國立成功大學
112學年度碩士班招生考試試題

編　號：65

系　所：機械工程學系

科　目：流體力學

日　期：0206

節　次：第 1 節

備　註：可使用計算機

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※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (15%) An automobile has just dropped into a river as shown in Figure 1. The car door is a rectangle, measures 0.91 m wide and 1.02 m high, and hinges on a vertical side. The water level inside the car is up to the mid-height of the door, and the air inside the car is at atmospheric pressure.

(a)(4%) Calculate the hydrostatic forces on the inside of the door.

(b)(4%) Calculate the hydrostatic forces on the outside of the door.

(c)(7%) Calculate the force required to open the door if the force is applied 0.61 m from the hinge line.

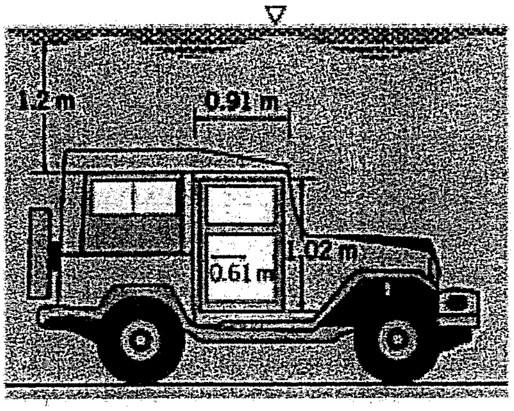


Figure 1

2. (15%) From potential theory, the potential function for a source of strength *m* located at origin is $\emptyset = m \times \ln r/4\pi$ where *r* is the distance to the origin. Now consider a source of strength *m* is located at a distance *l* from a vertical solid wall as shown in Figure 2.

(a)(8%) Modify the original potential function given above to obtain the potential function for flow field as shown in Figure 2. (Hint: Be careful about the boundary conditions at the wall and use Cartesian coordinate here)

(b)(7%) Determine the pressure distribution along the wall, assuming $p = p_0$ far from the source. Neglect the effect of the fluid weight on the pressure.

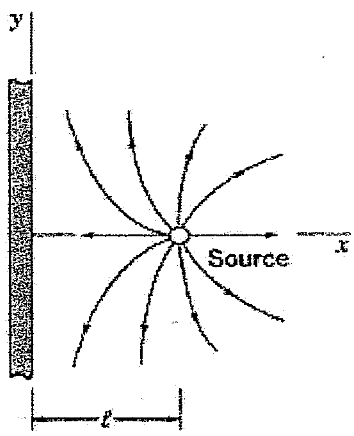


Figure 2

3. (20%) A wide moving belt passes through a container of a liquid with kinematic viscosity ν as shown in Figure 3. The belt moves vertically upward (y direction) with a constant velocity V_0, and the fluid of thickness h in x direction is also carried upward by the belt. Assume the flow is laminar, steady, and fully developed, and there is no shear stress at the interface between the fluid and ambient air.

(a)(10%) Simplify the Navier-Stokes equations as below with reasonable assumptions.

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

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

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

(b)(10%) Solve the velocity distribution in terms of ν, g (gravity, m/s^2), x, h, and V_0.

