一、試求下列常微分方程式之全解。(25%)

$$y'' - 3y' + 2y = xe^{2x} + \sin x$$

二、試求下列偏微分方程式之解。(25%)

$$\frac{\partial^2 u}{\partial x^2} = xe^y$$

$$u(0, y) = y^2$$

$$u(1, y) = \sin y$$

三、(a) 求 $f(t) = t^2 + at + b$ 之 Laplace Transform (10%)

(b) 求 $\tan^{-1}\frac{1}{s}$ (for $s \geq 0$) 之 Inverse Laplace Transform (10%)

四、求於平面上，通過點 (1,1) 與 $x = y$ 直線交成直角，並滿足 $y''x + 2y' = 0$ 之曲線方程式為何。(15%)

五、下列各函數在所示區間內為線性相依或線性獨立？並說明原因。

(a) e^{2x} ; e^{-2x} ($-\infty < x < \infty$) (5%)

(b) $x+1$; $x-1$ ($0 < x < 1$) (5%)

(c) $\ln x$; $\ln x^2$ ($x > 0$) (5%)

1. Define the following terms:　(10%)
   (1) total dissolved solids
   (2) total Kjeldahl nitrogen (TKN)
   (3) chemical oxygen demand (COD)
   (4) Winkler test for dissolved oxygen
   (5) eutrophication
   (6) MPN for E-coli measurement
   (7) brake horsepower (BHP)
   (8) sludge volume index (SVI)
   (9) nonpoint source water pollution
   (10) denitrification

2. Due to the presence of organics, a water treatment plant receives water with
   excessive color (much higher than 100 CU). The water is taken through the
   following processes:
   A. prechlorination
   B. flash mixing
   C. flocculation
   D. sedimentation
   E. filtration
   F. storage
   G. chlorination
   H. distribution

   (1) Briefly explain the purpose of each of the first seven steps.　(7%)
   (2) How are trihalomethanes (THMs) introduced into water supplies?　(2%)
   (3) How are THMs reduced?　(2%)
   (4) What are the problems inherent with THM treatments?　(2%)
   (5) What problems might the plant have in meeting the EPA requirements for
       chlorinated organics?　(2%)

3. The following three questions are related to wastewater treatment processes.
   (1) What is the objective of wastewater treatment?　(3%)
   (2) Describe the objectives and typical components of pretreatment, primary
       treatment, secondary treatment, and tertiary treatment.　(6%)
   (3) Describe the suitable pretreatment techniques for the following industrial
       wastes: (A) heavy metals (B) emulsified oil (C) hydrogen sulfide.　(6%)

4. Describe the general processes for sludge treatment and disposal. What are the sources of sludge? (10%)

5. Give five separation methods commonly employed by material recovery facilities of municipal solid waste (MSW). (10%)

6. What are the important characteristics for developing engineered solution to MSW management? Why? (12%)

7. Describe the final disposal methods practiced for wastes in Taiwan. Give a sample waste for each method. (10%)

8. Define and/or describe the following terms: (10%)
   (1) high-volume sample
   (2) opacity
   (3) photochemical smog
   (4) thermal fixation of atmospheric nitrogen
   (5) $L_{10} = 70$ dB(A)

9. Give four options or techniques for reducing emissions of sulfide oxides. (8%)

1. A hydroelectric power plant takes in 30 m³/s of water through its turbine and discharges it at $V_2 = 2$ m/s at atmospheric pressure. The head loss in the turbine and penstock system is $h_f = 20$ m. Estimate the power extracted by the turbine in megawatts. (15%)
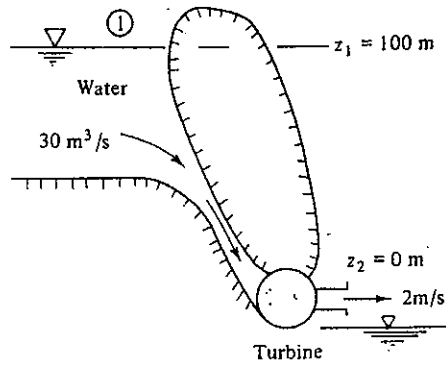

2. Explain: (a) Nonnewtonian Fluids (3%)

(b) Surface Tension (3%)

(c) Surtherland Law (4%)

