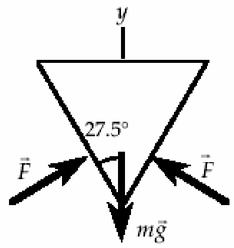
8. Each force from the water must act perpendicular to the surface of the wedge. From the symmetry of the force diagram, we see that the two forces must be equal.
From the vertical equilibrium, we have
$\sum F_y = 2F \sin 30° - mg = 0$, or
$2F \sin 30° = 20$ N, which gives $F = \boxed{20 \text{ N}}$.



17. On Venus, we have
$h_{\text{Venus}} = p/\rho_{\text{Hg}}\, g_{\text{Venus}} = (1.01 \times 10^5 \text{ N/m}^2)/(13.6 \times 10^3 \text{ kg/m}^3)(8.86 \text{ m/s}^2) = \boxed{0.838 \text{ m}}$.
On Neptune, we have
$h_{\text{Neptune}} = p/\rho_{\text{Hg}}\, g_{\text{Neptune}} = (1.01 \times 10^5 \text{ N/m}^2)/(13.6 \times 10^3 \text{ kg/m}^3)(12.0 \text{ m/s}^2)] = \boxed{0.619 \text{ m}}$.

$\boxed{19}$. The force in the large piston must equal the weight of the car. The pressures in the two pistons will be the same, so we have
$p = F/A_1 = mg/A_2$;
$F/\frac{1}{4}\pi D_1^2 = mg/\frac{1}{4}\pi D_2^2$, or $F = mg(D_1/D_2)^2 = (1200 \text{ kg})(9.8 \text{ m/s}^2)[(30 \text{ cm})/(2 \text{ cm})]^2 = \boxed{52 \text{ N}}$.
With no frictional losses, the work done by F must increase the potential energy of the car:
$F h_1 = mgh_2$;
$(52 \text{ N})(0.50 \text{ m}) = (1200 \text{ kg})(9.8 \text{ m/s}^2)h_2$, which gives $h_2 = 2.2 \times 10^{-3} \text{ m} = \boxed{22 \text{ mm}}$.
Note that this can be obtained by equating the volume changes.

26. When the bowl floats, the net force is zero:
$F_{\text{net}} = 0 = F_{\text{buoy}} - m_{\text{bowl}}\, g - m_{\text{water}}\, g$, or $F_{\text{buoy}} = m_{\text{bowl}}\, g + m_{\text{water}}\, g$;
$\rho_{\text{water}} \frac{1}{2}(\frac{4}{3}\pi R^3)g = m_{\text{bowl}}g + \rho_{\text{water}} V_{\text{water}}\, g$,
$(1.00 \times 10^3 \text{ kg/m}^3)(2\pi R^3/3)g = (0.6 \text{ kg})g + (1.00 \times 10^3 \text{ kg/m}^3)(4.3 \times 10^3 \text{ cm}^3)(10^{-6} \text{ m}^3/\text{cm}^3)g$,
which gives $R = 0.13 \text{ m} = \boxed{13 \text{ cm}}$.

33. When the cube floats, the net force is zero, so we have
$F_{\text{buoy1}} + F_{\text{buoy2}} = mg$;
$[\rho_1(H - D) + \rho_2 D]gA = \rho_3 gHA$, which reduces to
$\rho_3 = \rho_1 + (\rho_2 - \rho_1)(D/H)$.
Because $(\rho_2 - \rho_1) > 0$ and $D/H > 0$, we see that $\rho_3 > \rho_1$.
If we rewrite the result as
$\rho_3 = \{\rho_2 - [1 + (H/D)\rho_1]\}(D/H)$,
we see that $\rho_3 < \rho_2$, so the condition is $\boxed{\rho_1 < \rho_3 < \rho_2}$.
The fraction of the cube in the water is
$D/H = \boxed{(\rho_3 - \rho_1)/(\rho_2 - \rho_1)}$.