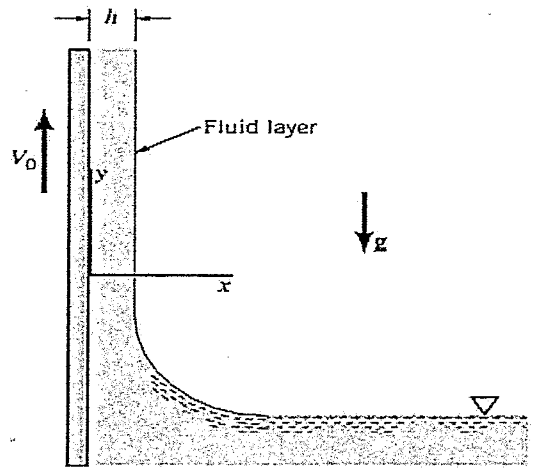
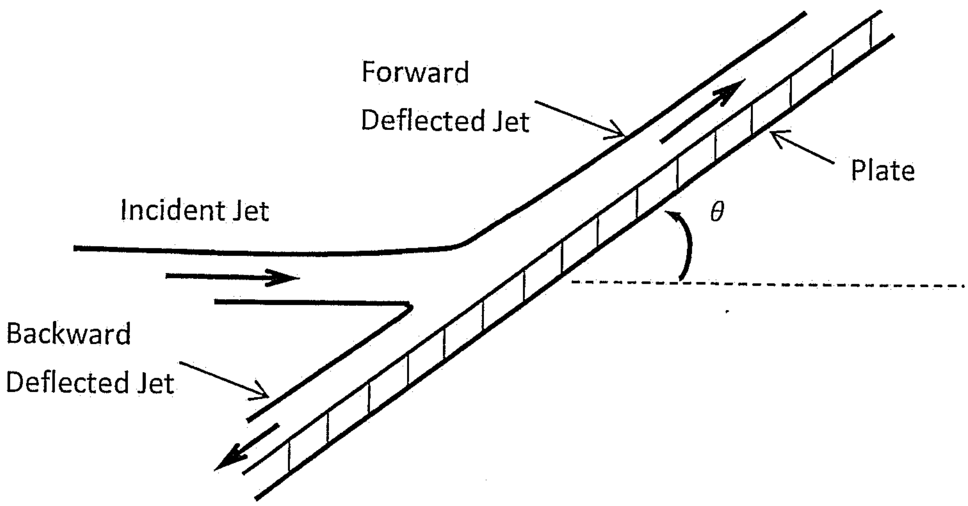


Figure 3

4. (15%) A jet of incompressible, inviscid fluid strikes a flat plate inclined at an angle, θ, to the jet. The jet breaks into two streams as shown in the figure:



If the fluid is frictionless (inviscid) what is the ratio of the flow rate in the forward deflected jet to the flow rate in the incident jet. Assume that far from the impact point the pressure in all jets is atmospheric. Neglect gravity.

5. (15%) Consider the long thin racing boats used in competitive rowing events. Assume that the major component of resistance to motion is the skin friction drag on the hull of the boat. Estimate this drag force for any velocity, U, by assuming that
   (a) the hull/water interface is like a flat plate with a length of 10 m and a width of 1 m.
   (b) that the boundary layer on the hull remains laminar (even though in practice this would not be the case) and unseparated.

Water density and kinematic viscosity are respectively 1000 kg/m^3 and 10^{-6} m^2/sec.
If the boat is propelled by eight humans each capable of a rate of output of work of 0.1 HP (1 HP=746 kg m^2/sec^3) and if half of this energy is uselessly dissipated in the rowing process what would be the top speed of the boat?

6. (20%) Consider a turbulent boundary layer on a flat plate (constant and uniform velocity and pressure in the flow outside the boundary layer). The plate is very rough, the size of the roughnesses, ϵ, being very much greater than the laminar sub-layer thickness which would occur in the absence of the roughness. It is anticipated that the velocity distribution within the turbulent part of the boundary layer can be approximated by

$$u^* = K\left(\frac{y}{\epsilon}\right)^{1/7}$$

where K is some constant, y is the distance from the wall, and $u^* = \bar{u}/u_\tau$, in which $\bar{u}$ is the mean velocity and $u_\tau = (\tau_w/\rho)^{1/2}$ is the friction velocity, τ_w being the wall shear stress and ρ the fluid density. Find an expression for the boundary layer thickness, δ, as a function of x, the distance along the plate from the leading edge. Assume initial conditions $\delta = 0$ at $x = 0$. The results includes ϵ, K and the profile parameter $\alpha = 0.0972$. (α is the ratio of momentum thickness to boundary layer thickness.)