注意：考試開始鈴響前，不得翻閱試題，

並不得書寫、畫記、作答。

國立清華大學 108 學年度碩士班考試入學試題

系所班組別：**工程與系統科學系 乙組**

考試科目(代碼)：**流體力學(3103)**

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 作答中如有發現試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 108 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 乙組(0531)

考試科目（代碼）：流體力學 (3103)

　　*請在【答案卷】作答

1. (20%)

(1) Please define the friction factor for pipe flow.

(2) Please explain the dependence of friction factors for the laminar flow and turbulent flow on the surface roughness.

(3) Plot the Moody diagram and explain it as possible as you can.

2. (15%)

As shown in Fig. 1, the fluid velocity along the streamline is $\vec{V} = V\vec{s}$.

The acceleration can be expressed as

$$\vec{a} = \frac{d\vec{V}}{dt} = a_s\vec{s} + a_n\vec{n}$$

Please prove

$$a_s = V\frac{dV}{ds} \text{ and } a_n = \frac{V^2}{R}$$

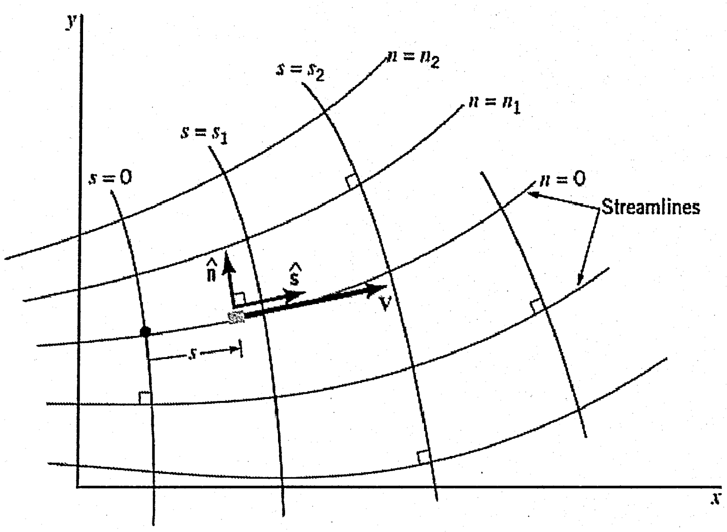

Figure 1

3. (20%)

Consider steady, incompressible, laminar flow of a Newtonian fluid in an infinitely long round pipe annulus of inner radius R_i and outer radius R_o (as shown in Fig. 2). Ignore the gravity effect. A constant negative pressure gradient $\partial p/\partial x$ is applied in the x-direction, $\frac{\partial p}{\partial x}=\frac{(P_2-P_1)}{(x_2-x_1)}$.

Derive an expression for the velocity field in the annular space in the pipe.

Hint:

The velocity field is axisymmetric with no swirl, implying that $u_\theta = 0$ and $\frac{\partial}{\partial \theta}=0$

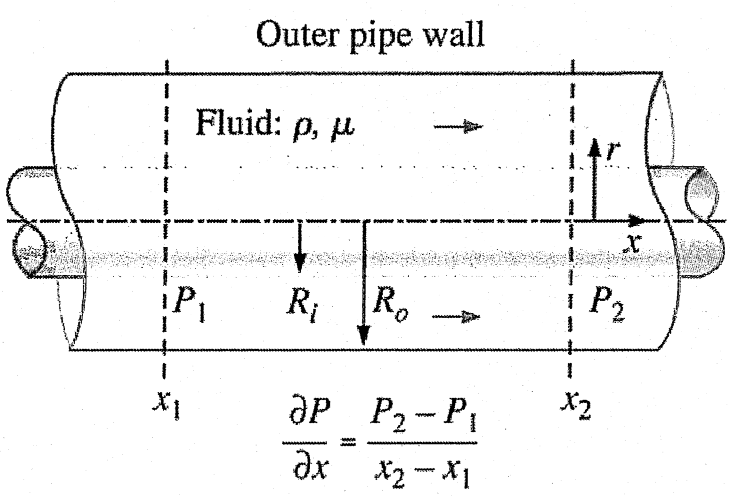

Figure 2

4. (25 %)

As the fluid with the velocity of U passes over a flat plate with the length of L (shown in Fig. 3), the boundary layer is laminar for a short distance downstream from the leading edge. In this flow condition, we consider a steady two dimensional laminar flow with negligible gravitational effect. The governing equations can be reduced to the followings. (δ is the boundary layer thickness)

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

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

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

Simplify above equations into the Boundary layer equation (as shown below) using the dimensional analysis. In addition, please find the relationship of boundary thickness and Reynolds number.

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{\mu}{\rho}\frac{\partial^2 u}{\partial y^2}$$

Hint : (1) L>>δ

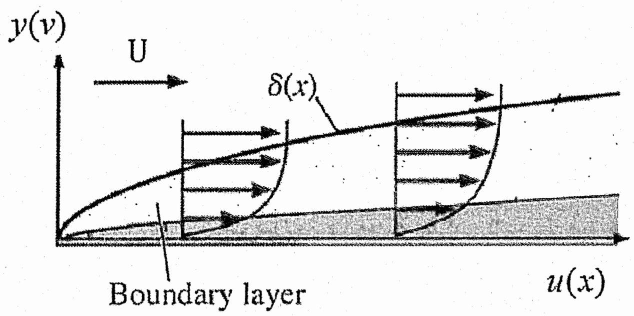

Figure 3

5. (20 %)

A liquid of density ρ and viscosity μ flows by gravity through a hole of diameter d in the bottom of a tank of diameter D (Fig. 4). At the start of the experiment, the liquid surface is at height L above the bottom of the tank, as sketched. The liquid exits the tank as a jet with average velocity U straight down as also sketched. Using dimensional analysis of Buckingham Pi Theorem, generate a dimensionless relationship for V as a function of the other parameters in the problem. Identify any established nondimensional parameters that appear in your results.

(Hint: There are three length scales in this problem. For consistency, choose L as your length scale.)

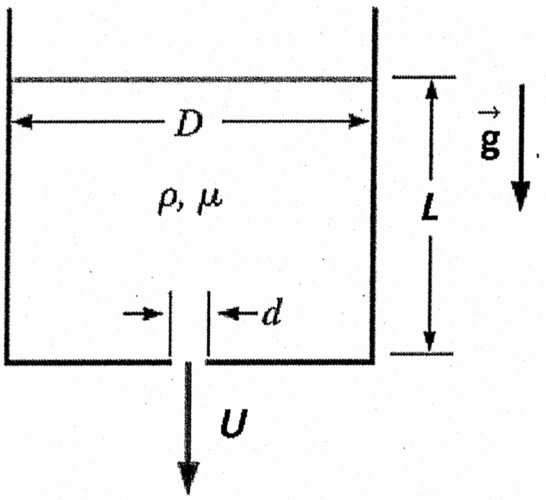

Figure 4