系所組別：化學工程學系甲組

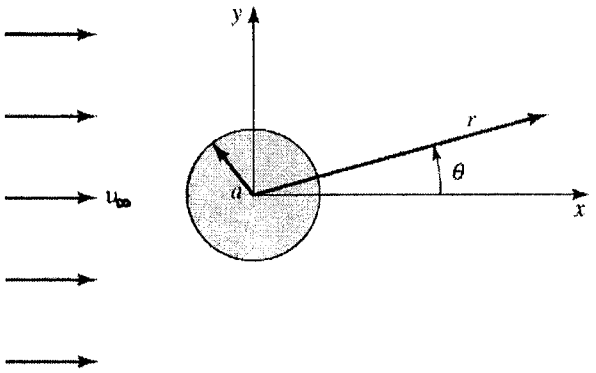
考試科目：單元操作與輸送現象　　考試日期：0222，節次：1

※ 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. Which of the following description(s) is(are) correct? (5%)
   (a) The conservation of momentum is based on the Newton's second law of motion.
   (b) The conservation of energy is based on the second law of thermodynamics.
   (c) If viscous forces exist, the flow has to be rotational.
   (d) Euler's equation is only applicable for inviscid flow but not for irrotational flow.
   (e) In an incompressible flow, the drag coefficient depends upon the Reynolds number and the geometry of a body.

2. Explain the meaning of the equivalent length, L_{eq}. What would influence the equivalent length? (6%)

3. An incompressible, irrotational Newtonian fluid approaches a stationary cylinder of radius a with a uniform, steady velocity, v_∞, as shown below. Assume the flow is laminar and steady. Answer the following questions:



   (a) This problem can be solved by the Laplace's equation of stream function, Ψ. Explain? (4%)

$$\nabla^2\Psi = \frac{\partial^2\Psi}{\partial r^2} + \frac{1}{r}\frac{\partial\Psi}{\partial r} + \frac{1}{r^2}\frac{\partial^2\Psi}{\partial\theta^2} = 0$$

   (b) Write down the boundary conditions. (4%)
   (c) Derive the stream function. The velocity components are given below. (7%)

$$v_r = \frac{1}{r}\frac{\partial\Psi}{\partial\theta}, v_\theta = -\frac{\partial\Psi}{\partial r}$$

   (d) The streamlines and velocity potential lines were plotted as shown below. Please explain why both the streamlines and velocity potential lines are perpendicular to each other. (4%)

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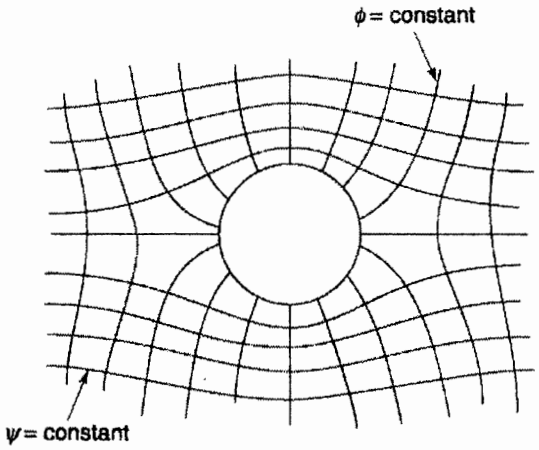
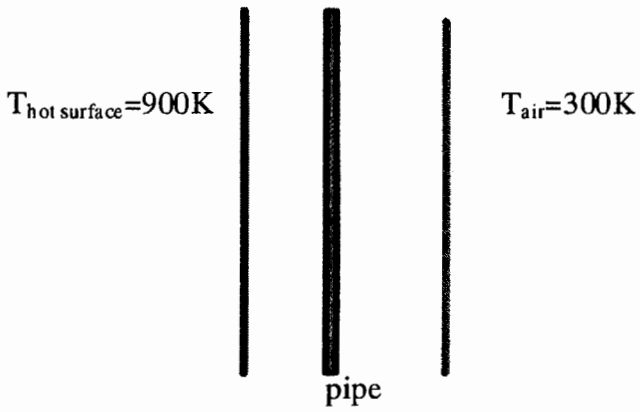


4. A pipe used to transport liquid metal is embedded in a 1.5m-thick wall at a point where the temperature is 700 K as shown in the following. The thermal conductivity of the wall varies with temperature according to the following equation:
   k=0.0008(1+0.005T^2) where T is in K and k is in W/m.K
   If the outside surface is exposed to air at 300 K with a convective heat transfer coefficient is 40 W/m^2.K
   (a) What is the heat flux for the wall? (8%)
   (b) How far from the hot surface should the pipe be located? (7%)



5. In a frigid winter where the temperature is below 0 °C, there is usually a layer of ice formed on top of a pond. Assume that the temperatures at the top surface (exposed to the air) and below the layer of ice are maintained at Ts and T_l (the temperature for change of phase), respectively (Ts < T_l). If the heat capacity of the ice is neglected, find the growth of the ice layer as function of time. (H: latent heat of fusion; k: thermal conductivity of the ice; ρ: density of the ice; t: time) (10%)

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6. A carbon fiber with a length of 1 cm and a diameter of 2 μm is processed in an oxidizing atmosphere at 1000 °C and 1 atm pressure. The oxidizing process is limited by the diffusion of oxygen counterflow to the carbon monoxide that is formed on the fiber surface. Under the condition of the combustion process, the diffusivity of oxygen in the gas mixture is assumed to be 1.0×10^{-5} m^2/s.
   (a) Starting from the conservation of mass, derive the general differential equation (as shown below) for mass transfer of component A in a binary mixture in terms of the cylindrical coordinate. (5%)
   $$\frac{\partial C_A}{\partial t}+\left(\frac{1}{r}\frac{\partial}{\partial r}(rN_{Ar})+\frac{1}{r}\frac{\partial N_{A\theta}}{\partial \theta}+\frac{\partial N_{Az}}{\partial z}\right)=R_A$$
   (b) Use the equation obtained from (a), determine the moles of CO that are produced per time at the distance of 10.0 μm away from the center of the fiber. Assume the oxygen concentration that is 5.0 μm radial distance from the center of the fiber is 30 mol%. (5%)
   (c) Find the log-mean average concentration of CO. (5%)
   (d) What would be the composition of oxygen 3.0 μm from the center of the fiber? (5%)

7. In the operation of a continuous fractionation column, the following unusual states were found around the top plate: (i) accumulation and flooding of the liquid, (ii) gradual decrease in the temperature of the top plate. Please **find out the reason** leading to these phenomena and **take response** to solve it. (8 %)

8. An aqueous solution containing 30 mole percent of ammonia. The ammonia is stripped by counter current contact with air to remove 95% of the ammonia. The equilibrium relationship is $y_e = 0.8\ x_e$
   (a) What is the minimum flow rate of air input (V_{min}) per 100 mole of liquid feed, and what is the ideal plate required? (7 %)
   (b) If the air input (V) is 1.5 times of the liquid input, determine the required number of ideal stage. (10 %)
   (請用所附方格圖作圖，但在答案卷上畫一簡圖，以顯示你的作圖結果)

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