

**National Cheng Kung University**  
**Department of Engineering Science**  
**Fluid Mechanics Mid-Term Exam** (total scores 110)

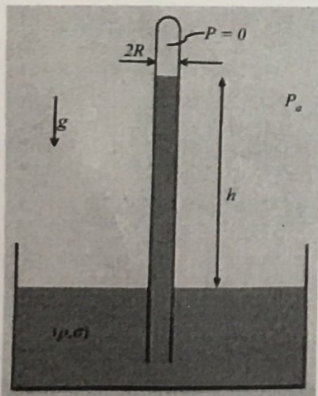
11/20/2018

ID:

Name:

*Instructions: Closed Book, no crib sheets, no Phones, no Laptops, no Ipads. Please show your work steps. State your assumptions and justify your equations.*

- (1) Explain/answer the following questions: ((a) to (h): 3 % each, (i): 6%, total 30%)
- What's the major difference between solid and fluid motion?
  - What is continuum assumption in fluid mechanics?
  - Why fluid has viscosity? What is the so-called "no-slip" condition?
  - What is Newtonian Fluid?
  - What is vorticity and circulation in fluid mechanics? What is their relation?
  - List three kinds of condition that make fluid in motion.
  - Explain why surface tension may exist between air and liquid interface.
  - Explain streamline, path line and streak line. What condition will make the three lines be the same?
  - 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%)
- (2) Consider a barometer shown in figure below. The density of the liquid is  $\rho$  and the acceleration due to gravity is  $g$ . The ambient pressure is  $P_a$  and the pressure above the liquid column in the tube is zero. (total 20%)



- What is the relation between the ambient pressure  $P_a$  and height of the liquid column  $h$ , when surface tension effects are neglected? (5%)
- Now consider a case when the radius  $R$  of the barometer tube is small and surface tension effects become important. The three phase contact angle is  $\theta$  and the surface tension of the liquid is  $\sigma$ . Consider a case when  $\theta > 90^\circ$  (hydrophobic 疏水性). What is the expression for  $P_a$  under this regime? (10%)
- Under what conditions can we neglect surface tension effects? Please express your answer in terms of the given quantities. (5%)

- (3) Reynolds Transport Theorem is given as:

$$\left(\frac{DB}{Dt}\right)_{sys} = \frac{\partial}{\partial t} \iiint_{CV} b \rho dV + \iint_{CS} b \rho \vec{V} \cdot d\vec{A}$$

For conservation of mass  $b=1$ , conservation of momentum  $b = \vec{V}$