P15.6 (a) $P = P_0 + \rho gh = 1.013\times10^5\ \text{Pa} + \left(1\,024\ \text{kg/m}^3\right)\left(9.80\ \text{m/s}^2\right)\left(1\,000\ \text{m}\right)$

$P = \boxed{1.01\times10^7\ \text{Pa}}$

(b) The gauge pressure is the difference in pressure between the water outside and the air inside the submarine, which we suppose is at 1.00 atmosphere.

$$P_{\text{gauge}} = P - P_0 = \rho gh = 1.00\times10^7\ \text{Pa}$$

The resultant inward force on the porthole is then

$$F = P_{\text{gauge}}A = 1.00\times10^7\ \text{Pa}\left[\pi(0.150\ \text{m})^2\right] = \boxed{7.09\times10^5\ \text{N}}.$$

P15.13 $P_0 = \rho gh$

$$h = \frac{P_0}{\rho g} = \frac{1.013\times10^5\ \text{Pa}}{\left(0.984\times10^3\ \text{kg/m}^3\right)\left(9.80\ \text{m/s}^2\right)} = \boxed{10.5\ \text{m}}$$

$\boxed{\text{No. Some alcohol and water will evaporate.}}$ The equilibrium vapor pressures of alcohol and water are higher than the vapor pressure of mercury.

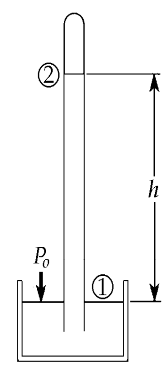

FIG. P15.13

P15.16 (a) $P = P_0 + \rho gh$

The gauge pressure is

$$P - P_0 = \rho gh = 1\,000\ \text{kg}\left(9.8\ \text{m/s}^2\right)\left(0.160\ \text{m}\right) = \boxed{1.57\ \text{kPa}} = 1.57\times10^3\ \text{Pa}\left(\frac{1\ \text{atm}}{1.013\times10^5\ \text{Pa}}\right)$$

$$= \boxed{0.015\,5\ \text{atm}}.$$

It would lift a mercury column to height

$$h = \frac{P - P_0}{\rho g} = \frac{1\,568\ \text{Pa}}{\left(13\,600\ \text{kg/m}^3\right)\left(9.8\ \text{m/s}^2\right)} = \boxed{11.8\ \text{mm}}.$$

(b) $\boxed{\text{Increased pressure of the cerebrospinal fluid will raise the level of the fluid in the spinal tap.}}$

(c) $\boxed{\text{Blockage of the fluid within the spinal column or between the skull and the spinal column would prevent the fluid level from rising.}}$

P15.21 (a) $P = P_0 + \rho g h$

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

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

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

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

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

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

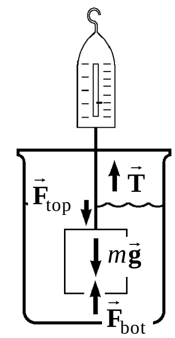

FIG. P15.21

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

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

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

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

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

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

P15.33 Apply Bernoulli's equation between the top surface and the exiting stream.

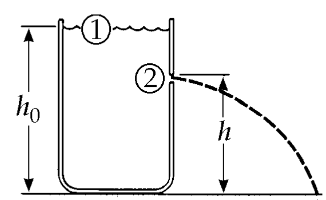

FIG. P15.33

$$P_0 + 0 + \rho g h = P_0 + \frac{1}{2}\rho v_x^2 + \rho g h$$

$$v_x^2 = 2g(h_0 - h)$$

$$\therefore\ v_x = \sqrt{2g(h_0 - h)}$$

$$x = v_x t:\ y = h = \frac{1}{2} g t^2$$

$$\therefore\ t = \sqrt{\frac{2h}{g}}$$

$$x = v_x \sqrt{\frac{2h}{g}} = \sqrt{2g(h_0 - h)}\sqrt{\frac{2h}{g}}:$$

and

$$x = \boxed{2\sqrt{h(h_0 - h)}}$$

P15.43 (a) $P_0 + \rho gh + 0 = P_0 + 0 + \frac{1}{2}\rho v_3^2 \qquad v_3 = \sqrt{2gh}$

If $h = 1.00$ m, $\qquad v_3 = \boxed{4.43 \text{ m/s}}$

(b) $P + \rho gy + \frac{1}{2}\rho v_2^2 = P_0 + 0 + \frac{1}{2}\rho v_3^2$

Since $v_2 = v_3$, $\qquad P = P_0 - \rho gy$

Since $P \geq 0 \qquad y \leq \frac{P_0}{\rho g} = \frac{1.013 \times 10^5 \text{ Pa}}{(10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)} = \boxed{10.3 \text{ m}}$

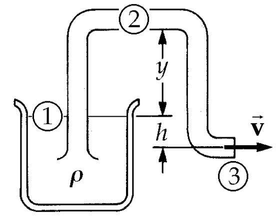

FIG. P15.43

P15.50 Assume $v_{\text{inside}} \approx 0$. From Bernoulli's equation

$$P + 0 + 0 = 1 \text{ atm} + \frac{1}{2}(1\,000)(30.0)^2 + 1\,000(9.80)(0.500)$$
$$P_{\text{gauge}} = P - 1 \text{ atm} = 4.50 \times 10^5 + 4.90 \times 10^3 = \boxed{455 \text{ kPa}}$$

P15.63 (a) Since the upward buoyant force is balanced by the weight of the sphere,

$$m_1 g = \rho V g = \rho\left(\frac{4}{3}\pi R^3\right)g.$$

In this problem, $\rho = 0.789\,45 \text{ g/cm}^3$ at 20.0°C, and $R = 1.00$ cm so we find:

$$m_1 = \rho\left(\frac{4}{3}\pi R^3\right) = (0.789\,45 \text{ g/cm}^3)\left[\frac{4}{3}\pi(1.00 \text{ cm})^3\right] = \boxed{3.307 \text{ g}}.$$

(b) Following the same procedure as in part (a), with $\rho' = 0.780\,97 \text{ g/cm}^3$ at 30.0°C, we find:

$$m_2 = \rho'\left(\frac{4}{3}\pi R^3\right) = (0.780\,97 \text{ g/cm}^3)\left[\frac{4}{3}\pi(1.00 \text{ cm})^3\right] = \boxed{3.271 \text{ g}}.$$

(c) When the first sphere is resting on the bottom of the tube,

$n + B = F_{g1} = m_1 g$, where n is the normal force.

Since $B = \rho' V g$

$$n = m_1 g - \rho' V g = \left[3.307 \text{ g} - (0.780\,97 \text{ g/cm}^3)\frac{4}{3}\pi(1.00 \text{ cm})^3\right]980 \text{ cm/s}^2$$
$$n = 34.8 \text{ g} \cdot \text{cm/s}^2 = \boxed{3.48 \times 10^{-4} \text{ N}}$$