＊作答前，請先核對試題、答案卷（試卷）與准考證上之所組別與考試科目是否相符!!

＊題目中如有未說明事項，請自行進行合理假設。

＊請於回答問題時使用下列參數符號：

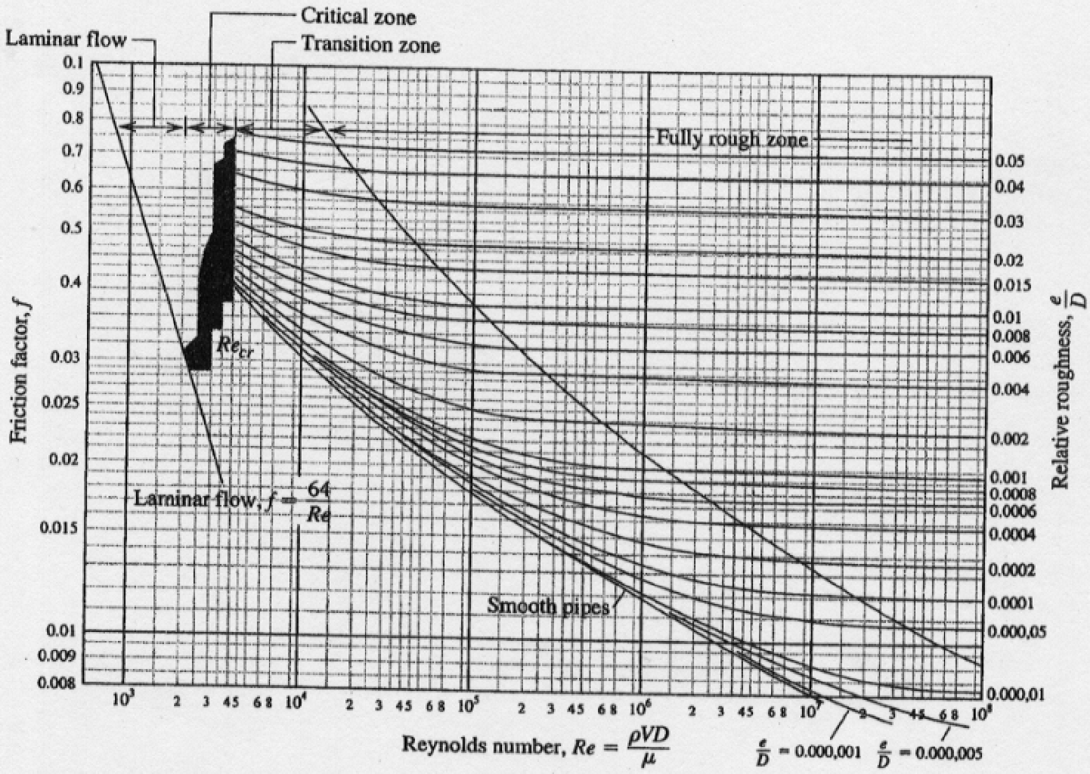
ρ =density; L= characteristic length; ΔP= pressure drop;

μ = viscosity; υ = kinematic viscosity; σ = surface tension;

g= gravitation; Q= volumetric flow rate; τ = shear stress;

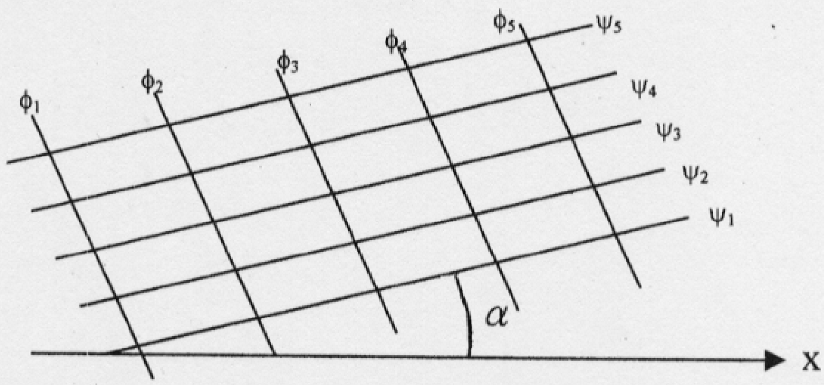
U= free stream velocity; e= roughness of the surface.

