Chapter 15 Hint for Exercise 1

The magnitude of F of the force of the nurse on the piston is related to the change Δp in the pressure by

$$F = A\,\Delta p\,,$$

where A is the cross-sectional area of the syringe. Use $A = \pi R^2$, where R is the radius of the syringe.

$\big[$ans: $1.1 \times 10^5\,\text{Pa}$ $(1.1\,\text{atm}$$\big]$

Chapter 15 Hint for Exercise 5

Let V be the expanded body volume, V_a be the volume of the filled air sacs, ρ_f be density of the uninflated fish, ρ_w be the density of water, and ρ_a be the density of air. Then, the mass of the fish with inflated air sacs is given by $\rho_f(V - V_a) + \rho_a V_a$. The first term represents the mass of the uninflated fish and the second represents the mass of air in the sacs. Set this equal to ρ_w and solve for V_a/V. Look up the densities of water and air in Table 15–1 of the text.

[ans: 0.074]

Chapter 15 Hint for Exercise 10

According to the graph the minimum pressure for which diamond forms at 1000° C is about 4.0 GPa. Use

$$p = p_{\text{atm}} + \rho g d\,,$$

with $p = 4.0\,\text{GPa}$, $\rho = 3.1\,\text{g/cm}^3$ and $p_{\text{atm}} = 1.0 \times 10^5\,\text{Pa}$. Notice that atmospheric pressure is negligible compared to the pressure of the rocks.

(a) and (b) The pressure on the bottom due to the water alone is given by

$$p_b = \rho g d\,,$$

where $\rho = 998i\,\mathrm{kg/m}^2$, $g = 9.8\,\mathrm{m/s}^2$, and $d = 2.5\,\mathrm{m}$. The pressure at a side varies from top to bottom. To find the force on a long side, you must add the forces on infinitesimal strips of length $L = 24\,\mathrm{m}$. Let $\mathrm{d}y$ be the width of a strip at a depth y. Then, the force on the strip is $\mathrm{d}F = \rho g L y\,\mathrm{d}y$ and the net force on the side is given by

$$F = \rho g L \int_0^d y\,\mathrm{d}y\,.$$

Carry out the integration and evaluate the result. The same result is obtained for a short end, but with L replaced by $W = 9.0\,\mathrm{m}$.

(d) Think about the upward force of the ground on the floor and the inward force of the ground on the walls.

[ans: (a) 5.3×10^6 N; (b) 2.8×10^5 N; (c) 7.4×10^5 N; (b) no]

Chapter 15 Hint for Exercise 14

The hydrostatic pressure on the bottom, due to the weight of the water alone, is given by

$$p = \rho g d\,,$$

where d is the depth measured from the top of the tube. Divide this by the weight of the water $\rho g V$. The total volume V, of course, is the sum of the volume of the barrel ($\pi R^2 L$) and the volume of the tube ($A\ell$).

Because the tube is filled, the pressure at the bottom of the barrel is greater by an amount equal to the weight of the water in the tube divided by the cross-sectional area of the tube. This is the same as the weight of the water in the barrel divided by the cross-sectional area of the barrel, so filling the tube doubles the pressure and the force on the bottom. From another viewpoint, the top of the barrel pushes down on the water in the barrel.

Chapter 15 Hint for Problem 18

(a) To calculate the force on face A, fist use

$$p = p_0 + \rho g h$$

to calculate the pressure at a depth $h = 2d$, then multiply by the area of the face. Here p_0 is atmospheric pressure (1.01×10^5 Pa) and ρ is the density of water ($998\,\mathrm{kg/m^3}$).

(b) The pressure at a depth y is $p_0 + \rho g x$. Consider a horizontal strip of width dx, of length d, and at depth y. The force of the water on the strip is

$$dF = d(p_0 + \rho g x)\,dy\,.$$

This should be integrated from $y = 2d$ to $y = 3d$. Thus

$$F = d\int_{2d}^{3d} (p_0 + \rho g y)\,dy\,.$$

(a) Since the pressure is the same at the two pistons,

$$\frac{f}{a} = \frac{F}{A},$$

Solve for F.