3. Flow through a converging nozzle can be approximated by a one-dimentional velocity distribution $u = u(x)$. For the nozzle shown, assume that the velocity varies linearly from $u = V_o$ at the entrance to $u = 3 V_o$ at the exit

$$u(x) = V_o \left(1 + \frac{2x}{L}\right) \qquad \frac{\partial u}{\partial x} = \frac{2V_o}{L}$$

(a) Compute the acceleration du/dt as a general function of x. (10%)

(b) Evaluate du/dt at the entrance and exit if $V_o = 3$ m/s and $L = 1$ m. (10%)
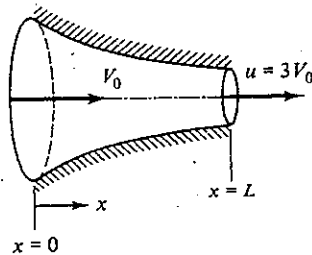
4.　An incompressible fluid passes an impermeable plate with a uniform inlet flow and a parabolic exit flow, as shown in the figure. The parabola has a maximum $(u = U_0)$ at $y = \delta$. Compute the volume flow Q across the top surface of the control volume. (20%)

U_0　$y = \delta$　Q?　U_0

$y = 0$　CV　Parabola

Solid plate, width b into paper
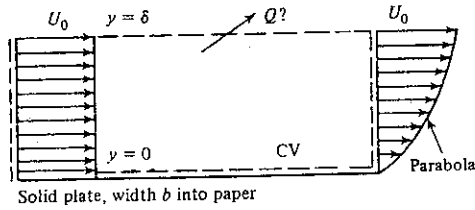
5.　A weir is an obstruction in a channel flow which can be calibrated to measure flow rate, as shown in the figure. The volume flow Q varies with gravity g, weir width b into the paper, and upstream water height H above the weir crest. If it is known that Q is proportional to b, use the pi theorem to find a unique dimensionless relationship $Q(g, b, H)$. (15%).

H

Q

Weir
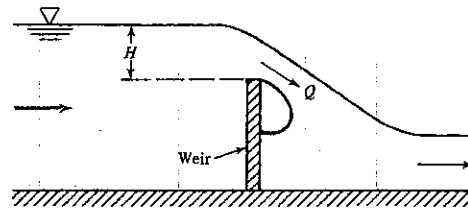
6. For laminar flow in a pipe, the head loss h_f is given by $\quad h_f = \dfrac{128 \mu L Q}{\pi \rho g d^4}$

where　h_f　=　head loss, [m]

　　　　ρ　=　fluid density, kg/m^3.

　　　　μ　=　fluid viscosity, [kg/m-s]

　　　　L　=　pipe length, [m]

　　　　d　=　pipe diameter, [m]

　　　　g　=　gravity = 9.8 m/s^2.

　　　　Q　=　volume flow rate, m^3/s.

Given an oil with　$\rho = 800$ kg/m^3 and $\nu = 0.0002$ m^2/s flows upward through an inclined pipe as shown in the figure. The pressure and elevation are known at sections 1 and 2, 10 m apart. Assuming steady laminar flow, (a) verify that the flow is up, (b) compute h_f　between 1 and 2, and compute　Q. (20%)

(c)

$d = 6$ cm
$p_2 = 250{,}000$ Pa
10 m
Q, V
40°
$p_1 = 350{,}000$ Pa, $z_1 = 0$
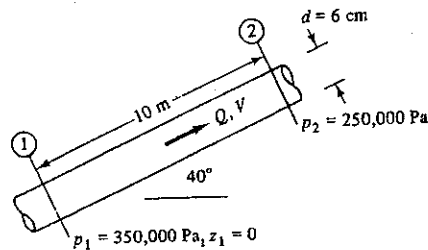
一、解釋名詞：（15%）

1. 酸度（Acidity）
2. 鹼度（Alkalinity）
3. 那斯特方程式（Nernst equation）
4. 化學需氧量（Chemical Oxygen Demand）
5. 硝化（Nitrification）

