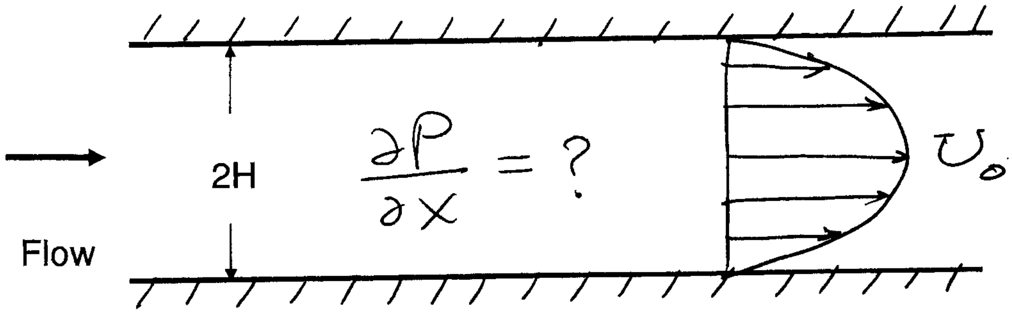
系所組別：航空太空工程學系甲、丁組
考試科目：流體力學
考試日期：0222，節次：2

※ 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。

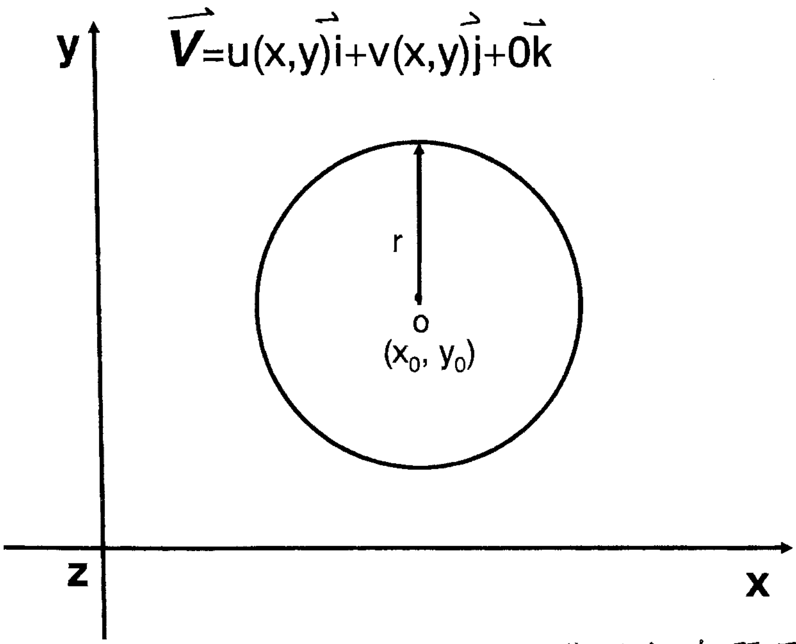
1. **20%**)

Consider a laminar, incompressible flow between two parallel, infinite long plates with a width of 2H, shown below. In the fully-developed region, the velocity at the center is known as U_0. Find the pressure gradient in the region. Note that in the figure x denotes the direction of the flow, and p denotes the static pressure of the flow. The density and viscosity of the flow are given as ρ and μ, respectively.



2. **20%**)

Consider a two-dimensional flow shown below, where u(x,y) and v(x,y) represent the velocities in the x and y directions, respectively, and i, j, k represent the unit vectors in the x, y, and z directions, respectively. Give the expression of vorticity of the flow. Also, show the circulation around the circle indicated in the figure below, in terms of vorticity. Note that the radius of the circle is r and the center of the circle is at (x_0, y_0).



(背面仍有題目,請繼續作答)

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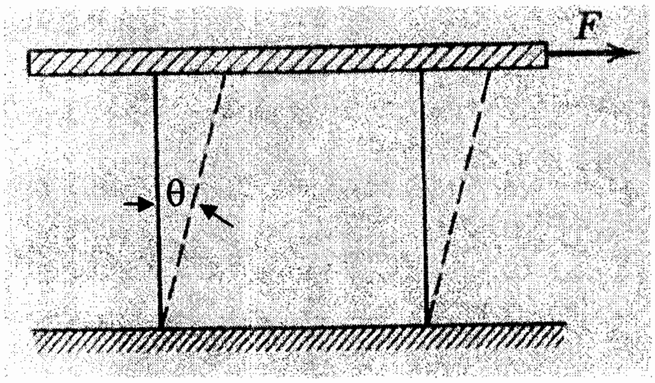
3. **20%**)

Please answer the following questions:

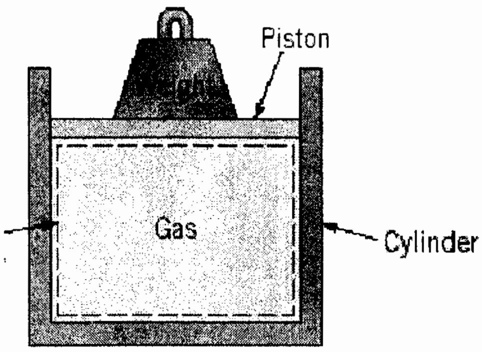
(a) If we place a specimen of substance (either solid or fluid) between two plates (figure below) and then apply a shear force F. Please describe the behavior difference between a solid and fluid under the action of a constant shear force F. (5%)



(b) Explain what are the so-called Newtonian fluid and non-Newtonian fluid. (5%)

(c) Given velocity field $\vec{V} = x\vec{i} - y\vec{j}$, find out the equations of streamline and pathline in xy plane through (2, 8). (5%)

(d) Please identify the dash line enclosed area in figure below is a system or a control volume. Figure shows a **piston-cylinder assembly:** If the gas is heated, the piston will lift the weight; The upper boundary will thus move upward with piston. (5%)



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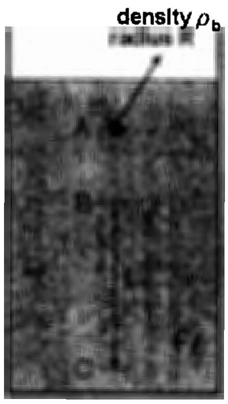
4. **20%)**

As shown in Figure below, consider a very small spherical ball with radius R and density ρ_b is allowed to fall freely from a point A in a fluid with a density of ρ_f. The initial velocity of the ball at point A equals zero. The small ball moving in fluids is known to experience buoyant force F_B, gravity force F_G, and drag force F_D. The drag force F_D is proportional to speed V and can be formulated as $F_D=6\pi\mu VR$, where μ is viscosity of fluid, V is the ball speed and R is the ball radius. The ball reaches its terminal speed V_t as it passes through point B and takes time T (second) falling from point B to point C. The distance between point B and point C is L. Please answer the following questions (each question 4%):

(a) Sketch the free body diagram of the forces acting on the ball and write down the equation for each force indicated on the free body diagram.
(b) Write down governing equation for the motion of the ball.
(c) Solve the governing equation and find out the velocity as function of time V(t).
(d) Determine the terminal speed V_t in terms of ρ_b, ρ_f, R, μ, and g.
(e) The falling ball experiment can be used to measure viscosity of a fluid. Determine the viscosity μ of fluid in terms of ρ_b, ρ_f, R, μ, L, T and g.



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5. 20%)

Consider a laminar flow developed fully on an inclined surface as shown below. The friction force exerting on the free surface is negligibly small.

a) State your arguments that help you to reduce the incompressible Navier-Stokes equations to the governing equations you will use to solve this problem.

b) Derive the velocity distribution by proposing appropriate boundary conditions.