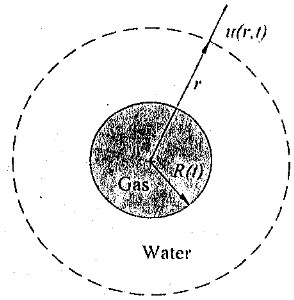
所別：機械工程學系碩士班丙組(熱流) 科目：流體力學及熱傳學

流體力學 (50%)

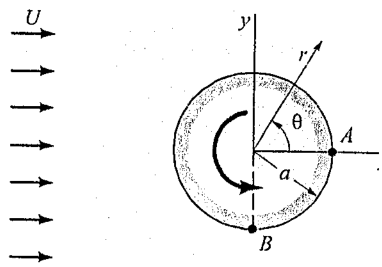
1. For an incompressible fluid flow, which of the following are true? (5%)
   (a) Fluid density must be constant everywhere in space.
   (b) Fluid density may not be constant everywhere in space.
   (c) The material derivative of fluid density must be zero.
   (d) The local derivative of fluid density must be zero.
   (e) The divergence of velocity is zero.
   (f) All of the above.

2. A bubble of high pressure gas expands in water in a spherical symmetric fashion. Assume the gas is not soluble in water, and water does not evaporate into the gas. At any instant, R is the radius of the bubble, dR/dt is the velocity of the interface, P_g is the gas pressure (assumed uniform in the bubble), u is the water velocity at the radius r, and P_∞ is the water pressure at a great distance from the bubble.



   (a) Defining a control volume, to which apply the principle of mass conservation, show that at any instant $u(r,t)=\frac{R^2}{r^2}\frac{dR}{dt}$. (5%)
   (b) Applying the principle of energy conservation, show that the rate of growth of the bubble may be described by
   $R\frac{d^2R}{dt^2}+\frac{3}{2}\left(\frac{dR}{dt}\right)^2+\frac{2\sigma}{\rho R}=\frac{P_g-P_\infty}{\rho}$, where σ is the surface tension at the water-gas interface, ρ is the water density.
   (10%)

3. A doublet combined with a uniform flow can be used to represent inviscid flow around a circular cylinder, for which the velocity potential is $\phi=Ur\left(1+\frac{a^2}{r^2}\right)\cos\theta$. Show that the pressure on the cylinder surface can be expressed as $p_s=p_0+\frac{1}{2}\rho U^2(1-4\sin^2\theta)$, where p_0 is the fluid pressure far from the cylinder. (5%)



4. Consider the boundary layer flow with an assumed velocity profile given as $u=u_0\sin(\pi y/2\delta)$, where the uniform velocity u_0 = constant, δ = the boundary layer thickness, and y is the vertical axis normal to the uniform flow direction.
   (a) Define the displacement thickness (δ^*) and the momentum thickness (θ) for the boundary layer flow. (2%)
   (b) Find δ^* and θ in terms of δ. (6%)

5. The Navier-Stokes equations for the two-dimensional flow field under consideration are

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+v\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right) \text{ and } u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+v\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$

   Assume the boundary layer thickness (δ) is very small compared with the distance x ($\delta/x << 1$), except near the leading edge.
   (a) How does the boundary layer thickness (δ) depend on x? (Hint: Derive the relation purely from dimensional analysis) (3 %)
   (b) When the flow Reynolds number is very large, please re-write the above boundary layer equations. (Hint: Neglecting terms using the order-of-magnitude consideration) (4 %)
   (c) Use the above boundary layer equations to explain briefly the separation point in the boundary layer flow. (Hint: The classical definition of a separation point in the boundary layer flow) (3 %)

注意：背面有試題

6. Simple compressible problems.
   (a) What is the speed of sound a as a function of temperature? What is the Mach number? (2 %)
   (b) The energy equation for isentropic flow is $h + u^2/2 = h_0$, where h is the enthalpy, u is the velocity, and h_0 is the total enthalpy. Please show that:

$$a^2 + \frac{\gamma - 1}{2} u^2 = a_0^2. \quad (5\%)$$

熱傳學 (50%)

7. A truncated cone of 0.2 m high is constructed of aluminum. The diameter at the top is 2 m, and the diameter at the bottom is 2.8 m. The lower surface is maintained at 93℃; the upper surface, at 540℃. The other surface is insulated. Assuming one-dimensional heat flow, what is the rate of heat transfer in watts. The conductivity of aluminum is 204 W/m℃. (15%)

8. A steel ball (ρ = 7800 kg/m^3, c=0.46 kJ/kg℃, k=35 W/m℃) 50 mm in diameter, and initially at a uniform temperature of 450℃ is suddenly placed in a controlled environment in which the temperature is maintained at 100℃. (10%)
   (a) Can the steel ball be considered as a lumped system, why?
   (b) What is the time required for the ball to reach a temperature of 150℃.

9. Plot fluid mean temperature T_m and tube wall temperature T_s vs. distance x from the entrance of a tube for the two cases:
   (a) T_s = constant, (b) q''_s = constant. (10%)

10. What are the values of a, b, c, d, and e of the following relation? (10%)

Laminar	Turbulent
$\delta \sim x^{1/2}$	$\delta \sim x^{a}$
$c_{fx} \sim x^{-1/2}$	$c_{fx} \sim x^{b}$
$h_x \sim x^{c}$	$h_x \sim x^{d}$
$Nu_x \sim x^{e}$	$Nu_x \sim x^{4/5}$

where δ, c_{fx}, and h_x are the boundary layer thickness, local friction coefficient and local heat transfer coefficient respectively.

11. What are the definition of radiative emissivity and absorptivity? (5%)