5U at center and U at top and bottom of the control volume. Find (a) the velocity profile u(y) at exit plane.(5%) (b) the mass flux across AB and CD, (5%) and (c) the thrust (F) of the submarine to have this flow conditions (15%).

(30%) (3) The incompressible Navier-Stokes equation can be written as following:

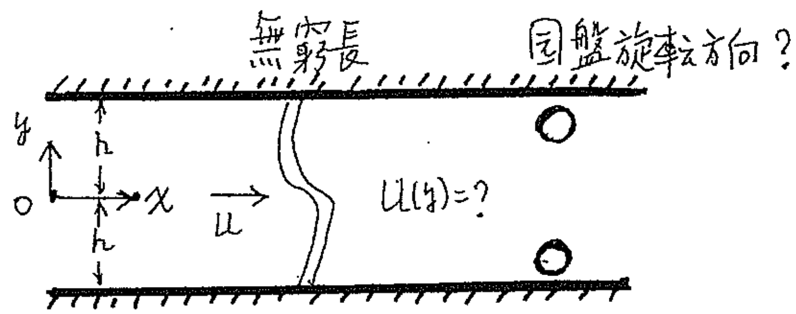
Continuity equation: $\nabla \cdot \vec{V} = 0$

Momentum equation: $\frac{\partial \vec{V}}{\partial t} + \vec{V} \cdot \nabla \vec{V} = -\frac{1}{\rho} \nabla P + \upsilon \nabla^2 \vec{V}$, where ρ is fluid density and $\upsilon = \mu / \rho$ is kinematic viscosity .

(a) Spell out the conservation of mass and conservation of momentum equations for a **steady 2-D incompressible** flow in Cartesian coordinate system (on XY plane). (6%)

(b) Analyze the viscous flow using the PDE from (a) for the flow between two infinite parallel **stationary** plates (the spacing between the two plates is 2h). Assume the flow is **laminar** and pumped by a pressure at inlet. Obtain the fully-developed x-component velocity profile u(y) across the channel (the streamwise direction is along x-axis). Calculate the mass flow rate. What's the relation between the pressure drop and the channel height (2h)?(20%)

(c) Draw the velocity profile u(y) and calculate its vorticity across the y-direction. If we put two circles at y= +0.8h and y= -0.8h and let the two circles flow down along x-direction, indicate the rotation direction of the two circles. (Assume the two circles are extremely light so that they will be simply convective down the stream without producing disturbance to the original flow field. (4%)



(15%) 4. (a) Find **three** important dimensionless parameters directly from the Navier-Stokes equations given in the problem (3) above. (6%)

(b)Using Buckingham Pi Theorem to find a set of dimensionless groups that can be used to correlate the pressure drop, Δp, for steady incompressible viscous flow through a straight horizontal pipe with its length, L, the average velocity, V, the fluid viscosity, μ, the pipe diameter, D, and the fluid density, ρ. (9%)