36. Neglect the mass of the air inside the balloon. The volume of the lead skin is $V_{Pb} = At = 4\pi R^2 t$, so its weight is $F_g = \rho_{Pb} V_{Pb}\, g = \rho_{Pb}(4\pi R^2 t)g$, which should be balanced by the buoyant force F_{buoy} exerted on the balloon (since it is in equilibrium):

$$F_g = F_{buoy}, \text{ or } \rho_{Pb}(4\pi R^2 t)g = \rho_w V_{balloon}\, g = \rho_w (4\pi R^3/3)g.$$

$$t = \rho_w R/3\rho_{Pb} = (1.00 \times 10^3 \text{ kg/m}^3)(0.1 \text{ m}^3)/[3(11.3 \times 10^3 \text{ kg/m}^3)] = 0.003 \text{ m} = \boxed{3 \text{ mm}}.$$

Now that you know the thickness of the lead skin, you can check for yourself numerically the validity of the assumption $m_{air} << m_{lead}$, or $\rho_{air}\, V_{balloon} << \rho_{Pb}\, V_{Pb}$.

$\boxed{43}$. If we ignore air resistance, the water has projectile motion. The maximum range is achieved with an initial angle of 45° and is given by

$$R = 2v_0^2/g, \text{ or } v_0 = (gR/2)^{1/2}.$$

From the mass conservation equation of continuity at the nozzle, with constant density, we have

$$v_1 A_1 = v_2 A_2;$$

$$(gR_1/2)^{1/2}\tfrac{1}{4}\pi d_1^2 = (gR_2/2)^{1/2}\tfrac{1}{4}\pi d_2^2.$$

After canceling the common factors, we have

$$(1.5 \text{ m})^{1/2}(1.2 \text{ cm})^2 = (18 \text{ m})^{1/2} d_2^2, \text{ which gives } d_2 = \boxed{0.81 \text{ cm}}.$$

50. (a) If we use Bernoulli's equation after the water leaves the fountain, we have

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2;$$

$$p_{atm} + \tfrac{1}{2}\rho v_1^2 + 0 = p_{atm} + 0 + \rho g h_2, \text{ which gives a familiar result:}$$

$$v_1^2 = 2gh_2 = 2(9.8 \text{ m/s}^2)(1.6 \text{ m}), \text{ which gives } v_1 = \boxed{5.6 \text{ m/s}}, \text{ the initial speed of the jet.}$$

From the equation of continuity at the nozzle, we have

$$dV/dt = v_1 A_1;$$

$$(0.33 \text{ L/s})(10^{-3} \text{ m}^3/\text{L}) = (5.6 \text{ m/s})\pi R_1^2, \text{ which gives } R_1 = 4.3 \times 10^{-3} \text{ m} = \boxed{4.3 \text{ mm}}.$$

(b) If we use Bernoulli's equation from inside the hole to the highest point, we have

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2;$$

$$p_{atm} + 0 + (1.00 \times 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(1.6 \text{ m}) = p_2 + 0 + 0, \text{ which gives}$$

$$p_2 - p_{atm} = \boxed{1.6 \times 10^4 \text{ Pa (gauge)}}.$$

(c) If we use Bernoulli's equation from the height of 1.20 m to to the top, we have

$$p_3 + \tfrac{1}{2}\rho v_3^2 + \rho g h_3 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2;$$

$$p_{atm} + \tfrac{1}{2}\rho v_3^2 + \rho g h_3 = p_{atm} + 0 + \rho g h_2, \text{ which gives}$$

$$v_3^2 = 2g(h_2 - h_3) = 2(9.8 \text{ m/s}^2)(1.6 \text{ m} - 1.2 \text{ m}), \text{ which gives } v_3 = \boxed{2.8 \text{ m/s}}.$$

From the equation of continuity, we have

$$dV/dt = v_3 A_3;$$

$$(0.33 \text{ L/s})(10^{-3} \text{ m}^3/\text{L}) = (2.8 \text{ m/s})\pi R_3^2, \text{ which gives } R_3 = 6.1 \times 10^{-3} \text{ m} = \boxed{6.1 \text{ mm}}.$$

52. If we use Bernoulli's equation between the two parts of the pipe, we have

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2;$$

$$p_1 + \tfrac{1}{2}(1.05 \times 10^3 \text{ kg/m}^3)v_1^2 + 0 = p_1 + (0.4 \times 10^4 \text{ Pa}) + \tfrac{1}{2}(1.05 \times 10^3 \text{ kg/m}^3)v_2^2 + 0.$$

From the equation of continuity, we have

$$v_1 A_1 = v_2 A_2; \quad v_1(42 \text{ cm}^2) = v_2(56 \text{ cm}^2).$$

Thus $v_1 = \boxed{17 \text{ m/s}}$, $v_2 = \boxed{13 \text{ m/s}}$ (both along the pipe).

