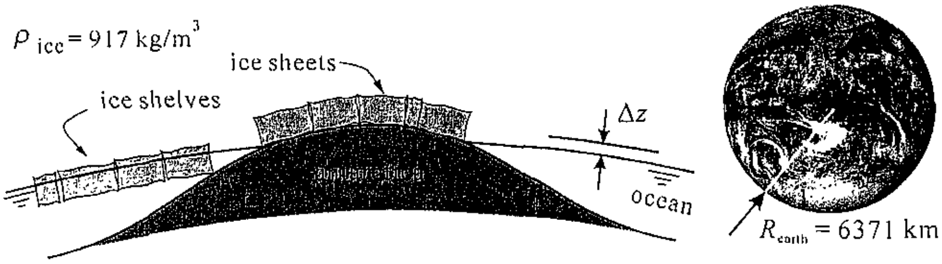

Figure 1. Sea level rise due to the melting of ice under the influence of global warming.

Problem 1. As illustrated on Fig. 1, ice on earth today is contained in ice shelves (3.0×10^{19} kg) and ice sheets (1.5×10^{19} kg). If ice melts into water because of global warming, we want to estimate the resulting sea level rise.

a) If all ice shelves melt, what will be the change in sea level Δz ?

b) If all ice sheets melt, what will be the change in sea level Δz ?

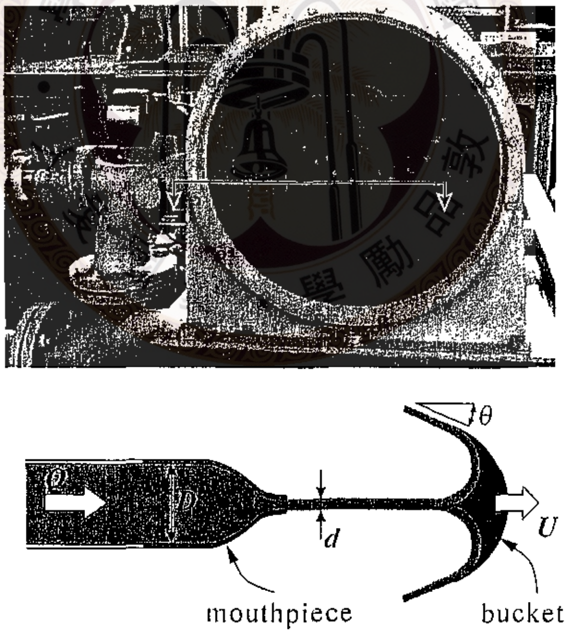

Figure 2. Pelton turbine (photo: fhAugsburg) and a schematic cross-section.

Problem 2. Consider a simplified Pelton turbine where water flows through a static mouthpiece and impacts a single bucket moving at speed U. The water discharge is $Q = 1$ ℓ/s, the diameters are $D = 10$ cm and $d = 1$ cm, and the deflection angle is $\theta = 30$ degrees.

a) What is the force F_1 exerted by the flowing water on the mouthpiece ?

b) What is the force F_2 exerted by the water on the bucket if the bucket speed is $U = 0$?

c) What is the force F_2 exerted by the water on the bucket if the bucket speed is $U = 5$ m/s ?

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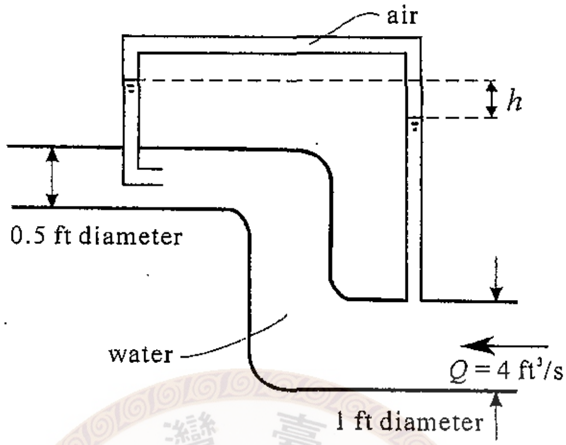

Figure 3

Problem 3. Water flows steadily as shown in Fig. 3. Find h.

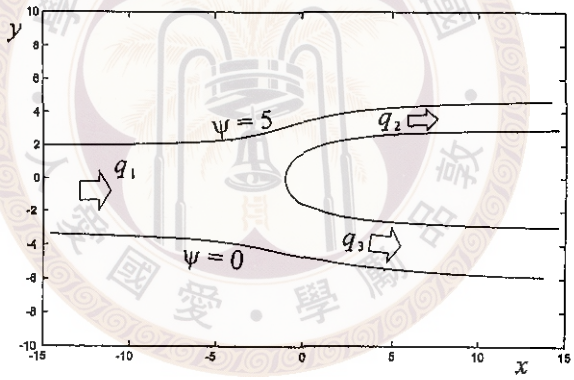

Figure 4

Problem 4. A river divides into two branches. The streamfunction is given in polar coordinates (r,θ) by

$$\psi(r,\theta) = r\sin\theta + \theta\,,$$

and the left and right banks of the river are given by $\psi = 5$ and $\psi = 0$.

a) Find $(v_r, v_\theta)(r,\theta)$ = velocity field in polar coordinates, and $(u,v)(x,y)$ = velocity field in cartesian coordinates.

b) If it exists, find the potential $\phi(r,\theta)$.

c) Find the position of any stagnation point(s), i.e. any point(s) where $V = 0$.

d) Draw the streamlines and equipotentials of the flow.

e) Find q_1, q_2 and q_3 = discharges (per unit depth) in the upstream river and in the two downstream branches.

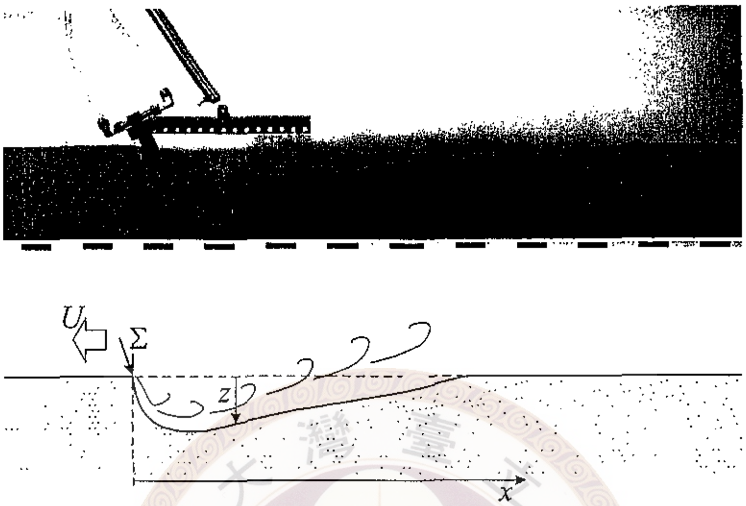

Figure 5

Problem 5. A machine advancing at speed U erodes sand from the sea bed using a water jet of strength Σ (expressed in m^3/s^2). The sand grains settle back to the bed at fall velocity W. The profile of the eroded trench is governed by the equation

$$U\frac{dz}{dx} = E(\Sigma, x) - D(W, x)$$

where $E(\cdot)$ and $D(\cdot)$ are functions of two variables governing erosion and deposition.

a) Use dimensional analysis to determine the form of function $E(\cdot)$.

b) Use dimensional analysis to determine the form of function $D(\cdot)$.

c) Solve the equation for the profile $z(x)$ and find the maximum depth of the trench $z_{\max}$.