＊附圖(Moody diagram)請參考：



Moody diagram: friction factor in pipe flow. From Moody, L.F. "Friction Factors for Pipe Flow," *Transactions of the ASME*, 66, 8, November 1944, pp. 671–684

1. **(10%)** Find the stream function (ψ) and velocity potential (ϕ) for an uniform flow of 40 m/s at an angle (α) 60° with respect to the horizontal.



2. **(15%)** Please give formula for the following non-dimensional groups, also indicate their significance (their physical meanings).

(a). Reynolds number (Re)

(b). Weber number (We)

(c). Euler number (Eu)

(d). Froude number (Fr)

(e). Stokes number (St)

3. (15%) Please describe the purpose of measurement, the basic operation principle and the design equation for the following devices:

(a). a multiple-liquid manometer

(b). a pitot-static tube

(c). orifice (or orifice plate)

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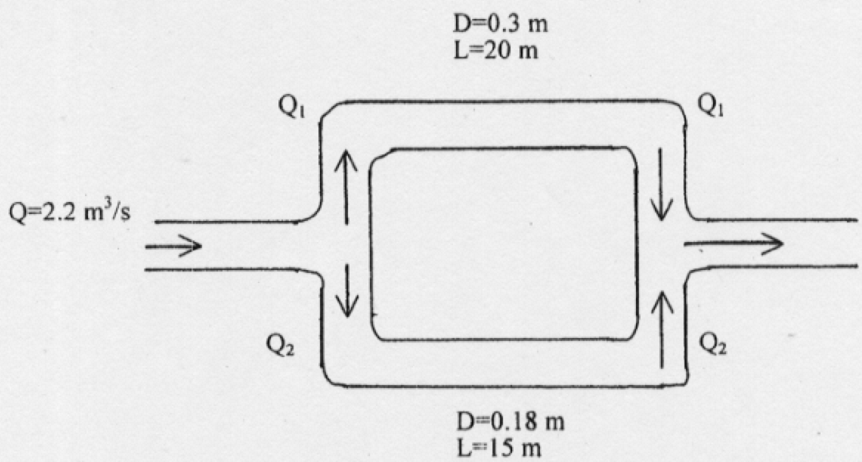
4. (20%) Consider the simple network shown below. Water at the rate of 2.2 m^3/s is divided between two pipes before merging at a common junction. The first pipe with diameter 0.3 m and length 20 m, is made with cast iron (the roughness of the surface (e)=0.2159×10^{-4} m). The second pipe with diameter 0.18 m and length 15 m is made with stainless steel (e=0.0381×10^{-4} m). For this system, calculate (a). the pressure drop across the two pipes, and (b). the volumetric flow rate in each pipe. You may assume no minor losses at the two junctions and elsewhere in the system.



5. (20%) The Navier-Stokes equations in rectangular coordinates are expressed as,

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=\rho\, g_x-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right) \qquad (5.1)$$

$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)=\rho\, g_y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right) \qquad (5.2)$$

$$\rho\left(\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)=\rho\, g_z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right) \qquad (5.3)$$

(a). Under what assumption(s) would the Navier-Stokes equations be expressed as equations (5.1)-(5.3)?

(b). For the case of frictionless flow, equations (5.1)-(5.3) can be reduced to what form? And what is the name of the reduced equation(s)?

(c). If equations (5.1)-(5.3) are reduced to the following equation (5.4) for flow over a horizontal flat plat, then what assumption(s) has been made? What is the name of the reduced equation (5.4)?

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\frac{\partial^2 u}{\partial y^2} \qquad (5.4)$$

(d). If I want to solve equation (5.4) for obtaining the velocity profiles of u and v, what other equation would you suggest me to be incorporated with (5.4)? Please write down the name and the formula of the equation as well.

6. (20%) The x-component of velocity (u) in an incompressible laminar boundary layer is a parabolic variation from u=0 at the surface (y=0) to u=U, the free stream velocity, at the edge of the boundary layer ($y=\delta$).

The equation for the profile is $u/U=2(y/\delta)-(y/\delta)^2$, where $\delta=cx^{1/2}$ and c is a constant.

(a). What is the simplest expression for the y-component of velocity v?

(b). Calculate the mass flow rate across surface bc of control volume abcd, where the boundary layer thickness is 5 mm. Assume the plate width to be 0.6 m, the fluid is air with density $\rho=1.24$ kg/m^3 and the free stream velocity U is 30 m/s.