編號： 68

國立成功大學 108 學年度碩士班招生考試試題

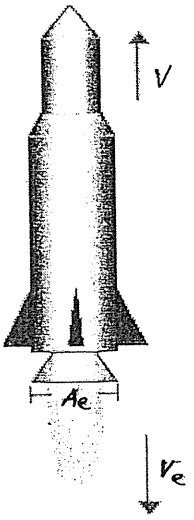
系　　所：機械工程學系

考試科目：流體力學

考試日期：0223，節次：1

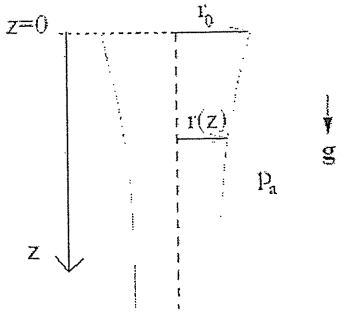
※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (16%) A rocket burns fuel with a constant exhaust velocity V_e to generate the thrust force and time-dependent rocket velocity V (V_e is relative to the velocity of rocket V). Since the fuel continues burning, the mass of the rocket m will reduce as a function of time t. Assume the density ρ of the jet is constant with a cross-sectional area A_e, and the flow is inviscid, derive two original differential equations that can determine $m(t)$ and $V(t)$ in terms of ρ, V_e, A_e, g (gravity), m, and t (please do not solve this equation).



2. Consider a fluid with the density ρ, viscosity μ, and average velocity V flowing inside horizontal and smooth pipe of a diameter D.
   (a) (8%) Perform a dimensionless functional form for the required pressure drop ΔP over a distance L.
   (b) (3%) It is reasonable to assume the pressure drop ΔP is proportional to the distance L. Please further simplify your equation in (a).
   (c) (5%) For V=5 m/s, D=1 m, and L=10 m, the pressure drop ΔP is 10 kPa. Determine ΔP if V=10 m/s, D=0.5 m, and L=30 m under the same fluid properties.

3. (18%) A water column flows vertically downward from a faucet with a volume flow rate Q under the influence of gravity where P_a is the constant ambient pressure. At the outlet of the faucet, the radius of the column is r_o. Show that the radius of the water column is $r = \left(\frac{2\pi^2 g}{Q^2} z^2 + \frac{1}{r_0^4}\right)^{-1/4}$.



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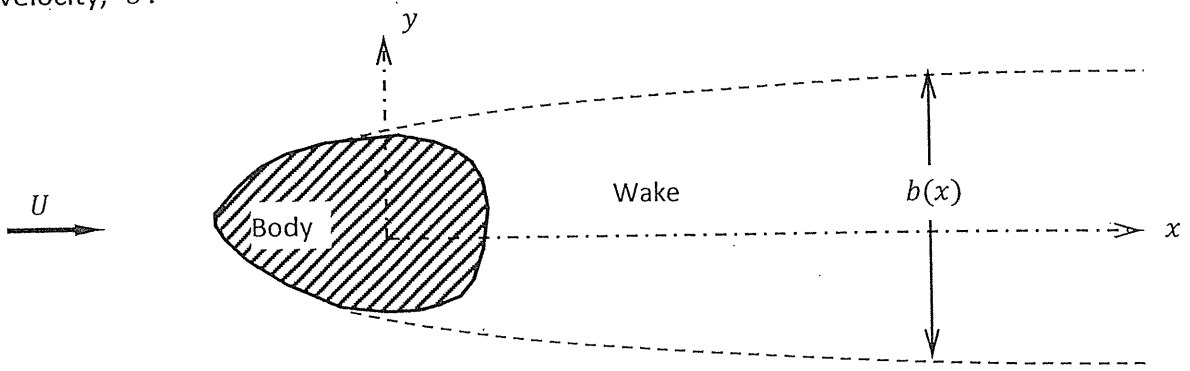
4. Briefly answer the following questions:
   (a) (6%) Physical meanings of $\nabla \cdot \mathbf{V}$ and $\nabla \times \mathbf{V}$, where $\mathbf{V}$ is the velocity field of a fluid flow
   (b) (4%) Under what conditions do both the stream function ψ and the velocity potential ϕ exist for a flow field? When does one exist but not the other?

5. (20%) Wake surveys are made in the two-dimensional wake behind a body (cylindrical) which is externally supported in a uniform stream of incompressible fluid approaching the cylinder with velocity, U:



The surveys are made at *x* locations sufficiently far downstream of the body so that the pressure across the wake is the same as the ambient pressure in the fluid far from the body. They indicate that, to a first approximation, the velocity in the wake varies with lateral position, *y*, according to

$$u = U - A(x)\cos\frac{\pi y}{b(x)} \qquad \text{for} \quad -\frac{b}{2} < y < +\frac{b}{2}$$

where $A(x)$ and $b(x)$ are the centerline velocity defect and wake width respectively both of which vary with position x. If the drag on the body per unit distance normal to the plane of the sketch is denoted by D and the density of the fluid by ρ, find the relation for $b(x)$ in terms of $A(x)$, U, ρ and *D*.

6. (20%) A wind tunnel is constructed primarily of 6 m diameter piping arranged with four 90°-elbows as shown in the sketch below. The working section is 3 m in diameter and is proceded by a nozzle and followed by a diffuser. A fan is installed to create the flow and is 80% efficient. If the tunnel is to achieve an air velocity of 80 m/s in the working section, find the power which must be provided to the fan (in *HP* where 1 *HP*=746 kg m^2/sec^3). Assume the following losses occur in the tunnel:
   (1) A loss in each of the four corner bends equivalent to a length of 20 diameters of the large piping.
   (2) A friction factor, *f*, of 0.02 in the 138 m of 6 m diameter pipe.
   (3) A total loss in the nozzle, working section and diffuser equivalent to one fifth of the dynamic head ($\rho u^2/2$) in the working section.

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Air at these speeds can be assumed essentially incompressible with a density of 1.2 kg/m^3