Problem 1 (20%)

A head loss ($h_L$) occurs because of a change in pipe diameter as is shown in Fig. 1. We consider the continuity and momentum equations for the control volume as shown in Fig. 1 and the energy equation applied between (1) and (3). We assume that the pipe flow is uniform at sections (1), (2), and (3) and pressure is constant across the left-hand side of the control volume ($p_a = p_b = p_c = p_1$). Write down the resulting three governing equations (mass, momentum and energy), and determine the loss coefficient, $K_L = h_L/(V_1^2/2g)$, as a function of the area ratio, $A_1/A_2$, where g is the gravity. Finally, show the values of $K_L$ as $A_1/A_2 = 1$ and $A_1/A_2 = 0$, and discuss their physical meanings.

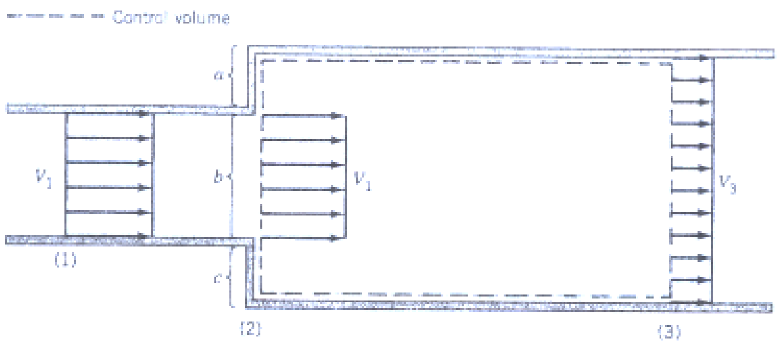


Fig. 1

(背面仍有題目,請繼續作答)

Problem 2 (10%)

Fig. 2 shows the effect of surface roughness ($\varepsilon$/D) on the drag coefficient of a sphere ($C_D$) in the Reynolds number (Re) range for which the laminar boundary layer becomes turbulent. Explain the physical meanings shown in Fig. 2 and the reason for dimples on golf balls.

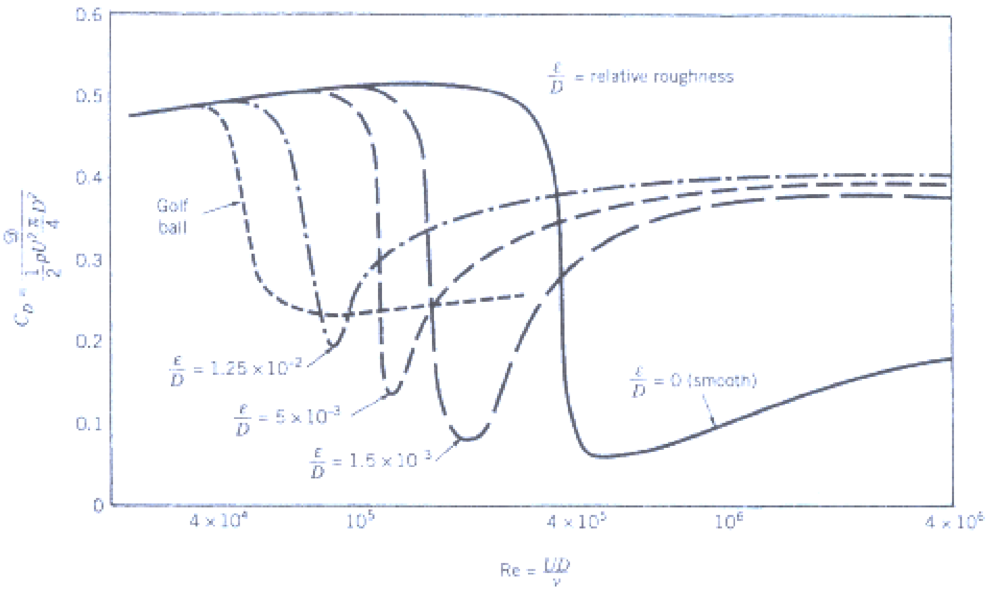


Fig. 2

Problem 3 (20%)

Considering a fully developed turbulent pipe flow, we assume that the pressure drop in the horizontal pipe ($\Delta p$), is a function of the average velocity of the fluid in the pipe ($V$), the length of the pipe ($l$), the pipe diameter ($D$), the wall roughness ($\varepsilon$) and the fluid viscosity and density ($\mu$ and $\rho$). Determine, with the aid of dimensional analysis, a general relationship between the pressure drop and the other variables.

4. Air flows through the device shown in Fig.1. If the flowrate is large enough, the pressure within the constriction will be low enough to draw the water up into the tube. Determine the flowrate, $Q$, and the pressure needed at section (1) to draw the water into section (2). Neglect compressibility and viscous effects. $(\gamma)_{water} = 9.80 \times 10^3\ N/m^3$, $(\gamma)_{air} = 12\ N/m^3$, $\gamma$: specified gravity. (15%)

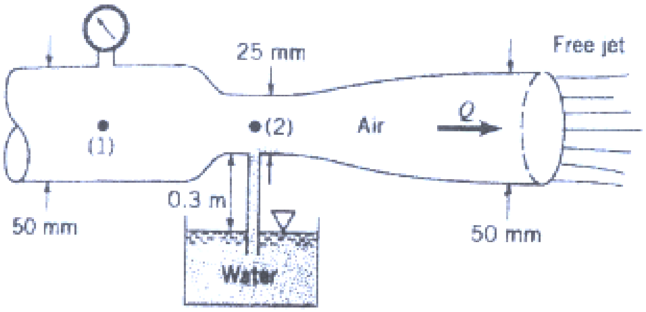


Fig.1

5. Find the total force on door $AB$ from fluids. Take oil specific gravity Soil=0.6. Find the position of this force from the bottom of the door that the door is under the close condition. $(\gamma)_{water} = 62.4\ lbf/ft^3$. (15%)

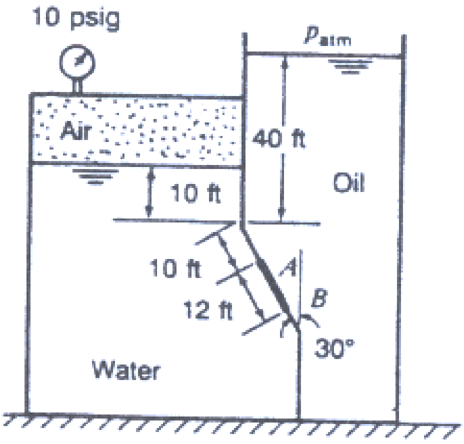


Fig. 2

6. In Fig.3 there is a small water turbine which is absorbing 10 hp from the flow of water proceeding through the apparatus. What horizontal force is developed on the tunnel from the flow of water inside and the atmospheric pressure outside? (20%)

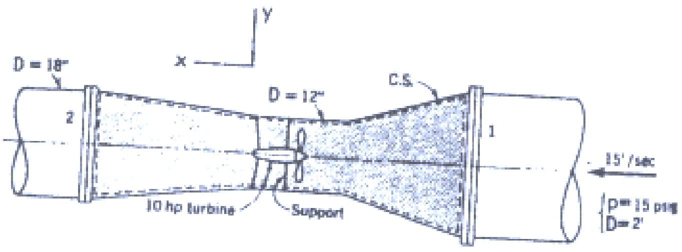


Fig.3