56. From the discussion in the textbook the flow speed v_2 at the (small) opening a distance h below the surface of the water is

$$v_2 = (2gh)^{1/2} = [2(9.8 \text{ m/s}^2)(1.0 \text{ m})]^{1/2} = \boxed{4.4 \text{ m/s}}.$$

The flow speed at point 3, which is 1.0 m below the opening, or $h' = 2.0$ m below the surface of the water, is $v_3 = (2gh')^{1/2}$. The flow rate is a constant: $\Phi = v_2 A_2 = v_3 A_3$, or $v_2(\tfrac{1}{4}\pi d_2^2) = v_3(\tfrac{1}{4}\pi d_3^2)$, which gives the diameter of the water stream at point 3 as

$$d_3 = d_2(v_2/v_3)^{1/2} = d_2(2gh/2gh')^{1/4} = (1 \text{ cm})(1.0 \text{ m}/2.0 \text{ m})^{1/4} = \boxed{0.8 \text{ cm}}.$$

$\boxed{63}$. The pressure at a depth h is

$$p = p_0 + \rho g h$$
$$= (1.01 \times 10^5\ \text{Pa}) + (1.0 \times 10^3\ \text{kg/m}^3)(9.8\ \text{m/s}^2)(30\ \text{m}) = 3.95 \times 10^5\ \text{Pa} = \boxed{3.9\ \text{atm}}.$$

The scuba diver will take in $\boxed{\text{less air}}$, because pressure on the chest and lungs decreases the volume change.

66. (a) If we use Bernoulli's equation for the flow between the water surface and opening, we have

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2;$$
$$p_{\text{atm}} + 0 + \rho g h_1 = p_{\text{atm}} + \tfrac{1}{2}\rho v_2^2 + 0, \text{ which gives } v_2 = \boxed{(2gh_1)^{1/2}}.$$

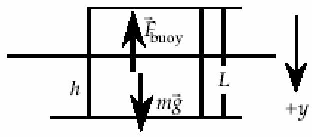
(b) The analysis is the same as in part (a), so we get $\boxed{(2gh_1)^{1/2}}$.

(c) The application of Bernoulli's equation is just the reverse of part (a), so $\boxed{\text{the water will rise to } h_1}$, the same height from which it started.

69. We choose down as positive.

(a) In the equilibrium position, the net force is zero, so we have

$$F_{\text{buoy}} = mg;$$
$$\rho_{\text{water}}\, g L^2 h = \rho g L^3, \text{ which gives}$$
$$\rho = \rho_{\text{water}}(h/L) = (1.0 \times 10^3\ \text{kg/m}^3)(12\ \text{m})/(20\ \text{m})$$
$$= \boxed{6.0 \times 10^2\ \text{kg/m}^3}.$$



(b) When the block is pushed down a distance Δ, the net force is

$$F_{\text{net}} = -\rho_{\text{water}}\, g L^2 (h + \Delta) + \rho g L^3$$
$$= -\rho_{\text{water}}\, g L^2 \Delta$$
$$= -(1.0 \times 10^3\ \text{kg/m}^3)(9.8\ \text{m/s}^2)(0.20\ \text{m})^2 \Delta = \boxed{-0.39 \times 10^3 \Delta\ \ \text{N (up)}}.$$

(c) When the block is a distance Δ above the equilibrium position, we have

$$F_{\text{net}} = -\rho_{\text{water}}\, g L^2 (h - \Delta) + \rho g L^3$$
$$= +\rho_{\text{water}}\, g L^2 \Delta = \boxed{0.39 \times 10^3 \Delta\ \ \text{N (down)}}.$$

