1. 由 first law of thermodynamics (公式如下)要推導出 Bernoulli equation 時之 assumptions 有哪些? (6%)

   [Note] 只需列出所須之 assumptions,不需推導

   First law of thermodynamics 的公式如下:

$$\iint_{c.s.} \sigma_{ii}(\mathbf{v}\cdot\mathbf{n})dA - \frac{\delta W_\tau}{dt} = -\iint_{c.s.} P(\mathbf{v}\cdot\mathbf{n})dA - \frac{\delta W_\mu}{dt}$$

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

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

   σ_{ii}: normal stress P: thermodynamic pressure

   $\frac{\delta W_\tau}{dt}$: the required work rate to overcome shearing stress

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

2. 冬天已過,春天到來,天氣漸趨暖和,則在你周遭的 viscosity 將會如何變化呢?這個變化主要的原因是什麼? (5%)

3. Newtonian fluids 與 non-newtonian fluids 是如何區分? (4%)

4. Navier-Stokes equations 描述的其實是 Newton's second law of motion, 公式如下:

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

   請問以上公式隱藏的 assumptions 是什麼? (4%)

5. In Blasius' solution for laminar flow over a flat plat, the pressure gradient was zero. However, a much more common flow situation involves flow with a pressure gradient. Now, consider a laminar flow over a flat plat with a pressure gradient. (14%)

   The equation for flow over a flat plat is

$$\rho\left(\frac{\partial v_x}{\partial t} + v_x\frac{\partial v_x}{\partial x} + v_y\frac{\partial v_x}{\partial y}\right) = -\frac{dP}{dx} + \mu\frac{\partial^2 v_x}{\partial y^2}$$

   From Bernoulli's equation, $\frac{dP}{dx}$ can be expressed as follows,

$$\frac{dP}{dx} = -\rho v_\infty\frac{dv_\infty}{dx}$$

   If the velocity outside of the boundary layer is denoted by $v_{x\delta}$ (i.e., $v_x(\delta) = v_{x\delta}$), please obtain the velocity profile of the form

$$\frac{v_x}{v_{x\delta}} = c_1 + c_2 y + c_3 y^2 + c_4 y^3$$

   i.e., to solve for c_1, c_2, c_3, and c_4.

   [Hint] 須化簡第一條公式,並列出所有 boundary conditions,即可將參數一一求出。

6. Consider a hollow spherical heat-transfer medium having inside and outside radii of r_i and r_o with the corresponding surface temperatures T_i and T_o. If the thermal-conductivity variation may be described as a linear function of temperature according to

$$k = k_o(1 + \beta T)$$

   calculate the steady-state heat-transfer rate in the radial direction, using the above relation for the thermal conductivity. (8 %)

(背面仍有題目,請繼續作答)

7. One normally considers a flux to be proportional to the driving force, thus the heat flux might be expected to increase continuously as the temperature difference between the heated surface and the saturated liquid increases. This, of course, in not the case; the very high heat fluxes associated with moderate temperature differences in the nucleate boiling region are much higher than the heat fluxes resulting from much higher temperature differences in the film boiling region. Please explain why it happens. (4 %)

8. A reaction mixture having a mean heat capacity c_{pm} = 2.1 kJ/kg·K is flowing at a rate of 7500 kg/h and is to be cooled from 380 K to 340 K in a heat exchanger. Cooling water (c_{pm} = 4.2 kJ/kg·K) at 290 K is available and the flow rate is 5000 kg/h. The overall heat transfer coefficient U_o is 600 W/m^2·K. For counterflow, calculate the outlet water temperature and the area A_o of the exchanger. (10 %)

9. 在蒸餾塔的設計中，有所謂 operating line 與 equilibrium line，請說明：
   a, equilibrium line 所代表的物理意義為何？
   b, 在何種情況下可視 equilibrium line 為直線？
   c, operating line 所代表的物理意義為何？
   d, 在何種情況下可視 operating line 為直線？ (12%)

10. 在探討流體中某一成份 (A) 的濃度變化時，有三種 time derivatives：partial time derivative, $\frac{\partial C_A}{\partial t}$，total time derivative, $\frac{dC_A}{dt}$，和 substantial time derivative, $\frac{DC_A}{Dt}$，請分別說明其物理意義. (6%)

11. 請說明 supercritical fluid extraction 的要點，有什麼優點，有什麼缺點. (7%)

12. 請說明 reverse osmosis 的原理，並舉一應用實例. (6%)

13. 過濾的設備可分為 cake filter，clarifying filter，及 crossflow filter 三類. 請分別說明其過濾的機制 (mechanism). (9%)

14. 請說明何謂 diffusion controlled chemical reaction. (5%)