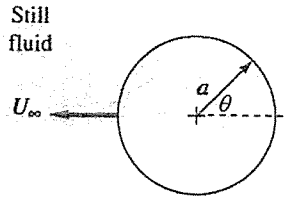
※ 注意：請於試卷內之「非選擇題作答區」依序作答，並應註明作答之部份及題號。

1. (25 %) Consider a sphere of radius a moving at velocity U_∞ in a still fluid with density ρ, as shown in the figure. Assume that the flow is potential and the respective potential function is given by $\phi = \frac{U_\infty a^3}{2r^2}\cos\theta$.

(a) Determine the velocity components u_r and u_θ of the fluid. (6%)

(b) Based on (a), calculate the kinetic energy of all the fluid in the flow field. (14%)

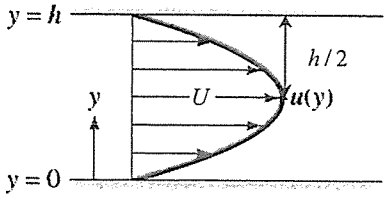
(c) According to (b), the kinetic energy of all the fluid is seen to be equal to the kinetic energy of $1/q$ the displaced mass of fluid if it were moving with the velocity U_∞. Give the value of q. (5%)



2. (25 %) A steady, two-dimensional, incompressible flow occurs between two flat plane surfaces spaced at a distance h apart. The velocity profile $u(y)$ is a parabola with its vertex at the center line (where the maximum velocity is U), as shown in the figure.

(a) Determine the stream function ψ for the flow. (20%)

(b) Is this flow irrotational? State your reason. (5%)



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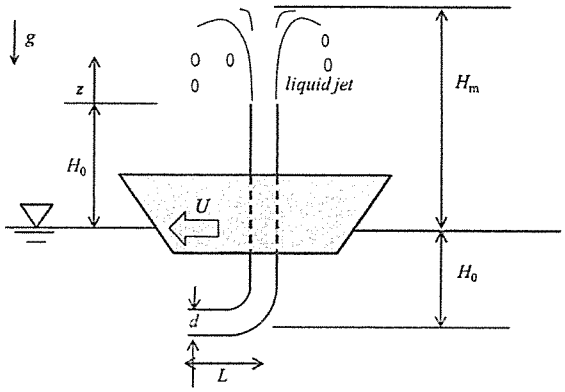
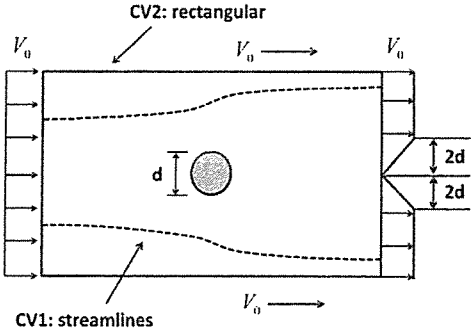
3. (25%) The boat in the sketch has an *L*-shaped tube of diameter *d* attached to it. The horizontal portion of the tube has a length *L* and its vertical arm has a height *H*. The tube is submerged to depth $H_0 < H$ below the free-surface. Assume the flow is irrotational.
(a) If the boat is cruising at a steady speed *U*, what is the maximum height H_m (above the free surface) reached by water jet ejected out of the tube? (6%)
(b) What is the pressure within the water jet at a height *z* from the jet origin? (4%)
(c) What is the jet area A_j at the height *z*? (10%)
(d) How will your answer in (a) change if the flow is NOT irrotational? (5%)



4. (25%) In an experiment to determine drag, a circular cylinder of diameter *d* was immersed in a steady, two dimensional, and unconfined incompressible flow. Measurement of velocity and pressure were made at the boundaries of the fixed control volumes CV1 and CV2 shown below. CV1 has sides that are streamline surfaces. CV2 is rectangular. The pressure was uniform over the control surfaces. The *x*-component of velocity was as indicated by the sketch. From the measured data applied to CV2, show that the drag coefficient of the cylinder, based on the projected area and free-stream velocity (V_0) is 4/3 (10%), i.e.,$C_D = \frac{\text{Drag}}{1/2\rho V_0^2 d} = \frac{4}{3}$. Next, obtain the same result for the drag coefficient by considering the control volume, CV1, instead (15%).



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