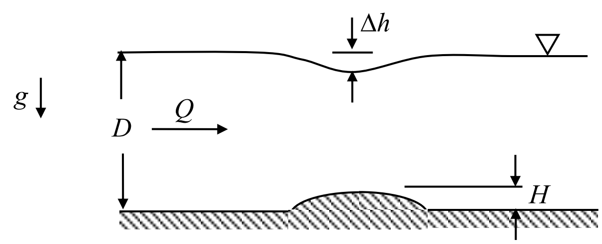
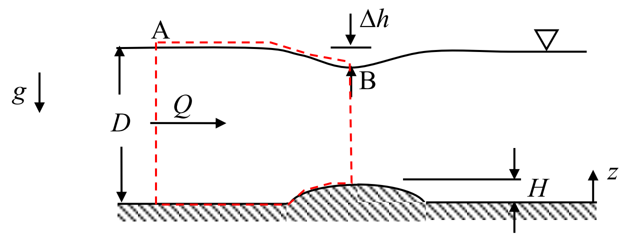
If the approach velocity is not too large, a hump of height, H, in the bottom of a water channel will cause a dip of magnitude Δh in the water level. This depression in the water can be used to determine the flow rate of the water. Assuming no losses and that the incoming flow has a depth, D, determine the volumetric flow rate, Q, as a function of Δh, H, D, and g (the acceleration due to gravity).



SOLUTION:

Assume steady, incompressible, inviscid flow with uniform velocity profiles at the inlet and outlet of the control volume.



Apply Bernoulli's Equation along a streamline on the free surface from point A to point B.

$$\left(\frac{p}{\rho g}+\frac{V^2}{2g}+z\right)_B=\left(\frac{p}{\rho g}+\frac{V^2}{2g}+z\right)_A \tag{1}$$

where

$$p_B = p_A = p_{\text{atm}} \tag{2}$$

$$V_B=\frac{Q}{D-H-\Delta h} \quad \text{and} \quad V_A=\frac{Q}{D} \tag{3}$$

$$z_B = D-\Delta h \quad \text{and} \quad z_A = D \tag{4}$$

Substitute and simplify.

$$\frac{p_{\text{atm}}}{\rho g}+\frac{1}{2g}\left(\frac{Q}{D-H-\Delta h}\right)^2+D-\Delta h=\frac{p_{\text{atm}}}{\rho g}+\frac{1}{2g}\left(\frac{Q}{D}\right)^2+D \tag{5}$$

$$\left(\frac{Q}{D-H-\Delta h}\right)^2-2g\Delta h=\left(\frac{Q}{D}\right)^2$$

$$\boxed{\therefore Q=\sqrt{\frac{2g\Delta h}{\left(\frac{1}{D-H-\Delta h}\right)^2-\left(\frac{1}{D}\right)^2}}} \tag{6}$$