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）

（每題 20 分）

1. 有二不同管流（pipe flow），其雷諾數（$\mathrm{Re} = Vd/\nu$，V 為管流平均速度、d 為管徑、ν 為運動黏滯係數）分別為 2,000 及 10,000，

（a） 請詳細繪出 Moody chart，並簡略說明摩擦係數 f 與雷諾數 Re 及管壁相對粗糙度 ε/d 的關係。

（b） 已知在光滑管壁的情形下，兩者摩擦係數的值約略相同，試問其值應為多少？

（c） 若增加管壁粗糙度時，對上述兩種不同管流，摩擦係數會增加或減少？

（d） 討論上述兩種管流，流速在徑向上的分佈有何差別？何者管壁所受剪應力較大？

2. It is often assumed that "sharp objects can cut through the air better than blunt ones." Based on this assumption, the drag on the object shown in Fig. P2 should be less when the wind blows from right to left than when it blows from left to right. Experiments show that the opposite is true. Explain.

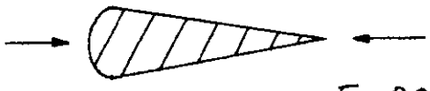

Fig. P2

3. A certain spillway for a dam is 20 m wide and is designed to carry 125 m^3/s at flood stage. A 1:15 model is constructed to study the flow characteristics through the spillway. Determine the required model width and flowrate. What operating time for the model corresponds to a 24-hr period in the prototype? The effects of surface tension and viscosity are to be neglected.

4. Water flows down the sloping ramp（坡道）shown in Fig. P4 with negligible viscous effects. The flow is uniform at sections (1) and (2). For the conditions given, show that three solutions for the downstream depth, h_2, are obtained by use of the Bernoulli and continuity equations. However, show that only two of these solutions are realistic. Determine these values.

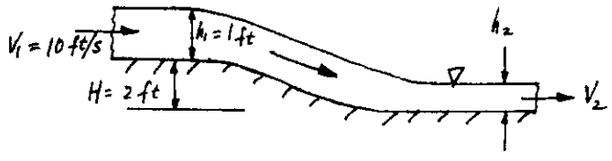

Fig. P4

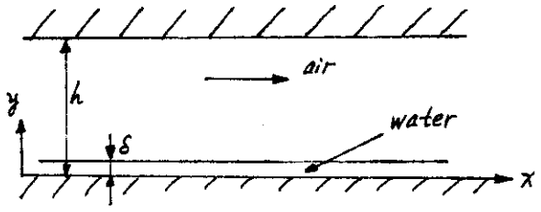

Fig. P5

5. A long horizontal two-dimensional channel of height h carries a steady fully-developed laminar flow of air in the x-direction caused by a constant negative pressure gradient dp/dx. (There is no flow or change in the z-direction.) A very thin layer of water of constant thickness δ flows along the bottom of the channel, as shown in Fig. P5. The water layer thickness δ is much less than the channel height h, and the viscosity μ_w of water is much greater than that of air, μ_a. In terms of the flow parameters h, δ, μ_a, μ_w and dp/dx, derive expressions for (a) the shear stress on the air-water interface, assuming the water layer has no effect on the air flow, and (b) the velocity profile $u(y)$ in the water layer, assuming the shear stress on the water surface has the value of (a). (c) Show that the direct effect of the pressure gradient on $u(y)$ is small.