(d) From parts (b) and (c), we see that the effective force constant is $\rho_{\text{water}}\, g L^2$. The frequency is

$$f = (k/4\pi^2 m)^{1/2} = (\rho_{\text{water}}\, g L^2/4\pi^2 \rho L^3)^{1/2} = (\rho_{\text{water}}\, g/4\pi^2 \rho L)^{1/2}$$
$$= [(1.0 \times 10^3\ \text{kg/m}^3)(9.8\ \text{m/s}^2)/4\pi^2(6.0 \times 10^2\ \text{kg/m}^3)(0.20\ \text{m})]^{1/2} = \boxed{1.44\ \text{Hz}}.$$

72. If we use Bernoulli's equation between points A and B, we have

$$p_A + \tfrac{1}{2}\rho v_A^2 + \rho g h_A = p_B + \tfrac{1}{2}\rho v_B^2 + \rho g h_B;$$
$$p_A + 0 + \rho g h_A = p_B + \tfrac{1}{2}\rho v_B^2 + \rho g h_A,$$

which gives

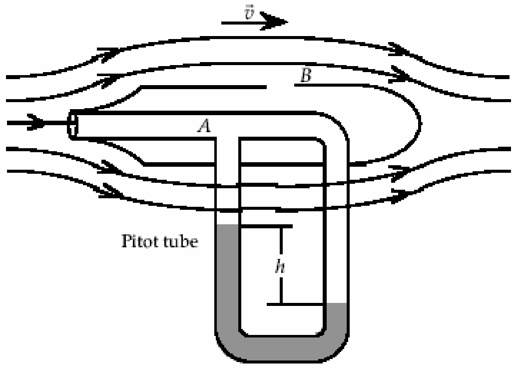
$$v_B = [2(p_A - p_B)/\rho]^{1/2}.$$

If we use Bernoulli's equation for the flow between the tops of the liquid levels, we have

$$p_L + \tfrac{1}{2}\rho v_L^2 + \rho g h_L = p_R + \tfrac{1}{2}\rho v_R^2 + \rho g h_R;$$
$$p_B + 0 + \rho_\ell\, g h. = p_A + 0 + 0, \text{ which gives}$$
$$p_A - p_B = \rho_\ell\, g h.$$

If we substitute thus in the previous result, we get

$$v_B = (2gh\rho_\ell/\rho)^{1/2}.$$



74. (a) If we use Bernoulli's equation for the flow from the top to the opening, we have

$$p_0 + \tfrac{1}{2}\rho v_0^2 + \rho g h_0 = p + \tfrac{1}{2}\rho v^2 + \rho g h;$$
$$p_{\text{atm}} + 0 + \rho g x = p_{\text{atm}} + \tfrac{1}{2}\rho v^2 + 0, \text{ which gives}$$
$$v = \sqrt{2gx}.$$

The volume flow is

$$\frac{dV}{dt} = v\,\sigma = \quad \sigma\sqrt{2gx}.$$

The amount of water that flows out in a time Δt is

$$\Delta V = \sigma\sqrt{2gx}\,\Delta t.$$

(b) If ΔV flows out, the level of the water in the tank must change by

$$\Delta x = -\frac{\Delta V}{A} = -\frac{\sigma}{A}\sqrt{2gx}\,\Delta t.$$

(c) As $\Delta t \to 0$, $\Delta x \to 0$, and we get $\dfrac{dx}{dt} = -\dfrac{\sigma\sqrt{2gx}}{A}$.

(d) To test the solution, we take its derivative:

$$\frac{dx}{dt} = \frac{d}{dt}\left[\sqrt{x_0} - \tfrac{1}{2}\left(\frac{\sigma}{A}\right)t\sqrt{2g}\right]^2$$
$$= 2\left[\sqrt{x_0} - \tfrac{1}{2}\left(\frac{\sigma}{A}\right)t\sqrt{2g}\right]\left[-\tfrac{1}{2}\left(\frac{\sigma}{A}\right)\sqrt{2g}\right] = -\frac{\sigma\sqrt{2gx}}{A},$$

which is the result from part (c).

(e) To find the time for the water to drop to the level of the hole, we set $x = 0$ in the solution:

$$0 = \left[\sqrt{x_0} - \tfrac{1}{2}\left(\frac{\sigma}{A}\right)t\sqrt{2g}\right]^2, \text{ which gives}$$
$$t = \frac{2A\sqrt{x_0}}{\sigma\sqrt{2g}} = \quad \frac{A}{\sigma}\sqrt{\frac{2x_0}{g}}\ .$$