

air3-1

國立臺北科技大學

九十四學年度冷凍空調工程系碩士班入學考試

流體力學試題

填准考證號碼

第一頁 共二頁

--	--	--	--	--	--	--	--

注意事項：

1. 本試題共四題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在答案卷之答案欄內，否則不予計分。

1. A steady laminar flow in a pipe with radius r_0 is shown in Fig. 1. The entrance flow is uniform, $u=U_0$, and the flow downstream is parabolic in profile, $u(r) = C(r_0^2 - r^2)$. Assume the pressure distribution at location 0 is P_0 and at location x is P_x . P_0 and P_x are constant. Please determine
- (a) the value of C . (10%)
 - (b) the viscous drag force exerted on the pipe walls between 0 and x . (15%)

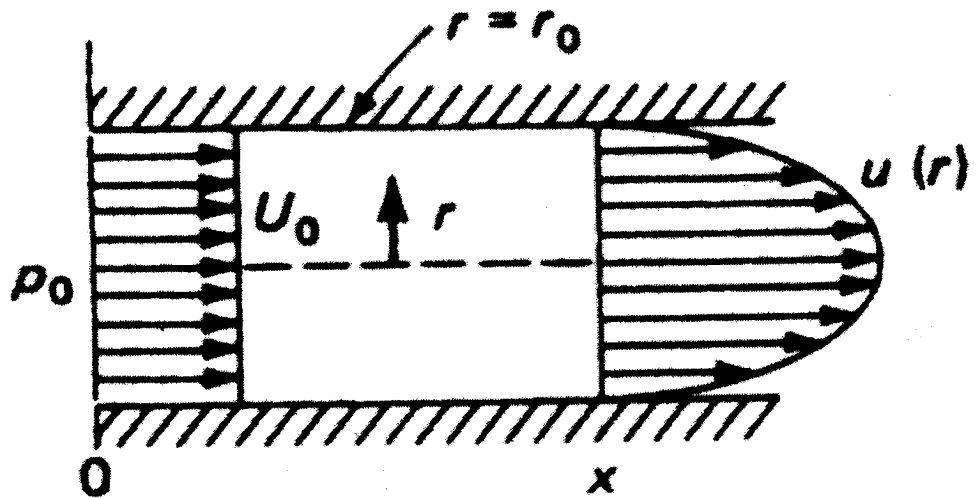


Fig. 1

2. As shown in Fig. 2, a tornado may be simulated as a Rankine vortex which has a two-part circulating flow in plane polar coordinates (r, θ, z) with $u_\theta = U$ at $r = R$ and $u_r = 0$.

For a Rankine vortex, the velocity distribution is given by

$$u_\theta = \frac{U}{R}r, \quad u_r = 0 \quad \text{if } r \leq R$$

$$u_\theta = \frac{C}{r}, \quad u_r = 0 \quad \text{if } r > R$$

where C is a constant. Please determine

(a) constant C . (2%)

(b) an expression of stream function φ for a Rankine vortex. (15%)

(c) Is the flow irrotational or rotational in the region $r \leq R$? (4%)

(d) Is the flow irrotational or rotational in the region $r > R$? (4%)

The relationship between velocity components and stream function is expressed by

$$u_\theta = -\frac{\partial \varphi}{\partial r}, \quad u_r = \frac{1}{r} \frac{\partial \varphi}{\partial \theta}. \quad \text{The vorticity component about the } z\text{-axis is}$$

$$\omega_z = \frac{1}{r} \frac{\partial}{\partial r}(ru_\theta) - \frac{1}{r} \frac{\partial u_r}{\partial \theta}.$$

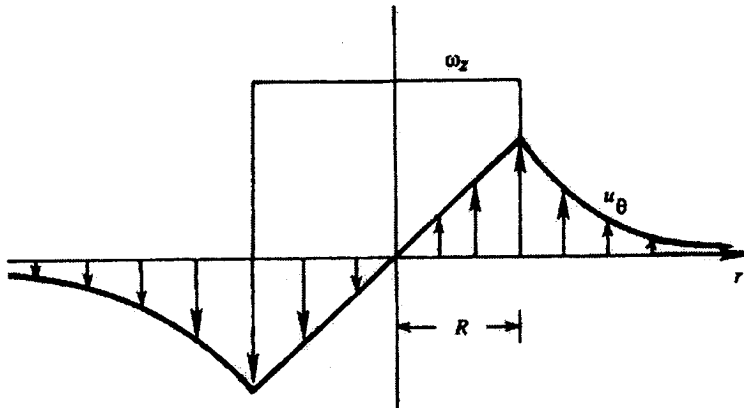


Fig. 2

3. Consider the laminar flow of a fluid layer falling down a plane inclined at an angle α with the horizontal, as depicted in Fig. 3. Assume air resistance is negligible at the free surface. If h is the thickness of the layer in the fully developed stage, please
- (a) determine the velocity distribution. (12%)
 - (b) find the volume flow rate per unit width. (5%)
 - (c) find the frictional stress on the wall. (5%)
 - (d) plot the distribution of shear stress between the bottom wall and free surface. (3%)

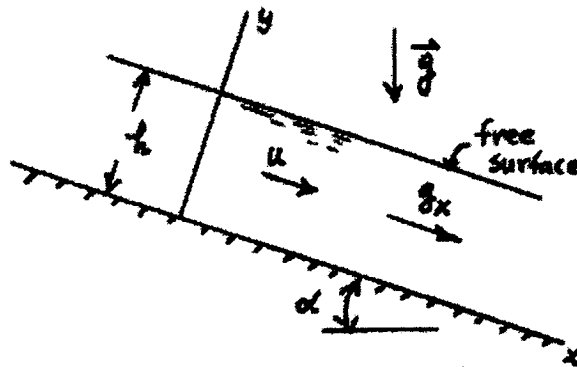


Fig. 3

4. Consider a two-dimensional laminar boundary-layer flow over a flat plate. Assume that the velocity profile is given by

$$\frac{u}{U} = a + by + cy^2$$

where U is the free stream velocity.

- (a) Determine the constants a , b and c . (10%)

- (b) Show that $\frac{\delta}{x} = \sqrt{\frac{30}{Re_x}}$, where δ is the boundary-layer thickness and $Re_x = \frac{Ux}{\nu}$.

(15%)