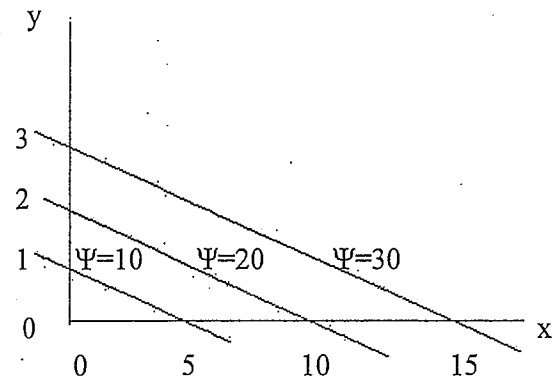
國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：流體力學及熱對流【機電系碩士班甲組】　　題號：438006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

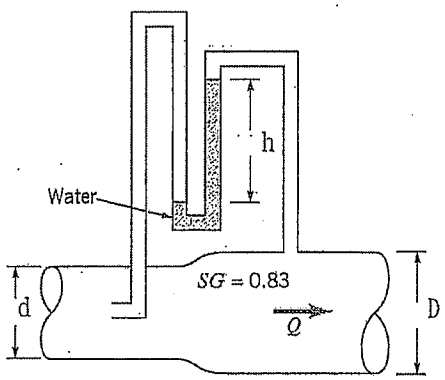
1. (6分) (a)何謂牛頓流體(Newtonian fluid) (3分)？(b)寫出 Reynolds number 的定義。其物理意義為何? (3分)
2. (6分) (a)寫出 Navier-Stokes equation 之向量式 (2分)。(b)寫出 Navier-Stokes equation 在 Cartesian coordinate 中 y-分量的式子(2分)。(c)Navier-Stokes equation 適用的條件為何？(2分)
3. (6分)一個 2-D, steady, incompressible 之流場若定義 $u = \frac{\partial \psi}{\partial y}$，則下圖(圖一)所顯示的 streamline 之流場其 (a)速度向量值 $\vec{V}$ = ?(3分), (b)單位面積的體積流率 =? (3分) Ψ 為 stream function。



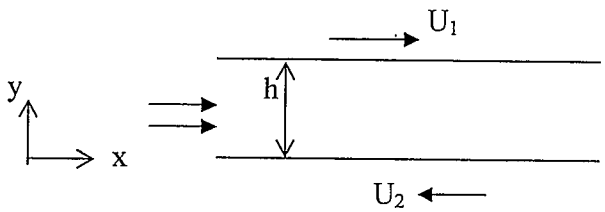
(圖一)

4. (6分) (a)Define Darcy friction factor (*f*) (3分). (b)What is the loss head (h_L) in terms of *f*, tube length (ℓ/D), and velocity head, for a fully developed flow in a horizontal tube? (3分)
5. (6分) 如果流場為 $\vec{V} = xyt\vec{i} + 2x^2\vec{j} + 3\vec{k}$，則該流場為 (a) steady or unsteady? (2分)寫出理由否則不計分。 (b)加速度場為何？(4分)
6. (8分) Oil of specific gravity 0.83 flows in the pipe shown in the Figure 2 (圖二). If viscous effects are neglected, what is the flow rate Q? (h = D = 0.1016 m, d = 0.0762 m)

(圖二)

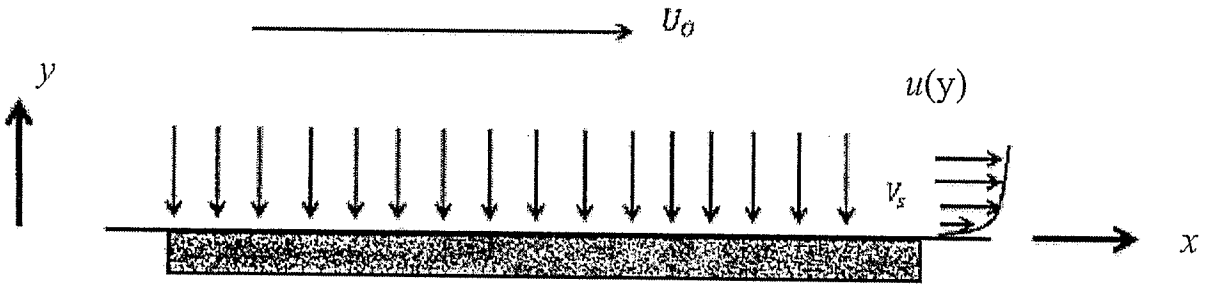


7. (12分) (a) An incompressible, viscous fluid flows between horizontal, infinite, parallel plates as shown below (圖三). The two plates move in opposite directions with constant velocities, U_1 and U_2, in the directions shown in the figure. Assume the flow is steady and fully-developed。請從完整的 2-D Navier-Stokes equations 開始，刪掉可刪掉的項，並說明可刪掉的原因(一般壓力梯度不為零，不可刪掉)。導出這個問題的 governing equation。寫出 boundary conditions。說明為何 x 方向之壓力梯度為 constant。解出含壓力梯度的速度場。(10分)
(b)當壓力梯度為零時，速度場為何? (2分)　　註：使用圖三上的座標(y = 0 在下板)



