國立雲林科技大學 115 學年度
碩士班招生考試試題

系所：化材系
科目：單元操作與輸送現象

1. During a quality control test, a process fluid flows through a viscometer at 25 °C. The measured kinematic viscosity of the fluid is 0.018 St, and viscosity is 1.89 cP. Calculate the density of the fluid at this temperature in g/cm^3. **(15%)**

2. A Newtonian, incompressible fluid flows steadily through a long circular tube of radius R and length L, which is inclined at an angle β with respect to the vertical direction. The pressures at the inlet and outlet of the tube are P_0 and P_L, respectively. Assuming that the flow is steady, fully developed, and laminar, and that entrance and exit effects are negligible, derive the momentum flux distribution, the velocity distribution, and volumetric flowrate of the fluid. **(20%)**

3. An oil flows steadily through a horizontal, smooth circular tube with an inner diameter of 0.08 m and a length of 12 m. The average velocity of the oil is 0.5 m/s. At the operating temperature, the density of the oil is 900 kg/m^3, and the viscosity is 2.0 cP. The friction factor for the flow may be estimated using the Blasius formula

$$f = \frac{0.0791}{Re^{\frac{1}{4}}}.$$

Calculate the pressure drop in the pipe. **(15%)**

4. A cup of hot coffee is well mixed and remains at a uniform temperature of 80 °C. The hand temperature is assumed to be constant at 33 °C. The effective contact area between the hand and the cup wall is A = 0.010 m^2. The convective heat transfer coefficient on the coffee side is h_i = 500 W·m^{-2}·K^{-1}, and the convective heat transfer coefficient on the hand side is h_o = 200 W·m^{-2}·K^{-1}. The cup wall is thin stainless steel with thickness t = 0.50 mm and thermal conductivity k = 15 W·m^{-1}·K^{-1}.

   (a) Calculate the steady-state heat transfer rate from the coffee to the hand. **(10%)**

   (b) Calculate the outer surface temperature of the cup (the temperature at the hand-cup interface). **(10%)**

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5. A pot contains 1.5 kg of water initially at 25 °C. The ambient temperature is 25 °C. The specific heat capacity of water is c_p = 4180 J·kg^{-1}·K^{-1}. The pot is heated by a stove that provides a constant effective heating power of 1200 W. The thermal mass of the pot is neglected. Heat loss from the water surface is modeled as:

$$\dot{Q}_{loss} = \mathbf{a}\,(T - T_\infty) + \mathbf{b}, \text{ where } \mathbf{a} = 12\ W\cdot K^{-1} \text{ and } \mathbf{b} = 100\ W.$$

Calculate the time required to heat the water from 25 °C to 100 °C. **(15%)**

6. A wet fabric with a surface area of 0.10 m^2 is hung in a room at 25 °C and 1 atm. Air flows parallel to the fabric surface, and the evaporation process is limited by gas-phase mass transfer. The fabric surface is assumed to remain saturated with water vapor at 25 °C, where the saturation vapor pressure of water is 3.17 kPa. The room air has a relative humidity of 40%. The mass transfer coefficient (k_m) for water vapor in air is 0.010 m·s^{-1}. Assume ideal gas behavior for water vapor, with a molecular weight of 0.018 kg·mol^{-1} and a gas constant of 8.314 J·mol^{-1}·K^{-1}.
   (a) Calculate the evaporation rate of water from the fabric surface. **(10%)**
   (b) Determine the total mass of water evaporated in 20 minutes. **(5%)**