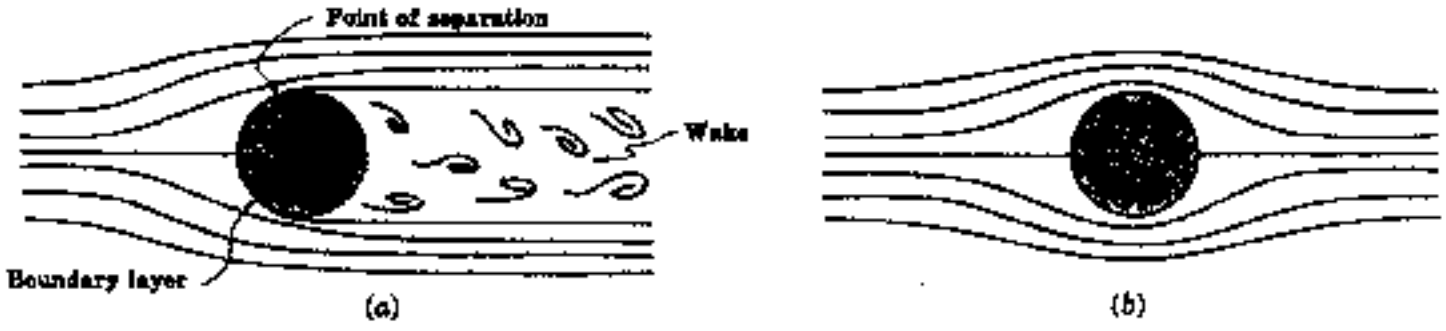
1. (10 points)

For the flow over a cylinder as shown in the figures (a) and (b), answer the following questions:

(i) Which figure, (a) or (b), shows the most likely streamline if the flow is inviscid ?

(ii) In (i), is there any drag force on the cylinder ? Why ?

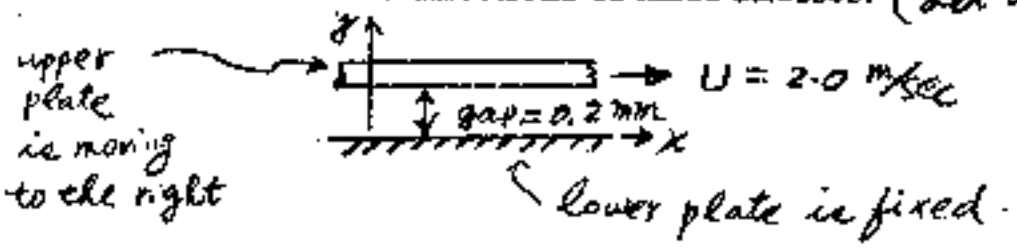
(iii) In figure (a), why there is a point of separation ?



2. (10 points)

(i) What are the units of dynamic viscosity in SI system and Metric system (g, cm, sec) ?

(ii) Refer to the figure, if the velocity profile between infinite parallel plates having a small gap is linear, determine the shear stresses on upper plate and lower plate in unit of Pa. What are the directions of these stresses. (Let dynamic viscosity $\mu = 0.01$ poise)



3. (10 points)

Answer the following questions :

(i) If the velocity vector of the fluid is **V**, write the vector form of vorticity of the fluid.

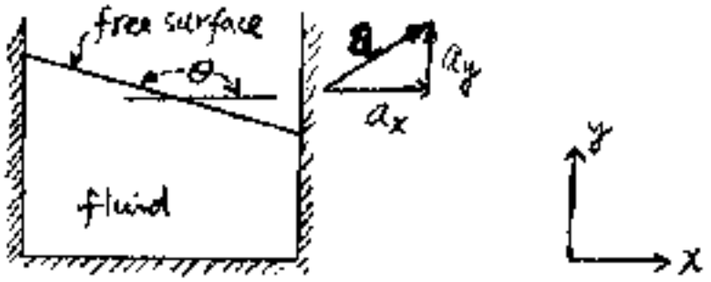
(ii) What is the vector form of physical angular velocity of the fluid ?

(iii) If the cartesian components of the velocity are u, v and w, what are the cartesian components of the angular velocity ?

