國立臺灣科技大學
九十三學年度碩士班考試試題

系所組別：機械工程系丙組
科　　目：流體力學

總分 100 分 共 5 大題

1. Please answer the following questions:
   a. Explain the physical meaning of momentum thickness（5%）
   b. What's cavitation（5%）
   c. What's the Newton's viscosity law? Give the definition of Newtonian fluids（5%）
   d. Describe why separation happens in boundary-layer flow. Is there a mathematical formula to define the location of separation? Give the definition or formula.（5%）
   e. What's the dynamic similarity?（5%）

2. We consider an atmospheric layer whose temperature distribution is

$$T(z) = T_o e^{-\alpha z},$$

where $T_o$ is the temperature at $z = 0$ and $\alpha$ is a constant. Now we'd like to estimate the pressure at a certain height, $z$. Please derive the formula for the pressure estimation. The fluids are assumed to be at rest in the layer. ($P(z = 0) = P_0$)(15%)

3. A fluid flow can be classified to be rotational and irrotational. What is the condition for an irrotational flow? (3%) In addition, there exists a velocity potential, $\phi$, for an irrotational fluid flow. Could you tell us the formula of the velocity potential? Please also substitute the formula into condition of an irrotational flow to check whether the formula satisfy the condition. (5%) Furthermore, we assume considered fluids to be inviscid and incompressibile. Could you write down the continuity equation for an incompressible fluid? (3%) Furthermore, substitute the velocity potential into the continuity equation. Please write down the resultant equation that should includes the velocity potential. Tell us the name of the equation and whether the equation is non-linear or not.（5%）Can the method of superposition be used to obtain solutions of the resultant equation? Why? (4%)

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4. Consider 2-D incompressible steady fluids flow between two infinite vertical parallel plates. The width of the gap between two plates is $b$. One of the vertical plate moves upward at a constant speed, $U_o$. The other plate is at rest. Please determine (a) the velocity profile along the gap (5%) (b) The location of the maximum velocity (5%) (c) The shear stress exerted on the still plate. (5%) (d) The volumetric flow rate between those two plates. (5%)
5. Two-dimensional, steady, laminar boundary-layer flow along a flat plate. Schlichting points out that the boundary-layer velocity profile is

$$\frac{u}{U}=\sin\left(\frac{\pi}{2}\frac{y}{\delta}\right) \quad \text{for } 0\le y\le\delta$$

and

$$\frac{u}{U}=1 \quad \text{for } y>\delta$$

Please find (a) boundary thickness, $\delta(x)$ (6%)(b) displacement boundary thickness $\delta^*(x)$ (7%)(c) Total friction force on a plate of length $L$ and width $b$. (7%) .(Hint: $\tau_w=\rho U\frac{d\theta}{dx}$)

## 2-D continuity equation for an incompressible fluid

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$$

## 2-D Navier Stokes equations

$x$-dir

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+g_x+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

$y$-dir.

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+g_y+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$