1. 何謂 dimensional analysis **(4%)**，其用處何在？**(3%)**

2. First law of thermodynamics 之公式可表示如下：

$$\frac{\delta Q}{dt} - \frac{\delta W_s}{dt} = \iint_{c.s.} \left(e + \frac{P}{\rho}\right)\rho(\mathbf{v}\cdot\mathbf{n})dA + \frac{\partial}{\partial t}\iiint_{c.v.} e\rho dV + \frac{\delta W_\mu}{dt}$$

其中, *c.s.*: control surface, 即所討論之表面積　*c.v.*: control volume, 即所討論之體積

$\mathbf{v}\cdot\mathbf{n}$: for efflux or influx of mass across the control surface

$P$: thermodynamic pressure

$e$: specific total energy (maybe expanded to include the kinetic, potential, and internal energy)

$\frac{\delta Q}{dt}$: the rate of heat addition to the control volume, $\frac{\delta W_s}{dt}$: the shaft work

$\frac{\delta W_\mu}{dt}$: the work rate to overcome viscous effects at the control surface.

請由上式推導出 Bernoulli equation. **(6%)** 並列出 Bernoulli equation 之 limitations **(4%)**

**[Note]** 在推導過程中**務必**列出所有可忽略或可簡化的項目

3. What is inviscid flow **(2%)**? What will the Navier-Stokes equation be if the flow is inviscid **(2%)**　**[Hint]** Navier-Stoke equation 之一般式可表示如下

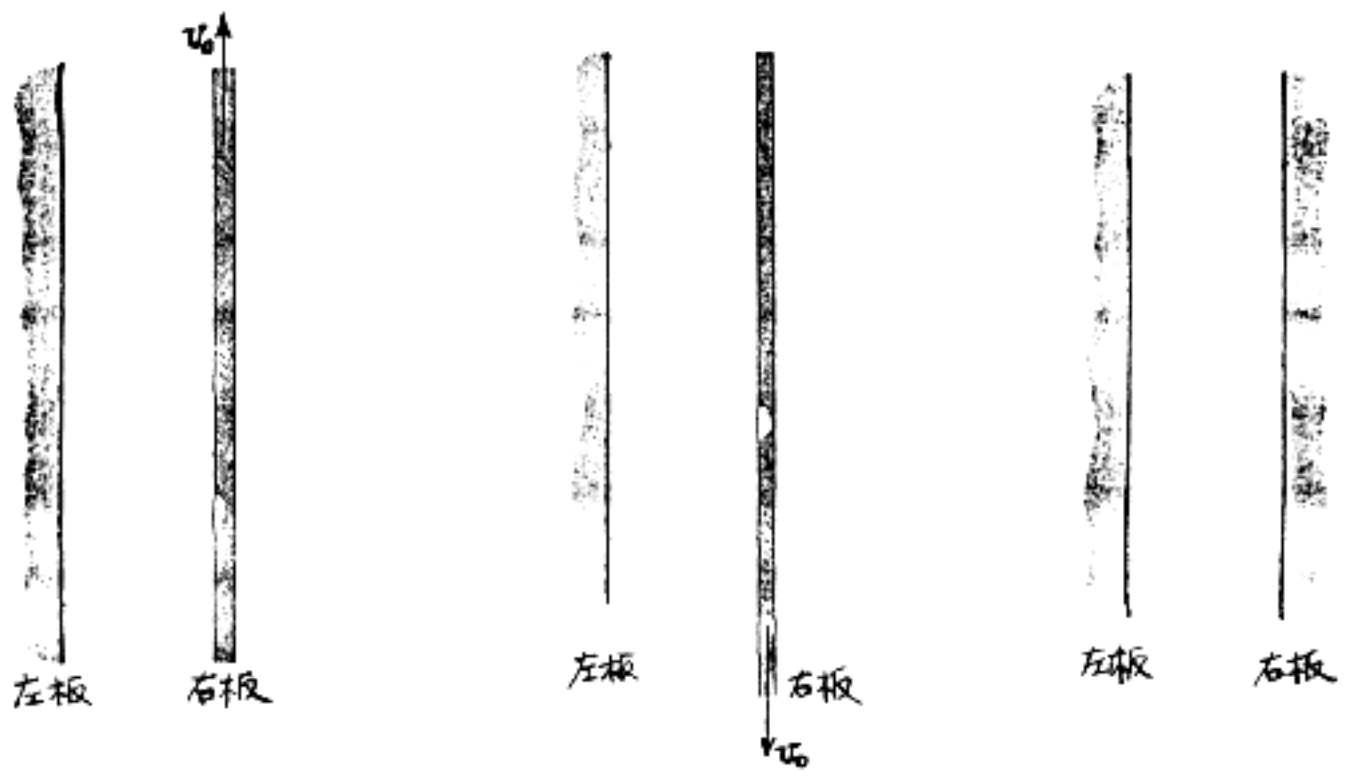
$$\rho\frac{D\mathbf{v}}{Dt} = \rho\mathbf{g} - \nabla P + \mu\nabla^2\mathbf{v}$$