(圖三)

8. (15分) A laminar boundary layer on a flat porous plate can reach a constant asymptotic boundary layer thickness and profile shape if suction is applied. Consider the case where the flow is steady and developed (no variation in the stream-wise direction). The velocity components of the flow are u and v. The velocity far from the surface is U_0. The velocity of the fluid passing into the plate is V_s (With V_s<0). Assume that $u = 0$ on the plate surface. 參考圖四



(圖四)

(a) Simplify the 2-dimensional continuity equation to show that $u = u(y)$ and $v = V_s$.

Hint: $\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}) = 0$, where $\boldsymbol{u}$ is the flow velocity vector field.

(b) Simplify the 2-dimensional Navier-Stokes equations with Newtonian viscous stress to derive a differential equation relating $u(y)$, U_0, and V_s (ρ and μ are the fluid density and viscosity).

Hint: $\rho\left(\frac{\partial \boldsymbol{u}}{\partial t} + \boldsymbol{u} \cdot \nabla \boldsymbol{u}\right) = -\nabla p + \mu \nabla^2 \boldsymbol{u}$, where μ is the dynamic viscosity.

(c) What are the correct boundary conditions to solve the ODE equation (Do NOT solve the equation)?

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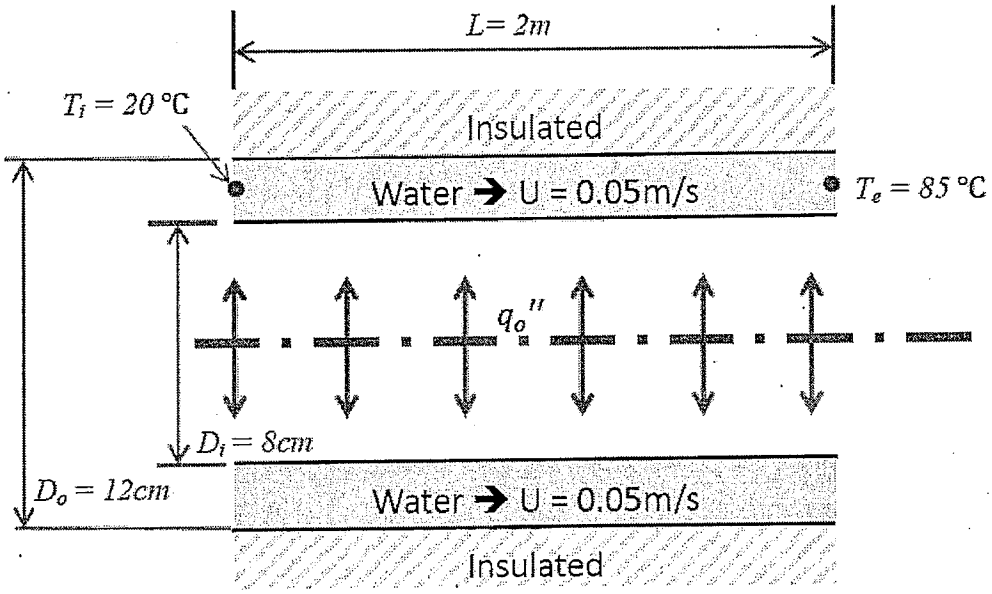
9. (15 分) In an experiment designed to measure the power output from a combustion process, two cylindrical shells of diameters of 8 cm and 12 cm and length of 2 m have been placed concentrically around a flame. This process yields a uniform heat flux on the walls of the inside W/m^2. Saturated water flows between the cylinders with an inlet temperature of 25 ℃ and a velocity of 0.05 m/s. The water temperature at the exit is measured to be 85 ℃. The outer cylinder is insulated externally. Find the value of q_0". 參考圖五



(圖五)

10. (20 分) A current carrying (current I and voltage V) pure copper cable of diameter D and length L is initially at T_i and suddenly placed in a water stream with h and T_∞. Determine the time at which its temperature becomes 5℃ from its final temperature.

T_i = 80℃, h = 50 W/m^2-K, T_∞ = 20 ℃, D = 2 cm, L = 1 m, I = 5 A, V = 20 V