國立成功大學75學年度航空太空工程研究所考試(流體力學 試題)

1. (20%) Two infinite plates are $2h$ apart (see the figure below), whose temperatures are $T = T_0$ and T_1 respectively. Find the temperature and velocity distributions of the flow between the plates, if

(a) the pressure gradient $\frac{dP}{dx} = 0$,

(b) the pressure gradient $\frac{dP}{dx} = c \neq 0$, where c is a constant.

Note : Assume the velocity and temperature distributions are functions of y only.

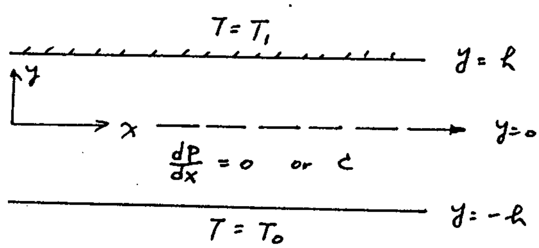
Given : continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$, u and v are the velocities in x and y directions respectively,

x - component momentum equation :

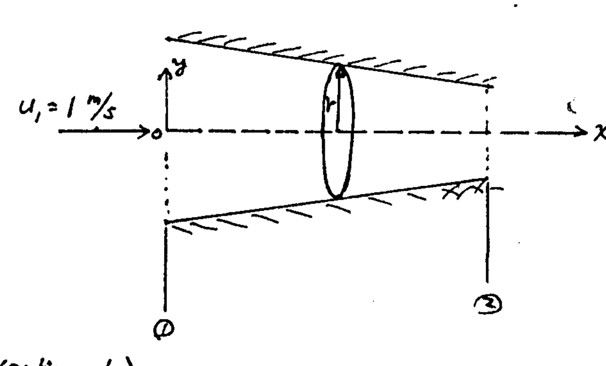
$$\rho \left(\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} \right) = - \frac{dP}{dx} + \mu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$$

energy equation :

$$\rho C_p \left[\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} \right] = K \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + \mu \left(\frac{\partial u}{\partial y} \right)^2$$



2. (20%) In a 2 m long circular cross section flow nozzle, as shown in the figure, the radius r of the flow nozzle varies linearly along x from 0.4 m at section ① to 0.2 m at section ②. The water velocity at section ① is 1 m/sec. If the water supplying to the nozzle is gradually shut down, such that (to be continued)



the volume flow rate decreases linearly with time from the above value at $t=0$ to zero at $t=10$ seconds. Find the acceleration a in the nozzle during the interval $0 \le t \le 10$ sec. (Assume one dimensional flow.)

3. Explain the following terms. You can use both equations and verbalism, but please answer concisely.

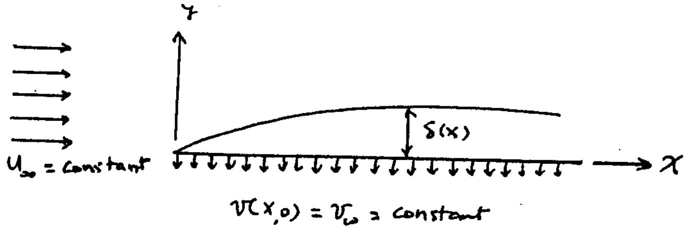
(5%) a. Lagrangian and Eulerian descriptions.

(5%) b. Stream line, streak line, and path line.

(5%) c. Static pressure, thermodynamic pressure, and hydrostatic pressure.

(5%) d. Kutta condition.

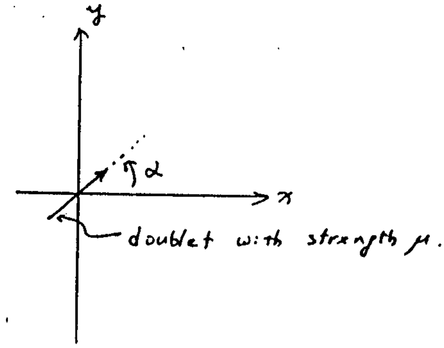
4. (20%) If suction is applied to flat plate flow, as illustrated below, the flow will asymptote to a downstream flow which is "fully developed" and will not grow further. Solve for this fully-developed boundary layer profile and find the value of $\delta^* v_w / \nu$, in which δ^* is the displacement thickness, where ν is the kinematic viscosity.



5. (20 %)

(a) A doublet of strength μ is located at the origin of a Cartesian coordinates, with an inclination α to the x-axis as shown in the figure. Drive the stream and potential functions of this flow.

Hint: The direction of a doublet is defined as the direction from sink to source.



(b) If the doublet of problem (a) is located near an infinitely long wall, what will be the expressions for the stream as well as the potential functions? The coordinate system is shown below.

Given: $\phi_x = \psi_y$, ϕ: potential function

$\phi_y = -\psi_x$. ψ: stream function.