(一) 問答題 (40%)

1. 流體是層流 (laminar flow) 時，管徑表面粗造度 (surface roughness) 對壓降 (pressure drop) 的影響 ? 若是湍流 (turbulent flow) 又如何 ? (5%)
2. 導出流體經過直徑 D 的圓形管 (circular pipe) 其雷諾數 (Reynolds number), $Re = 4m/(\pi D \mu)$, m 是質量流速 (mass flow rate), μ 是黏度。 (5%)
3. 伯努力方程式 (Bernoulli equation), $(u^2/2) + g\triangle z + \triangle p/\rho = 0$。此方程式中的單位在國際系統 (SI system) 是什麼 ? (5%)
4. 何謂牛頓流體 (Newtonian fluid) ? (5%)
5. 試說明擬塑性流體 (pseudoplastic fluid), 其剪應力 (shear stress) τ 和剪切速率 (shear strain rate) du/dy 之關係? (5%)
6. 在沸騰機構 (Mechanisms of boiling) 中, 何以在最大熱通量 (maximum heat flux) 出現後, 隨著加熱的溫度差加大, 熱通量不增卻反降, 試說明此原因 ? (5%)
7. 最小回流比 (Minimum reflux ratio) 可以得到蒸餾板數爲何 ? (5%)
8. 如何應用 x-y 圖上求得此最小回流比 (Minimum reflux ratio) 的值? (5%)

(二) 計算題 (60%)

1. Based upon the equivalent length (L/D) of the fitting, estimate the equivalent length (feet) for three standard 90^0 elbows in a 5 inch inside diameter pipe cause a pressure drop. (10%)

Equivalent Lengths of Pipe Fittings

TYPE OF FITTING	L/D
Square 90° elbow	70
Standard 90° elbow	30
45°elbow	15

2. The following equations can be used for problem 2

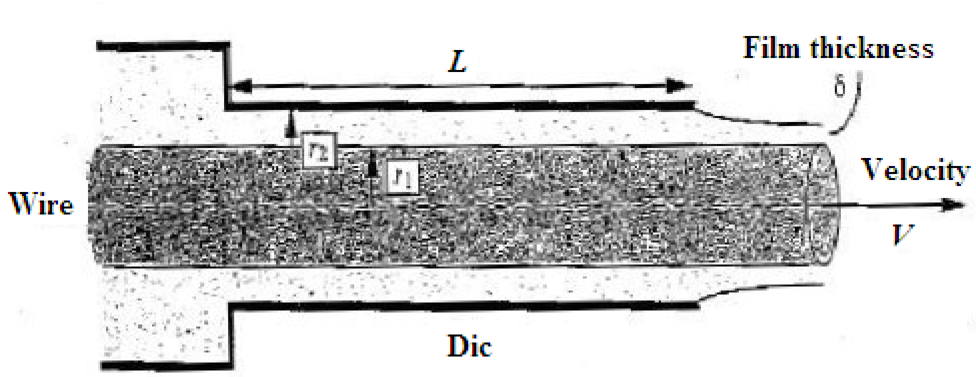
$$\frac{\partial \rho}{\partial t} + \frac{1}{r}\frac{\partial(\rho r v_r)}{\partial r} + \frac{1}{r}\frac{\partial(\rho v_\theta)}{\partial \theta} + \frac{\partial(\rho v_z)}{\partial z} = 0$$

$$\rho(\frac{\partial v_z}{\partial t} + v_r\frac{\partial v_z}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta} + v_z\frac{\partial v_z}{\partial z}) = -\frac{\partial p}{\partial z} + \mu[\frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial v_z}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2} + \frac{\partial^2 v_z}{\partial z^2}] + \rho g_z$$

A rodlike wire of radius r1 that is being pulled steadily with velocity V in the z direction through a horizontal die of length L and internal radius r2. The wire and the die are coaxial, and the space between them is filled with a liquid of viscosity μ. The pressure at both ends of the die is atmospheric. The wire is coated with the liquid as it leaves the die, and the thickness of the coating eventually settles down to a uniform value, δ.

(a) List assumptions and simplify the above continuity and Navier-Stokes equations (5%)

(b) Do not solve the equation, only list two boundary conditions for solving the simplified equation. (5%)



3. An electric wire having a diameter of 1.5mm and covered with a plastic insulation (thickness = 2 . 5 mm) is exposed to air at 300K and $h_o = 20 \frac{W}{m^2 \cdot K}$. The insulation has a $k = 0.4 \frac{W}{m \cdot K}$. It is assumed that the wire surface temperature is constant at 400 K and is not affected by the covering. (a) Calculate the value of the critical radius. (10%) (b) Calculate the heat loss rate per unit length with no insulation. (5%) (c) Repeat (b) for insulation being present. (5%)

4. A spherical ball of solid, nonporous naphthalene, a "moth ball", is suspended in still air. The naphthalene ball slowly sublimes, releasing the naphthalene into the surrounding air by molecular diffusion-limited process. Estimate the time required to reduce the diameter from 2 to 0.5 cm when the surrounding air is at 347K and 1.013×10^{5} Pa. Naphthalene has a specific gravity of 1.145, a diffusivity in air of 8.19×10^{-6} m^2/sec, a molecular weight of 128 g/mole, and exerts a vapor pressure of 666 Pa at 347K.　(20%)