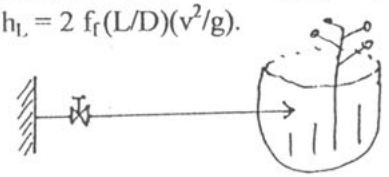
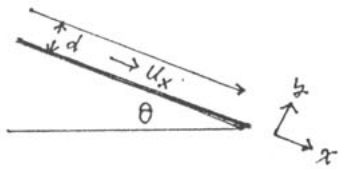
1. 何謂 Pump 的 NPSH？[5%] 在安裝 Pump 時，必需考慮那些事項？[4%]
2. Every summer I carefully grow a giant tomato plant because I love the taste of its fresh-picked fruit. Since these plants need 2 liters of water each day of the growing season to produce these delectable and irresistible fruit, how do I grow my plant next summer when I will be away for four weeks with no way to water it? One solution would be to connect a long plastic tube 0.4 mm ID to the faucet at my home where the water pressure is 100 kPa above atmosphere and lead it to the plant. Determine how long the tube would have to be to deliver 2 liters/day of water. Of course, everything is on the level. [12%] Hint: for turbulent flow, $f_f^{-0.5} = 4 \log_{10}\{\mathrm{Re}\, f_f^{0.5}\} - 0.4$; for laminar flow, $f_f = 16/\mathrm{Re}$; $h_L = 2 f_f (L/D)(v^2/g)$.



3. 如圖所示，一很薄的流體在一傾斜板上流動，若考慮此流動爲二維不可壓縮、完全展開的穩態流，請導出速度 u_x 分佈和在壁上的 shear stress。[12%]



$$\left\{ \rho \frac{D\tilde{u}}{Dt} = \rho \tilde{g} - \nabla p + \mu \nabla^2 \tilde{u} \right\}$$

4. 半徑爲 R、長度爲 L_1 之實心硫粒置於空氣中進行燃燒。若燃燒僅在表面進行，且反應方程式爲 $S_{(S)} + O_{2\,(g)} \rightarrow SO_{2\,(g)}$，又各種氣體可視爲以擴散方式經過厚度爲 L_2 之氣膜傳送至大氣。假設：(1)穩定狀態；(2)Fick's 定律可適用，故 $D_{O\text{-}m}$、$D_{N\text{-}m}$、$D_{S\text{-}m}$ 分別代表 O_2、N_2、SO_2 在空氣中之擴散係數（爲常數）；(3)$L_1 >> R$，故氣體濃度視爲僅隨圓柱坐標半徑方向而變；(4)大氣中 O_2、N_2、SO_2 之濃度（莫耳分率）分別爲 0.21、0.79 及零；(5)硫粒表面單位時間、單位面積氧氣因化學反應而消耗之速率方程式爲 $kc_g y_{O2}$，其中 k、c_g、y_{O2} 分別爲反應速率常數、氣體莫耳密度（爲常數）及 O_2 莫耳分率；(6)系統爲恆溫狀態，試
   (1) 導衍 O_2、N_2、SO_2 濃度隨座標變化之守恆式，並寫出邊界條件。[6%]
   (2) 求解 O_2 單位時間之莫耳流率。[6%]
   (3) 解出 SO_2 之濃度分佈 y_{SO2}。[6%]
   (4) 若空氣中有風吹動，簡答其對 O_2 單位時間莫耳流率之影響。[3%]

(背面仍有題目,請繼續作答)

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5. 簡答以下各題：
   (1)設計填充床式液体氣提塔(stripping tower)時，提高氣體入口流量對氾濫速度(flooding velocity)、塔截面積、單位塔高度壓降、塔高之影響如何？[8%]
   (2)設計板式精餾塔時，提高進料溫度對總板數、塔頂冷凝器與塔底再沸器熱負荷之影響如何？[9%]
   (3)以水萃取煤油中所含低濃渡醋酸，則本系統之質量傳送可能爲水相或煤油相質傳控制？改用弱鹼水溶液進行萃取可以大幅度提高萃取效率嗎？[6%]

6. Derive an appropriate expression of the "mean" area, $\bar{A}$, for radial heat flow by steady-state heat conduction through a long, hollow cylinder which satisfies an equation of the form

$$q = k\bar{A}\,(T_i - T_o) / (r_o - r_i)$$

with the boundary conditions: temperature $T = T_o$ at the outside radius r_o, and $T = T_i$ at the inside radius r_i. Repeat the problem for the hollow sphere case. (8%)

7. (a) What is the physical significance of the Biot number? Is the Biot number more likely to be larger for highly conducting solids or poorly conducting ones? Why? (3%)
   (b) What is the physical significance of the Nusselt number? Consider the forced-convection heat transfer for laminar flow past a horizontal flat plate. Is the Nusselt number more likely to be higher at the leading edge or at the tail of the plate? Why? (4%)

8. What is a gray body? Two parallel opaque, diffuse, and gray surfaces are maintained at uniform temperatures T_1 and T_2 and have emissivities ε_1 and ε_2, respectively. Each surface is sufficiently large that they may be considered infinite. Generate an expression for the net rate of radiation heat transfer between the two surfaces per unit surface area. (8%)