1. (a) Explain the restrictions of the Bernoulli's equation. (5%)

   (b) Draw a picture of Pitot tube and explain the reason of measurement of fluid velocity of usage of Pitot tube. (10%)

   (c) Estimate qualitatively how much time to be consumed to drain the water of a tank shown in Fig. 1 (10%)

   (D and d are diameters, $\rho_{water} = 1000 kg/m^3$)

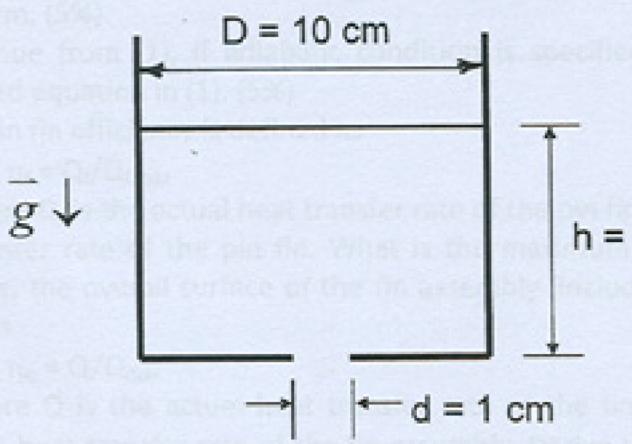


Fig. 1

2. (a) Explain the physical meanings of fully developed flow. (5%)

   (b) Derive a equation to express velocity distribution of a fully developed laminar flow driven by a pump in a circular duct shown in Fig. 2 (10%)

   (c) Calculate the mass flow rate and average velocity. (10%)

   (μ : viscosity, ρ : density)

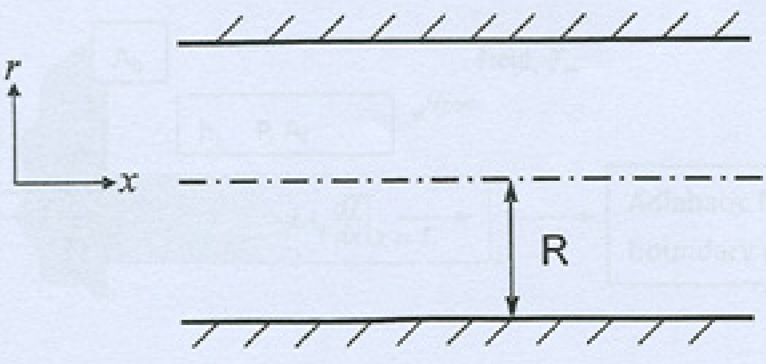


Fig. 2

3. A pin fin with a surface area of A_f and a perimeter of P is attached to the base surface A_b, the cross-sectional area for the pin fin is A_c and the convective heat transfer coefficient of the ambient is given as h (constant). The associated fin temperature along the one-dimensional fin is T_f with the fin temperature at the base being T_b (i.e. $T_f(0) = T_b$). The ambient temperature is T_∞, and the thermal conductivity of the fin and base material is k. The fin length is L.

Questions:

(1) Derive the equation for fin temperature if the cross-sectional fin area, A_c, is uniform. (5%)

(2) Continue from (1), if adiabatic condition is specified at the fin tip, solve the derived equation in (1). (5%)

(3) The pin fin efficiency is defined as

$$\eta_f = Q_f/Q_{f,max}$$

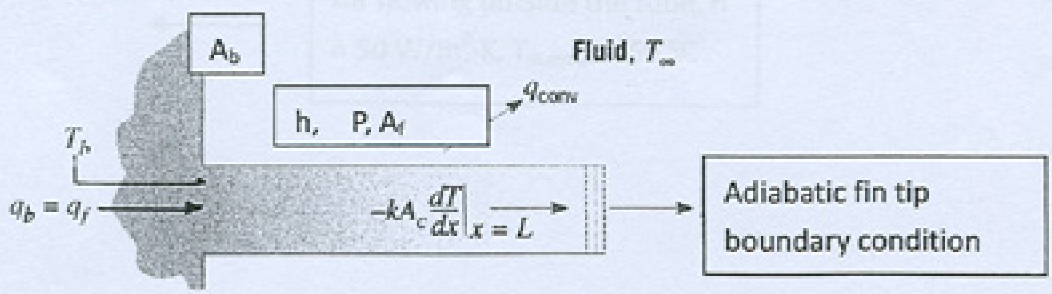
Where Q_f is the actual heat transfer rate of the pin fin and $Q_{f,max}$ is the maximum heat transfer rate of the pin fin. What is the maximum heat transfer rate? In the meantime, the overall surface of the fin assembly (including base area A_b and A_f) is defined as

$$\eta_o = Q/Q_{max}$$

Where Q is the actual heat transfer rate of the fin assembly and Q_{max} is the maximum heat transfer rate of the fin assembly. Derive the relationship between η_f and η_o. (7%)

(4) The original fin material is aluminum. If the convective heat transfer coefficient remains the same, but the fin material is replaced by copper material then what happens to the fin heat transfer rate and fin efficiency. (increase? Decrease? Remain the same?). Please explain. (4%)

(5) Continue from previous question, if the fin is replaced by stainless steel, then what happens to the fin heat transfer rate and fin efficiency? (4%)



國立交通大學 99 學年度碩士班考試入學試題

科目：流體力學(3023)　　考試日期：99 年 3 月 14 日 第 2 節

系所班別：機械工程學系　　組別：機械系乙組　　

【可使用計算機】＊作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符！！

4. An aluminum round tube (inside diameter d_i = 2 cm, outside diameter d_o = 2.4 cm, tube length L = 10 m, thermal conductivity k = 204 W/m·K) with water flowing inside the tube and with air flowing counter-currently outside the tube. The air-side convective heat transfer coefficient is 50 $W/m^2 \cdot K$ and the mean air temperature is 50 °C. The water mass flowrate is 30 liters/min, with mean water temperature of 20°C (viscosity $\mu = 1002 \times 10^{-6}$ $N \cdot s/m^2$, density ρ = 998.2 kg/m^3, thermal conductivity = 0.603 W/m·K, Prandtl number = 6.95). And the heat transfer correlation applicable to the tube side is

$$Nu = 0.023\, Re^{0.8} Pr^{0.4}$$

Questions:

(1) Calculate the convective heat transfer coefficient of the flowing water. (6%)

(2) Calculate the overall heat transfer coefficient U (based on inside surface area). (7%)

(3) Estimate the heat transfer rate from air to water. (6%)

(4) If the tube is replaced by copper, what happens to the water-side convective heat transfer coefficient h_i, air-side heat transfer coefficient h_o, and heat transfer rate Q (Increasing? Decreasing? Remains the same?) (3%)

(5) If the tube is replaced by stainless steel, then what happens to the water-side convective heat transfer coefficient h_i, air-side heat transfer coefficient h_o, and heat transfer rate Q (Increasing? Decreasing? Remains the same?) (3%)