國立成功大學九十六學年度碩士班招生考試試題

編號： 176 系所：系統及船舶機電工程學系甲組 科目：流體力學

本試題是否可以使用計算機： ☑可使用 ， ☐不可使用 （請命題老師勾選）

1. 請先閱讀下段英文敘述，然後明確指出文中的哪些描述（包括名詞與情形）與哪些流體力學的現象或原理有關，再盡你所知分別詳細解釋這些流體力學的現象及原理。請以條列式回答，每條依序包括 (a)原英文中的關鍵字詞及所在的行數、(b)流體力學的現象或原理的中文名稱、(c)你的解釋。(21%)

Ludwig Prandtl (1875-1953) was a German physicist born near Munich. He earned his Ph.D. degree from University of Munich in 1900, and was trained in solid mechanics. In 1901, Prandtl became a professor of mechanics at a technical school in Hannover where he developed many of his most important theories.

Throughout the 18th and 19th century the top physicists and mathematicians of Europe examined flows from a mathematical point of view. Many of them tried to construct potential flows over bodies. Although the mathematics was elegant, it was recognized that such flows failed to mimic "real" flows seen in nature. Furthermore, it was known that potential flows frequently resulted in zero drag; a clear contradiction with everyday experience (d'Alembert paradox)!

In 1904, Prandtl delivered a groundbreaking paper, in which he described the boundary layer and its importance for drag and streamlining. The paper also described flow separation as a result of the boundary layer, clearly explaining the concept of stall for the first time.

2. Bernoulli's Equation ($p+\rho\frac{V^2}{2}+\rho gz = constant$) is an expression for energy conservation. The second term and the third term represent kinetic energy and potential energy, respectively. But,

(a) Why do these two terms have the same dimension as pressure (the first term) in the above equation, instead of the dimension of energy? What are their exact physical meanings in the above forms? (10%);

(b) In addition to "static pressure", what is the first term's physical meaning? What kind of energy form does it represent? Why? (5%)

(c) Under what conditions can the above form of Bernoulli's equation be applied in a flow field? (4%)

3. Please design a simple instrument for measuring air velocities in a turbulent air channel based on things and technologies available now. Please:

(a) Draw a figure of this instrument (3%);

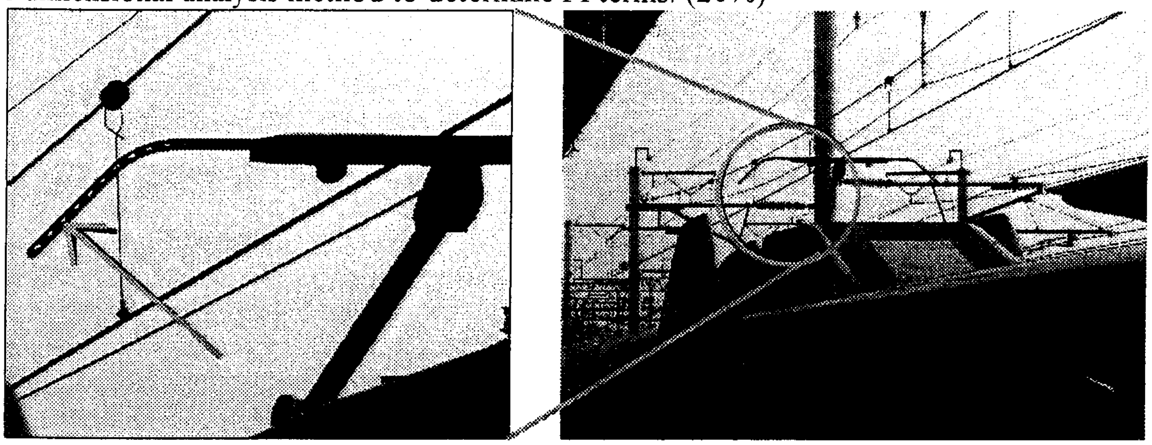
(b) Describe how to use it and explain its principles in fluid mechanics and other sciences (10%);

(c) Explain its advantages and disadvantages (2%); and

(d) Analyze its measuring error. (5%)

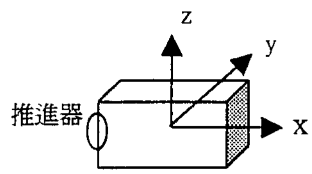
本試題是否可以使用計算機： ☑可使用 ， □不可使用 （請命題老師勾選）

4. The pantograph (集電弓) of Taiwan High Speed Rail's (台灣高鐵) Train Model 700T is a small structure on the top of the train to collect electricity from the electricity supply wire as shown in the following pictures. This small T-shape structure has some small holes to reduce the drag force. To study this problem, we will consider the following variables: train speed U, pantograph length l, pantograph diameter d, density of air ρ, viscosity of air μ, small hole's diameter h (assuming a round hole), average spacing between small holes s, and drag force D. Use dimensional analysis method to determine PI terms. (20%)



5. 我們考慮一個簡化的水下載具的流體動力問題，牽涉到的物理量符號與機制假設如下：

- 直角座標系的原點在載具的幾何中心，向前為+x 方向，往左舷為+y 方向，往上為+z 方向。水的密度為ρ，黏滯係數為μ，重力加速度為 g。
- 載具為一長方體，寬 w，高 h，長 l，質量為 m，平均密度為 0.99ρ，往+x 方向前進，速率為 $U(t)$。



- 載具在三個方向的阻力係數 C_{Dx}、C_{Dy}、C_{Dz} 分別為其雷諾數 Re_x、Re_y、Re_z 的函數，$C_D=C_D(Re)$。而阻力係數分母中的面積為載具在該方向的正投影面積。
- 在 x-y 平面上的控制翼（圖中沒有畫出）所產生的升力 L 由 Kutta-Joukowski Theorem 計算，其環流量為Γ，假設作用在質心上，作用方向與升力大小可使載具保持一定的深度。
- 後方圓罩內的推進器提供向+x 方向的推力 T。
- 洋流流速為一常數 V，往+y 方向。
- 任一瞬間載具的加速度為 $a(t)$(三個分量為 a_x, a_y, a_z)。

此水下載具受所有下列力量作用：重力、浮力、阻力、推力、控制翼的升力。
請依據上述符號與假設，

(a)先畫一包含所有的力的示意圖(2%)；

(b)求環流量應該為何？(3%)

(c)若載具從時間 $t=0$ 起，從 $U(0)=0$ 開始加速，列出計算三個方向加速度所需的所有理論方法（含方程式）與演算步驟 (12%)。不需進行實際的數學計算，僅需依序詳細說明方法；

(d)如果你/妳將來遇到類似現在這樣需要解決的問題，卻發現自己不會，或沒有把握能完全解決時，你/妳怎麼辦？(3%)