4. (10 points)

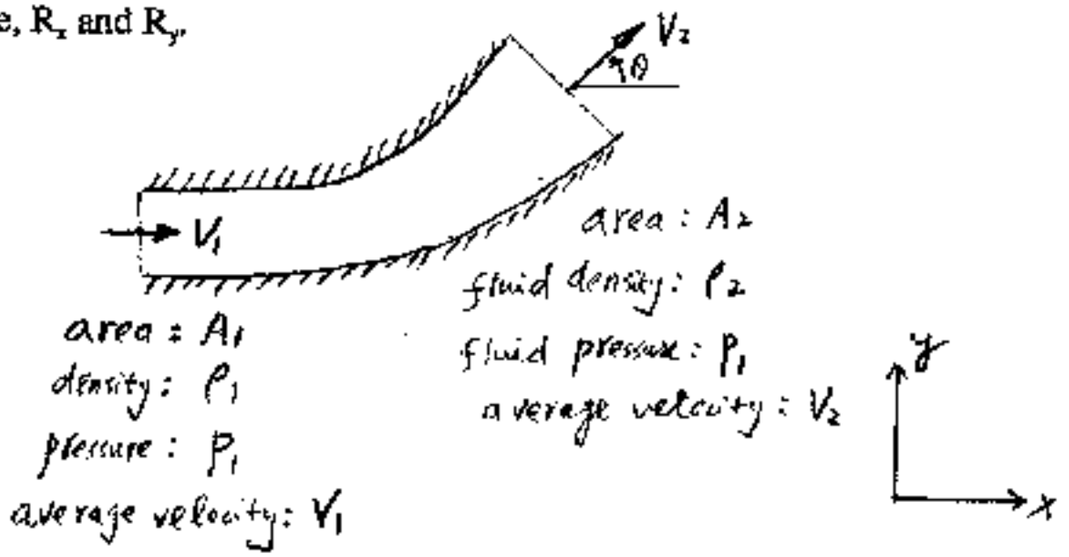
Consider a container of liquid which has a constant acceleration **a** upward and to the right as shown in the figure, (i) derive pressure in the liquid as a function of position in cartesian coordinate, x and y, assuming that the ambient pressure above the free surface is P_0 (ii) Calculate the slope of the free surface with respect to the horizontal plane, θ.

(fluid density: ρ
fluid pressure: p)



5. (10 points)

Consider the steady flow of a fluid through a pipe bend as shown in the following figure. Determine the force of the fluid on the pipe between sections A and B. ~~Write the control volume equation in vector form including body force.~~ Then assume that the fluid body force is negligible and derive the x and y components of the fluid on the pipe, R_x and R_y.



6. Please compare the differences of following items for laminar and turbulent (9 points)
(fully developed) flows in a circular pipe:

a. range of the *Reynolds number*

b. velocity profile (briefly describe it, equation is not required)

c. relationship between head loss and velocity

7. A *Lr* scale model of a hydraulic structure is to be tested in open channel (9 points)
flow to verify their performance. Note that $Lr = l_m/l_p$ (scale ratio between model and prototype) .What are the followings:

a. velocity ratio

b. time ratio

c. force ratio

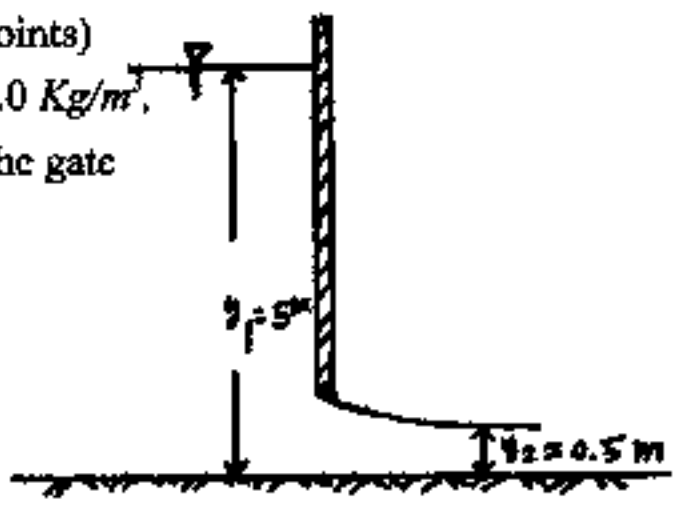
8. When neglecting the dilatation, the *Navier-Stokes* (*N-S*) equation expressed (6 points)
in the vector form is:

$$\rho\vec{g} - \nabla p + \mu\nabla^2\vec{q} = \rho\frac{d\vec{q}}{dt}$$

a. How may the *N-S* equation be simplified for inviscid fluid and is there a name for the reduced equation?

b. What assumptions should be made to simplify the *N-S* equation to the *Bernoulli* equation?

9. Flow of water under a sluice gate is indicated in the figure. (14 points)
Assume that the viscous force is negligible, the water density is 1.0 Kg/m^3, and $g = 9.8KN/m^3$. What is the total force (*KN/m*) acting on the gate per unit width?



10. The velocity potential for a steady incompressible flow is given (12 points)
by $\phi = A(x^2 + 2y - z^2)$

a. Prove that the irrotational condition is satisfied.

b. Find the equation for the velocity vector

c. Find the equation of the stream function in $y = 0$ plane

d. Prove that the continuity equation is satisfied