1. (25%)

An open tank containing water has a bulge in its vertical side that is semicircular in shape as shown in Fig. 1. Determine the magnitude and direction of the horizontal and vertical components of the force that the water exerts on the bulge. Note that length of the bulge is b, specific weight of water is denoted as γ_{H_2O} .

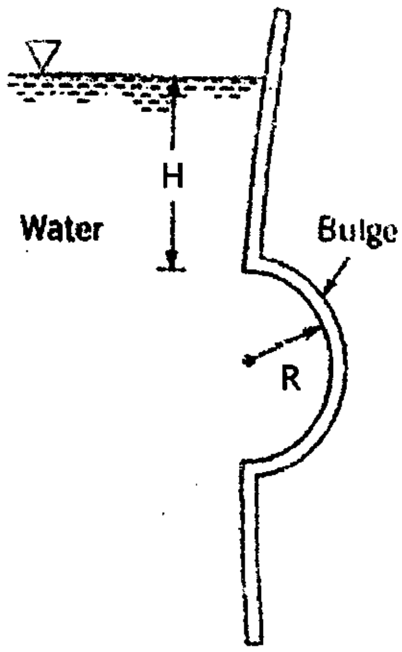

Fig. 1

2. (25%)

A bathtub is being filled with water from a faucet. The rate of flow from the faucet is steady. The tub volume is approximated by a rectangular space as indicated in Fig. 2. Estimate the time rate of change of the depth of water in the tub, dh/dt , at any instant. Choose the deformable water body including vertical water column as your control volume, and compute $\frac{d}{dt}\int_{c.v.} \rho\, dV$ and $\int_{c.s.} \rho(\underline{v}-\underline{w})\cdot\underline{n}\, dA$ respectively.

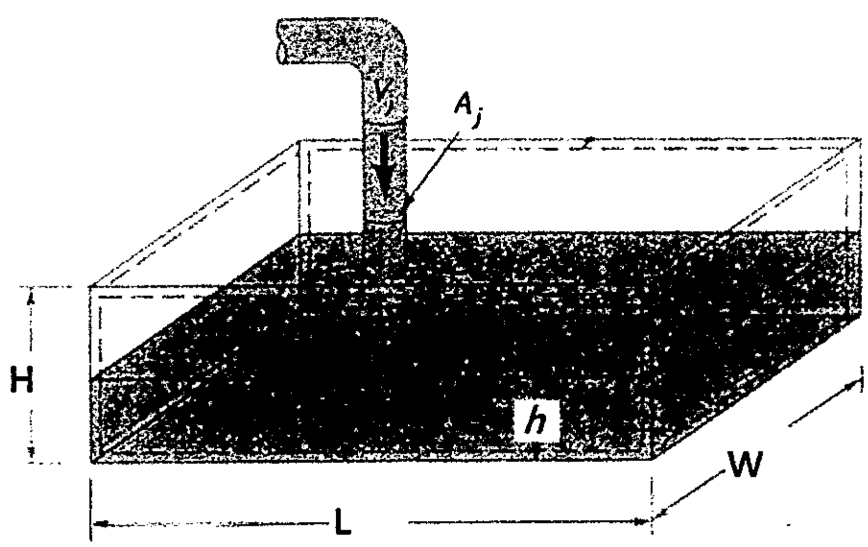

Fig. 2

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3. (25%)

The fluid flows horizontally through an abrupt expansion as indicated in Fig.3, where A_1 is the cross-sectional area upstream of expansion, A_2 is the cross-sectional area downstream of expansion, and V_1 is the velocity of flow upstream of expansion. Indicate the control volume you choose. Write down the title of conservation laws you use, and derive the head loss from upstream to downstream in terms of $\frac{V_1^2}{2g}$ and $\frac{A_1}{A_2}$.

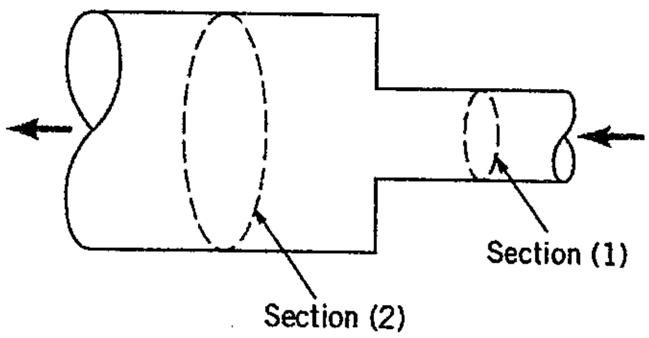

Fig. 3

4. (25%)

(a) For a segment between two points in a circular pipe, show that the major head loss due to friction is $h_f = \Delta\left(\frac{p}{\gamma} + z\right)$.

(b) If the wall shear stress of a circular pipe, τ_w, is a function of ε, V, d, μ, ρ, where ε is the roughness height of the pipe, V is the cross sectional averaged speed of the flow, d is the pipe diameter, μ is the fluid viscosity, ρ is fluid density, i.e. $\tau_w = f(\varepsilon, V, d, \mu, \rho)$. Perform dimensional analysis to see the friction factor $f = 8\frac{\tau_w}{\rho V^2}$ is a function of what non-dimensional parameter(s).

(c) If $\tau_w = \frac{d}{4}\left[-\frac{d(p+\rho g z)}{dx}\right]$, i.e. $\tau_w = \frac{d}{4}\left[\frac{\Delta(p+\rho g z)}{\Delta x}\right]$ is given by force balance, derive Darcy–Weisbach equation for pipe flow.

試題隨卷繳回