1. 回答下列各問題：

   a. (5 %) 你也許聽說過一個荷蘭兒童用手指塞住堤埧上的小孔從
      而挽救了整個城市免受海水淹沒的故事。為什麼一個兒童用一
      隻手指就能擋住北海洶湧澎湃的海水？

   b. (5 %) 打開水龍頭，注意觀察均勻流出的水流，可以看到越是
   往下水流越細。這是為什麼？

   c. (5 %) 飛機比空氣要重得多，為什麼它能在空中飛翔？

2. (20 %) A particle of 1 mm diameter and density $\rho_p = 1.1 \times 10^3 \text{kg m}^{-3}$ is

   falling freely from rest in an oil of density $\rho_o = 0.9 \text{kg m}^{-3}$ and viscosity

   $\mu = 0.03 \text{N s m}^{-2}$. Assuming that Stokes' law applies, how long will the

   particle take to 99 per cent of its terminal velocity? What is the
   Reynolds number corresponding to this velocity? Given that: the drag

   for flow past a sphere is $D = 3\pi\mu dv$, the volume of a sphere is

   $V = \pi d^3/6$, and the terminal velocity is $v_t = d^2(\rho_p - \rho_o)g/18\mu$, in which

   d is the diameter of a spherical particle, v is the velocity of particle
   and g is the gravitational constant.

3. (15 %) A sluice gate (水閘門) is in the form of a circular arc of radius

   6 m. Calculate the magnitude and direction of the resultant force on
   the gate, and the location with respect to O of a point on its line of

   action. (Note: the density of water is 1000 kg m^{-3}).
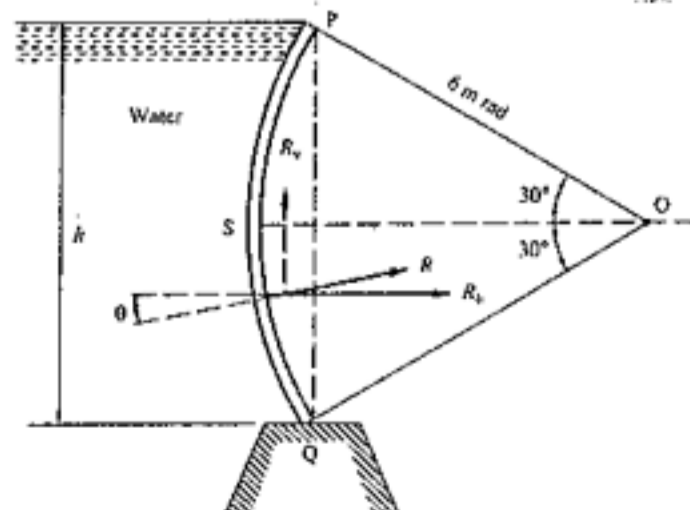
4. (20 %) A fire engine pump develops a head of 50 m, i.e. it increases the energy per unit weight of the water passing through it by 50 NmN^{-1}.

The pump draws water from a sump (水槽) at A through a 150 mm diameter pipe in which there is a loss of energy per unit weight due to friction $h_1 = 5u_1^2/2g$ varying with the mean velocity u_1 in the pipe, and discharges it through a 75 mm nozzle at C, 30 m above the pump, at the end of a 100 mm diameter delivery pipe in which there is a loss of energy per unit weight $h_2 = 12u_2^2/2g$. Calculate (a) the velocity of the jet issuing from the nozzle at C and (b) the pressure in the suction pipe at the inlet to the pump at B.
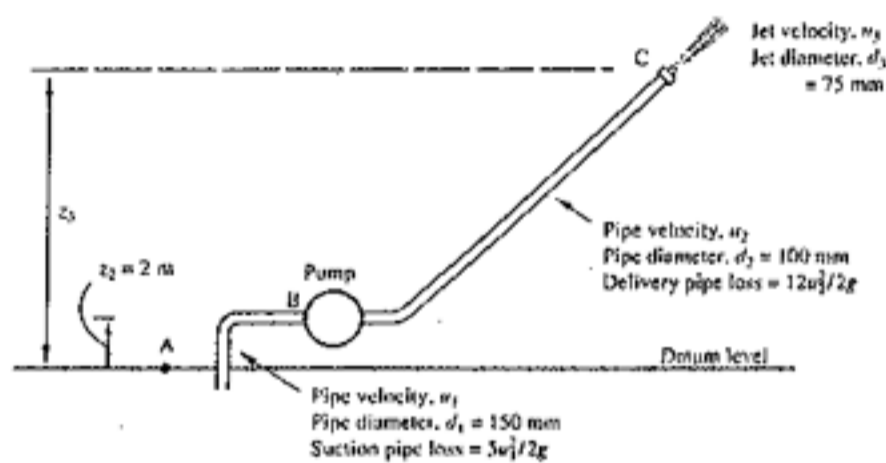
5 .Consider a 0.6m*0.6m thin square plate in a room at 30℃ (Both the room Air and background temperatures are 30℃), one side of the plate is maintained at a temperature of 74℃, while the other side is insulated. Determine the rate of heat transfer from the plate if the plate is
(a)vertical
(b)horizontal with hot surface facing up
(c)horizontal with hot surface facing down
which of the above quantities is the highest? the lowest? why?
[15%]

The average properties of air at the interesting temperature range are
$$K = 0.0279 w/m\text{-}°C, \qquad P_r = 0.705$$
$$v = 0.815 \times 10^{-5} m^2/s, \qquad \beta = 0.00308 k^{-1}$$

※Use your best engineering judgement to answer this problem, even if you don't remember any empirical formula.

6 .Water is to be heated from 15℃ to 65℃ as it flows through a 3-cm-internal diameter 5-m-long tube. The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the heater is well insulated, so that in steady operation all the heat generated in the heater is transferred to the water in the tube. If the hot water flow rate is 10 l/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the pipe at the exit.[15%]

the average properties of water are
$$\rho = 992 kg/m^3, \qquad C_p = 4179 J/kg\text{-}°C$$
$$K = 0.631 w/m\text{-}°C, \qquad P_r = 4.32$$
$$v = \mu/\rho = 0.658 \times 10^{-6} m^2/s$$

※Don't give up to estimate the results even if you forget the empirical formula.