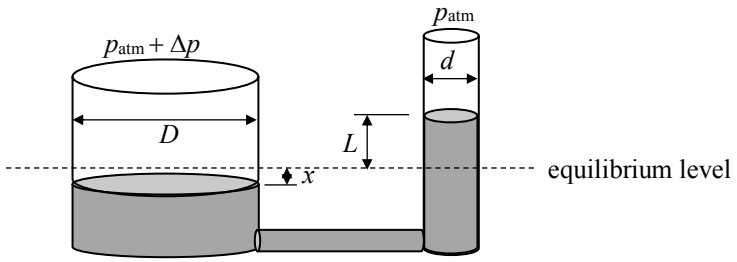
A reservoir manometer has vertical tubes of diameter D and d. When the pressure at the liquid surfaces in both tubes is the same, the liquid levels in each tube are at the same elevation. When an additional pressure Δp is applied to the left tube, the liquid layer in that tube drops a distance x while the liquid in the right tube rises a distance L. Develop an algebraic expression for the liquid deflection L in the small tube when the additional pressure Δp is applied to the large tube.



SOLUTION:
Relate the pressure at the liquid surface in the left tube to the pressure at the liquid surface in the right tube using manometry,

$$p_{\text{atm}} = \left(p_{\text{atm}} + \Delta p\right) - \rho g\left(x + L\right), \tag{1}$$

$$x + L = \frac{\Delta p}{\rho g}. \tag{2}$$

The distances x and L may be related by noting that the liquid mass remains the same in the system. Assuming that the liquid is incompressible (a good assumption), the volume displaced in the left tube will equal the volume gained in the right tube,

$$x\frac{\pi D^2}{4} = L\frac{\pi d^2}{4}, \tag{3}$$

$$x = L\left(\frac{d}{D}\right)^2. \tag{4}$$

Now substitute Eq. (4) into Eq. (2) and solve for L,

$$L\left(\frac{d}{D}\right)^2 + L = \frac{\Delta p}{\rho g}, \tag{5}$$

$$\boxed{L = \frac{\Delta p}{\rho g}\left[\frac{1}{1+\left(d/D\right)^2}\right]}. \tag{6}$$