P14.27 (a) $P = P_0 + \rho g h$

Taking $P_0 = 1.013 \times 10^5 \text{ N/m}^2$ and $h = 5.00 \text{ cm}$

we find $P_{top} = 1.017\,9 \times 10^5 \text{ N/m}^2$

For $h = 17.0 \text{ cm}$, we get $P_{bot} = 1.029\,7 \times 10^5 \text{ N/m}^2$

Since the areas of the top and bottom are $A = (0.100 \text{ m})^2 = 10^{-2} \text{ m}^2$

we find $F_{top} = P_{top}A = \boxed{1.017\,9 \times 10^3 \text{ N}}$

and $F_{bot} = \boxed{1.029\,7 \times 10^3 \text{ N}}$

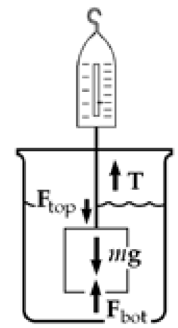

FIG. P14.27

(b) $T + B - Mg = 0$

where $B = \rho_w V g = (10^3 \text{ kg/m}^3)(1.20 \times 10^{-3} \text{ m}^3)(9.80 \text{ m/s}^2) = 11.8 \text{ N}$

and $Mg = 10.0(9.80) = 98.0 \text{ N}$

Therefore, $T = Mg - B = 98.0 - 11.8 = \boxed{86.2 \text{ N}}$

Continued on next page

(c) $F_{bot} - F_{top} = (1.029\,7 - 1.017\,9) \times 10^3 \text{ N} = \boxed{11.8 \text{ N}}$

which is equal to B found in part (b).

P14.28 Consider spherical balloons of radius 12.5 cm containing helium at STP and immersed in air at 0°C and 1 atm. If the rubber envelope has mass 5.00 g, the upward force on each is

$$B - F_{g,\text{He}} - F_{g,env} = \rho_{\text{air}} V g - \rho_{\text{He}} V g - m_{env} g$$

$$F_{up} = (\rho_{\text{air}} - \rho_{\text{He}})\left(\frac{4}{3}\pi r^3\right) g - m_{env} g$$

$$F_{up} = \left[(1.29 - 0.179) \text{ kg/m}^3\right]\left[\frac{4}{3}\pi (0.125 \text{ m})^3\right](9.80 \text{ m/s}^2) - 5.00 \times 10^{-3} \text{ kg}(9.80 \text{ m/s}^2) = 0.040\,1 \text{ N}$$

If your weight (including harness, strings, and submarine sandwich) is

$$70.0 \text{ kg}(9.80 \text{ m/s}^2) = 686 \text{ N}$$

you need this many balloons: $\frac{686 \text{ N}}{0.040\,1 \text{ N}} = 17\,000 \boxed{\sim 10^4}$.

P14.45 (a) Suppose the flow is very slow: $\left(P + \frac{1}{2}\rho v^2 + \rho g y\right)_{\text{river}} = \left(P + \frac{1}{2}\rho v^2 + \rho g y\right)_{\text{rim}}$

$$P + 0 + \rho g (564 \text{ m}) = 1 \text{ atm} + 0 + \rho g (2\,096 \text{ m})$$

$$P = 1 \text{ atm} + (1\,000 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(1\,532 \text{ m}) = \boxed{1 \text{ atm} + 15.0 \text{ MPa}}$$

(b) The volume flow rate is $4\,500 \text{ m}^3/\text{d} = Av = \frac{\pi d^2 v}{4}$

$$v = (4\,500 \text{ m}^3/\text{d})\left(\frac{1 \text{ d}}{86\,400 \text{ s}}\right)\left(\frac{4}{\pi (0.150 \text{ m})^2}\right) = \boxed{2.95 \text{ m/s}}$$

(c) Imagine the pressure as applied to stationary water at the bottom of the pipe:

$$\left(P + \frac{1}{2}\rho v^2 + \rho g y\right)_{\text{bottom}} = \left(P + \frac{1}{2}\rho v^2 + \rho g y\right)_{\text{top}}$$

$$P + 0 = 1\text{ atm} + \frac{1}{2}\left(1\,000\text{ kg/m}^3\right)\left(2.95\text{ m/s}\right)^2 + 1\,000\text{ kg}\left(9.8\text{ m/s}^2\right)\left(1\,532\text{ m}\right)$$

$$P = 1\text{ atm} + 15.0\text{ MPa} + 4.34\text{ kPa}$$

The additional pressure is $\boxed{4.34\text{ kPa}}$.

P14.48 $Mg = (P_1 - P_2)A$ for a balanced condition

$$\frac{16\,000(9.80)}{A} = 7.00 \times 10^4 - P_2$$

where $A = 80.0\text{ m}^2$

$$\therefore P_2 = 7.0 \times 10^4 - 0.196 \times 10^4 = \boxed{6.80 \times 10^4\text{ Pa}}$$

P14.49 $\rho_{\text{air}} \frac{v^2}{2} = \Delta P = \rho_{\text{Hg}} g \Delta h$

$$v = \sqrt{\frac{2\rho_{\text{Hg}} g \Delta h}{\rho_{\text{air}}}} = \boxed{103\text{ m/s}}$$

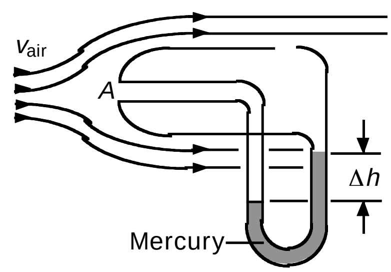

FIG. P14.49