4. 流體在兩塊直立平板間流動(當然是向下流動)，其中一板(圖中之左板)固定不動，而右板分別以某一速度(a)向上移動，(b)向下移動，以及(c)固定不動(分別如下圖所示)，分別畫出在此三種狀況下其間流體各別之 velocity profile. (12%)

**[Note]** 直接畫圖，不需求解，簡圖即可。

**[Assumptions]** Incompressible flow, newtonian and laminar flow

(a) 左板不動，右板向上移動　(b) 左板不動，右板向下移動　(c) 左右兩板皆不動




(背面仍有題目,請繼續作答)

5. What is the physical significance of the following terms?
   (a) The heat exchanger effectiveness in the Number-of-Transfer-Units (NTU) method of heat-exchanger analysis and design. (3 %)
   (b) The view factor in the radiant heat transfer between black bodies. (3 %)

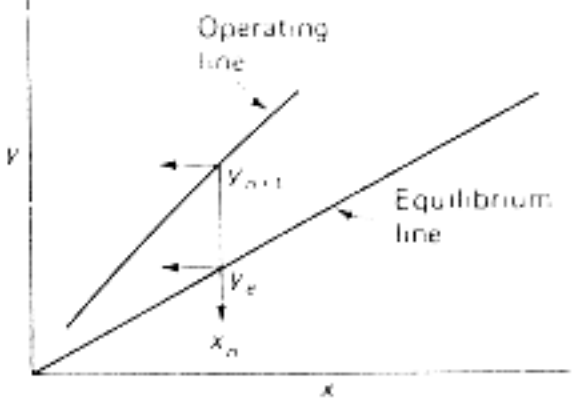
6. A heated sphere of radius R is suspended in a large, motionless body of fluid. It is desired to study the heat conduction in the fluid surrounding the sphere. It is assumed in this problem that free convection effects can be neglected.
   (a) Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. The thermal conductivity of the fluid k is constant. (4 %)
   (b) Integrate the differential equation and use the following boundary conditions to determine the constants of integration. (4 %)

   B. C. 1: $T = T_R$ at $r = R$

   B. C. 2: $T = T_\infty$ at $r = \infty$

7. Water at a temperature of $T_0$ enters a heat-exchanger tube having an inside diameter of D and a length of L. The water flows at a velocity of v. Entrance effects are to be neglected. The convective heat-transfer coefficient, h, and the properties of water, such as density, $\rho$, and constant-pressure heat capacity, $c_p$, may be considered to be constant. For a constant wall temperature of $T_s$, please derive an expression for the exit temperature of the water, $T_L$. (8 %)

8. 在右圖中，x是某可溶性成份在液相中的濃度，y是其在氣相中的濃度，n是由塔頂起算的板數.




   a. 由圖中兩條線的相對位置看來，這是個 gas absorption 還是 desorption 的塔？ (4%)

   b. 為什麼？ (6%)

9. a. 請用方程式寫出 Fick's second law of diffusion，並註明式中每一個符號的定義 (4% )
   b. 說明在何種情況下此一方程式才可適用 (4% )

10. 在處理 absorption into falling liquid film 的問題時常利用 R. Higbie 所提出的 penetration theory 來將問題簡化. 請寫出此 theory 的要點, 以及在何種情況下才可適用. (8%)

11. 各種分離方法都是要利用被分離的成份間性質的差異性, 請寫出以下分離方法各是利用什麼性質的差異:
a. 蒸餾 (distillation) b. 液相萃取 (liquid extration)
c. 氣体吸收 (gas absorption) d. 乾燥 (drying)
e. 篩分 (screening) (10%)

12. 為什麼蒸餾 (distillation) 是一種很耗能的分離方法? (3%)
有什麼節約蒸餾時所耗能量的辦法? (3%)
在許多化工製程中, 可以採用蒸餾也可以採用液相萃取時, 為什麼還是多選用蒸餾? (3%)