國立中央大學97學年度碩士班考試入學試題卷

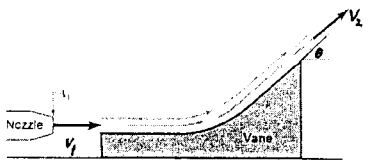
所別：機械工程學系碩士班 丙組(熱流)　科目：流體力學及熱傳學　共 2 頁 第 1 頁

＊請在試卷答案卷（卡）內作答

流體力學 (50 分)

1. Define and explain the following terms. (6 分)
   (a) inertia force, (b) momentum flux, (c) Eulerian description.

2. A horizontal water jet steadily strikes a stationary vane with a uniform speed of V_1, and is turned through a angle θ. Neglect gravity and viscous effects.



   (a) Explain why the exit speed V_2 of the water jet may be considered equal to V_1? (2 分)
   (b) Determine the cross-sectional area A_2 for the water jet to leave the vane by applying a suitable physical principle. (2 分)
   (c) Determine the force that the vane exerts on the water using control volume analysis. Present the vertical and horizontal force component respectively. (5 分)

3. A two-dimensional flow field is defined by $u = 1$, $v = 1 + \sin(t)$.
   (a) Determine the equation of the streamline through the point $(x, y) = (0, 0)$ at time $t = 0$. (2 分)
   (b) Determine the equation of the pathline for the particle that at $t = 0$ passes through the point $(x, y) = (0, 0)$ (3 分)
   (c) Determine the equation of the streakline at $t = 0$ for the particles that previously passed through the point $(x, y) = (0, 0)$ (5 分)

4. What is the dynamic similarity? (2 分)

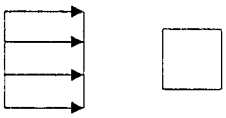
5. A vortex ring with a size of δ and a velocity of U is a toroidal loop of its vorticity ($\omega = U/\delta$) which is formed by an impulse at t = 0. Assuming that the impulse of the ring $I = \rho U\delta^3 = \rho\omega\delta^4$ is thereafter constant. How do U and δ depend on z, if the ring is self-similar? (Note that z is the propagating direction of the vortex ring.) (6 分)

Briefly answer and/or define questions 6 and 7.

6. What is the fully developed flow in a circular pipe? (2 分)

7. What are the displacement thickness (δ^*), the momentum thickness (Θ), and the wall shear stress (τ_ω)? (3 分)

8. Please draw the appropriate flow patterns for a uniform flow passing through a 2-D square body at three different Reynolds numbers, Re = 1, Re = 25, and Re = 10,000, where Re is based on the width of the 2-D square body. (6 分)



9. A small spherical particle of 1 μm in diameter having a density of ρ_s = 1 g/cm^3 is falling through air (ν = 0.15 cm^2/s and ρ = 0.0013 g/cm^3, where ν is the kinematic viscosity of air) under the force of gravity. Assuming that the stokes law is valid for this flow. Please answer the following three questions. (6 分)
   (a) What is the terminal falling speed (V) of such particle?
   (b) Is the flow $Re << 1$?
   (c) How does the terminal speed of the particle depend on the air density? (Hint: the stokes drag $D = 3\pi\mu V d_p$, where μ, V and d_p are the absolute viscosity of air, the speed and the diameter of the particle)

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熱傳學 (50 分)

10. A semi-infinite electrical cable with constant parameters (k, A_c, h, p) is attached to a base wall of temperature T_b.

The electrical resistivity of the cable material is such that the Joule heating effect $\dot{q}$ increases linearly with the local temperature of the cable, $T(x)$:

$$\dot{q}/k = C_1 + C_2(T - T_\infty)$$

In this expression, C_1 and C_2 are two known constants, whereas T_∞ (also constant) is the temperature of the surrounding fluid. Determine the temperature distribution $T(x)$ and the condition that must be met to avoid the thermal runaway (burnup) of the cable. (15 分)

11. (a) The solar energy becomes more and more important today, thus the use of solar absorber to generate heat is very common. Suppose the solar irradiation (solar constant) is 1352 W/m^2, and the absorber plate is a black surface. Find the surface temperature of the absorber. No convection effect is considered and the ambient temperature is taken as 0 Kelvin degrees. The Stefan-Boltzmann constant is 5.67 x 10^{-8} W/(m^{2}K). (4 分)

(b) In the design of solar panel, a glazing (glass widow) is normally installed with certain distance above the absorber. The greenhouse effect increases the absorber plate temperature because the glazing transmits solar radiation but absorbs thermal radiation emitted from the absorber surface. Find the surface temperature of the absorber as the glazing is installed. (6 分)

12. Please evaluate the heat transfer coefficients of fully developed water and oil flow heated in a circular tube with constant heat flux. The flow rate is 10 liter/min, and the tube inside diameter is 1.0 cm. (20 分)

The properties of Oil and water at 300K and 1 atm are listed below.

	ρ(kg/m^3)	μ(Ns/m^2)	k(W/m K)	c_p(kJ/kg K)
Oil	884.1	8.6 x 10^{-2}	0.145	1.909
Water	997.0	855 x 10^{-6}	0.613	4.179

參考用

Some related equations are also given below:

$f = 0.316\ Re^{-0.25}$ for Re < 20,000

$f = 0.184\ Re^{-0.2}$ for Re > 20,000

$f = (0.790\ \ln Re - 1.64)^{-2}$

For laminar flow over a flat plate: $Nu = 0.664\ Re^{0.5} Pr^{0.5}$

Dittus-Boelter equation: $Nu = 0.023\ Re^{0.8}\ Pr^n$, where n = 0.3 for cooling and 0.4 for heating.

Petukhov equation: $$Nu = \frac{(f/8)RePr}{1.07 + 12.7(f/8)^{1/2}\left(Pr^{2/3} - 1\right)}$$

13. Please sketch the velocity boundary layer and thermal boundary layer qualitatively of uniform liquid metal flow over a flat plate from the left to the right side. (5 分)

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