二、以氯氣處理受有机物污染之原水，其處理過程中極易形成三鹵甲烷，試述三鹵甲烷形成之反應方程式。（10%）

三、試描述玻璃電極之構造及其量測 pH 之原理。（10%）

四、以 $NaHSO_3$ 可將六價鉻（Cr^{6+}）還原為三價鉻（Cr^{3+}），三價鉻可加鹼形成 $Cr(OH)_3$ 後沉澱去除。試述：

(1). 上述還原及沉除反應之方程式。（5%）

(2). 應以何種方式控制避免 $NaHSO_3$ 添加過量？（5%）

五、二氧化硫（SO_2）溶於水中可形成 $SO_2 \cdot H_2O$、HSO_3^-、SO_4^{2-}，其溶解方程式如下：（10%）

$$SO_2 + H_2O \longrightarrow SO_2 \cdot H_2O \qquad K_H = 1.242 \text{ M/atm}$$

$$SO_2 \cdot H_2O \longrightarrow HSO_3^- + H^+ \qquad K_1 = 1.32 \times 10^{-2} \text{ M}$$

$$HSO_3^- \longrightarrow SO_3^{2-} + H^+ \qquad K_2 = 6.42 \times 10^{-8} \text{ M}$$
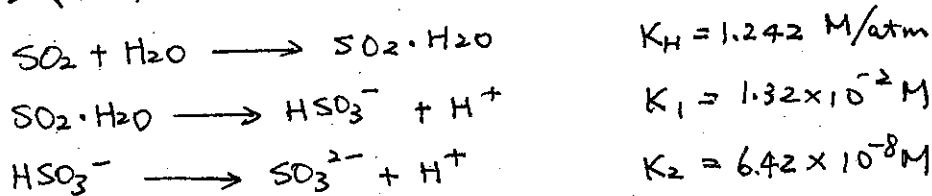
(1). 試求在 pH=4.0 時，$[SO_2 \cdot H_2O]$、$[HSO_3^-]$、$[SO_4^{2-}]$ 為多少 M？

(2). 試繪 pC/pH 圖。

六、某實驗擬以磷酸（phosphate）為緩衝溶液，控制 pH 值為 2.0 ± 0.3，請估算 H_3PO_4 及 NaH_2PO_4 之添加量為多少 M？已知 H_3PO_4 之 pka = 2.1，溶液中強酸濃度為 10^{-2} M，溶液溫度為 25℃，且可忽略活性校正（activity corrections）。（10%）

七、某工廠廢水中含有 10^{-6} M 之鉛及 10^{-5} M 之鋅，擬採添加 NTA^{3-} 方式加以處理。當 NTA^{3-} 之添加量為 10^{-4} M 時，請計算放流水中 Zn^{2+} 及 Pb^{2+} 之濃度為多少 M？ 錯合反應方程式如下：（10%）

$$Pb^{2+} + NTA^{3-} \rightleftharpoons PbNTA^- \qquad P\beta_{Pb} = -11.8$$

$$Zn^{2+} + NTA^{3-} \rightleftharpoons ZnNTA^- \qquad P\beta_{Zn} = -10.4$$
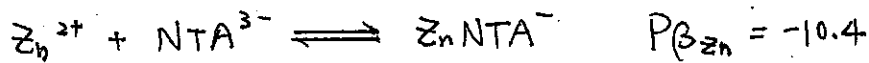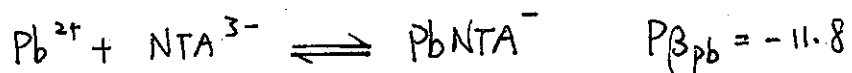
八、氮氧化物（NO_x）在大氣環境中受強烈陽光之照射而產生光化學反應（photochemical reactions），其反應式如下：（15%）

$$NO_2 + h\nu \xrightarrow{k_1} NO + O^{\cdot}$$

$$O^{\cdot} + O_2 \xrightarrow{k_2} O_3$$

$$O_3 + NO \xrightarrow{k_3} NO_2 + O_2$$
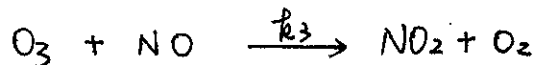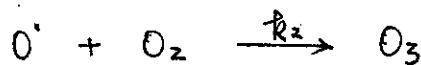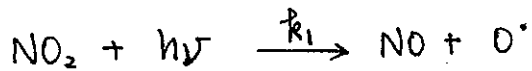
(1) 請證明 $[O_3]$ 與 $[NO_2]/[NO]$ 成正比例關係。

(2) 試繪圖說明 $[NO]$、$[NO_2]$、$[O_3]$ 在大氣中逐時變化趨勢。

九、試就土壤 pH 值大矯正，回答下列問題：（10%）

(1) 土壤 pH 值之重要性及其表示方式。

(2) 土壤 pH 值矯正方式。