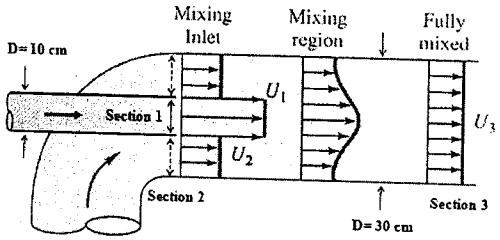
# 國立中央大學100學年度碩士班考試入學試題卷

所別：機械工程學系碩士班 丙組(熱流)(一般生)　科目：流體力學及熱傳學　共 3 頁　第 1 頁

本科考試可使用計算器，廠牌、功能不拘　＊請在試卷答案卷（卡）內作答

流體力學 (50 分)

1. As shown in the figure, a mixing ejector pump injects water ($\rho$=1000 kg/m$^3$, $\mu$=0.001 N·s/m$^3$) at $U_1$=50m/s and $P_1$=200kPa through a 10cm circular pipe (section 1) and entrains a secondary flow of water at $U_2$=4m/s and $P_2$=200kPa in the annular region around the small pipe (section 2). Two fluids start mixing in the mixing region and become fully mixed downstream (section 3). The distance between section 1(or 2) and section 3 is 2 m and the average wall shear stress $\tau_w$ in the mixing region (between section 1 and 3) is 300 Pa.

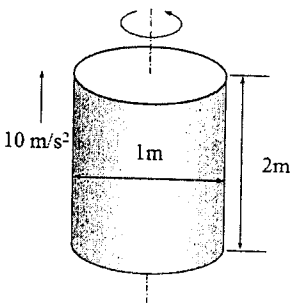



(1) Please estimate the velocity, $U_3$ and pressure $P_3$ in the fully mixing region (section 3) (7%)

(2) If density, pressure, diameter and velocity in section 1 and section 2 are known as ($\rho$, P, $D_1$,$V_1$) and ($\rho$, P, $D_2$,$V_2$) respectively. Assume wall friction is negligible, please derive general formulas for $V_3$ and $P_3$ (in section 3) to analyze the mixing ejector pump. (6%)

(3) Please discuss the mixing phenomenon in the mixing region between section 2 and section 3 (5%)

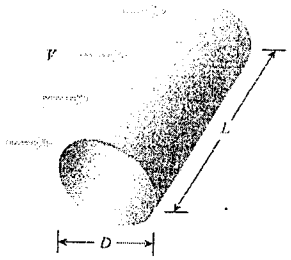
2. As shown in the figure, a cylinder tank is filled with water ($\rho$=1000 kg/m$^3$) and rotate about its vertical axis at a rate of 100 rpm while being accelerated upward with 10 m/s$^2$.




(1) Please determine the difference between the pressures at the centers of the bottom and top surfaces. (4%)

(2) Please determine the difference between the pressures at the center and the edge of the bottom surface. (3%)

3. Please use the dimensional analysis or the Buckingham pi theorem to determine all of the dimensionless parameters associated with a drag force problem: Consider the drag force $F_D$ associated with a circular cylinder of diameter $D$ and length $L$ exposed to a flow having a mean velocity of $V$ which is directed perpendicular to the cylinder length, as shown below. (10%)




4. Consider a 100-mm-wide, 200-mm-long, flat plate. Air at 300K and 1 atm flows over the plate at a velocity of 10 m/s, where the air density $\rho$ = 1.17 kg/m$^3$ and the air absolute viscosity $\mu$ = 18.58 x 10$^{-6}$ N·s/m$^2$. (15%)

(1) Please estimate the thickness of the hydrodynamic boundary-layer at the trailing edge of the aforementioned flat plate.

(2) If consider the drag exerted on both sides of the flat plate, please determine the force required to hold the plate stationary.

注意:背面有試題

參考用

熱傳學 (50 分)

5. Starting from the following conservation equations, please derive the boundary layer equations by applying the boundary layer approximations. Be sure to clearly state all assumptions that you made and the reasons for each term you deleted. (15%)

**Conservation Equations:**

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

x-mom: $\rho\left(u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+X$

y-mom: $\rho\left(u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)+Y$

energy: $\rho c_p\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)=k\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right)+\mu\Phi+q,$

where $\Phi=\left\{\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)^2+2\left[\left(\frac{\partial u}{\partial x}\right)^2+\left(\frac{\partial v}{\partial y}\right)^2\right]\right\}$

**Boundary Layer Equations:**

x-mom: $u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\frac{\partial^2 u}{\partial y^2}$

y-mom: $\frac{\partial p}{\partial y}=0$

energy: $u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\frac{\partial^2 T}{\partial y^2}+\frac{\nu}{c_p}\left(\frac{\partial u}{\partial y}\right)^2$

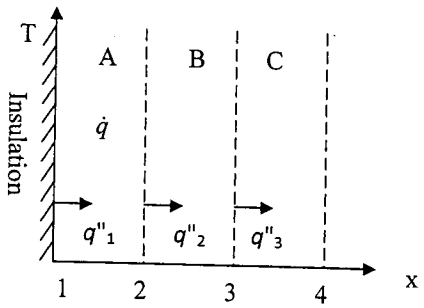
參考用

6. Please evaluate the heat transfer coefficients of fully developed water flow heated in a circular tube with inside diameter is 1.0 cm at constant wall temperature condition. The flow rate is 0.5 liter/min. The properties of water at 300 K and 1 atm are listed below. You must check if it is laminar or turbulent before applying any equations. (10%)

| $\rho$(kg/m$^3$) | $P_{sat}$ (bar) | $\mu$(Ns/m$^2$) | k(W/mK) | Pr | $c_p$(kJ/kgK) |
|---|---|---|---|---|---|
| 997.0 | 0.03531 | 855 x 10$^{-6}$ | 0.613 | 5.83 | 4.179 |

注意：背面有試題

7. A composite plane wall is composed of three different materials, A, B, and C. Each material has constant thermal conductivity and $k_a < k_b < k_c$. Material A is encountered a uniform volumetric heat generation ($\dot{q}$), and its outside surface is well insulated. The wall is sitting in a big room at room temperature.
   (1) Sketch the steady-state temperature distribution in the composite wall. (5%)
   (2) $q''_1$, $q''_2$, and $q''_3$ are the heat flux cross the surfaces located at x =1, 2, 3, and 4, respectively. Which of the following are true regarding their relative magnitudes: (a) $q''_1 = q''_2 = q''_3$, (b) $q''_1 > q''_2 > q''_3$, (c) $q''_1 < q''_2 < q''_3$, (d) $q''_1 > q''_2 = q''_3$, (e) $q''_1 = q''_2 > q''_3$, (f) $q''_1 < q''_2 = q''_3$, (g) $q''_1 = q''_2 < q''_3$, (h) $q''_1 > q''_2 < q''_3$, or (i) No certain relation. (5%)
   (3) Write down the heat diffusion equation that can describe the steady-state heat transfer in material A. (5%)




8. An ordinary egg can be approximated as a solid with constant properties. The egg is initially at a uniform temperature of 10°C and is dropped into boiling water at 100°C. Derive the equation that can describe the time-dependent temperature change of the egg. (5%)

9. What is Wien's displacement law? (5%)