(b) Solve for f and substitute numerical values for F, A, and a. Remember that the cross-sectional area of a tube is proportional to the square of its diameter.

Chapter 15 Hint for Exercise 24

(a) The boat floats in salt water so it displaces water with weight equal to the weight of the boat just as it does in fresh water.

(b) The weight of water is given by $W = \rho g V$, where ρ is the density ($998\, kg/m^2$ for fresh water and $1.1 \times 10^3\,\mathrm{kg/m^3}$ for salt water) and V is the volume of water displaced. Calculate the volume for each case and find the difference.

(a) and (b) The downward force of the liquid on the top face of the object is given by

$$F_t = p_t L^2 \,,$$

where p_t is the pressure there. Since the top of the object is a distance $L/2$ below the surface of the liquid, the pressure is

$$p_t = p_0 + \rho g L/2 \,,$$

where p_0 is atmospheric pressure ($1.01 \times 10^5\,\mathrm{Pa}$) and ρ is the density of the liquid. The bottom face of the object is a distance $3L/2$ below the surface, so the pressure there is

$$p_b = p_0 + 3\rho g L/2$$

and the upward force of the liquid on the bottom face of the object is

$$F_b = p_b L^2 \,.$$

(c) The object is not accelerating, so the net force on it is zero. Thus

$$F_t + mg - F_b - T = 0 \,,$$

where m is the mass of the object and T is the tension force of the rope. Solve for T.

(d) According to Archimedes' principle, the buoyant force is given by $\rho g L^3$. This is $F_b - F_t$ or $(p_b - p_t)L^2$.

(a) Let V_s be the submerged volume. Then, according to Archimedes' principle, the buoyant force has magnitude

$$F_B = \rho g V_s\,,$$

where ρ is the density of water ($998\,\mathrm{kg/m^3}$). The net force on the wood block is zero, so

$$\rho g V_s = (m_w + m_\ell)g\,,$$

where m_w is the mass of the wood block and m_ℓ is the mass of the lead. The total volume of the wood block is $V = m_w/\rho_w$, where ρ_w is the density of the wood. Set V_s equal to $0.90V$ and solve for m_ℓ.

(b) There is now a buoyant force on the lead as well as on the wood block. If ρ_ℓ is the density of lead, then the volume of lead is

$$V_\ell = \frac{m_\ell}{\rho_\ell}\,.$$

The total buoyant force is

$$F_b = \rho g\left(V_s + \frac{m_\ell}{\rho_\ell}\right)$$

and this must equal $(m_w + m_\ell)g$. Again set $V_s = 0.90V$ and solve for m_ℓ.

(a) Since the car is floating, its weight W equals the weight of the displaced water: $W = \rho_w g V_d$, where ρ_w is the density of the water and V_d is the volume of water displaced. Solve for V_d.

(b) Let V_c be the total volume of the car and V_w be the volume of water that enters. Then, the volume of water displaced is given by $V_d = V_c - V_w$. If the acceleration of the car is very small (negligible), then

$$W = \rho_w g V_d = \rho_x g (V_c - V_w)\,.$$

Solve for V_w. Use $V_c = 5.00 + 0.750 + 0.800 = 6.55\,\mathrm{m}^3$.

The volume flow rate in the river must be the sum of the volume flow rates for the two streams:

$$A_1v_1 + A_2v_2 = A_rv_r\ ,$$

where A_1 and A_2 are the cross-sectional areas (width times depth) for the streams and A_r is the cross-sectional area of the river; v_1 and v_2 are the current speeds in the streams and v_r is the current speed in the river. Let d_1, d_2, and d_r be the corresponding depths and w_1, w_2, and w_r be the corresponding widths. Then

$$d_1w_1v_1 + d_2w_2v_2 = d_rw_rv_r\ .$$

Solve for d_r.

Chapter 15 Hint for Exercise 44

(a) Assume the water is incompressible and use the continuity equation in the form

$$A_1 v_1 = A_2 v_2 \,.$$

If A_p is the cross-sectional area of the unconstricted pipe and A_t is the cross-sectional area of the torpedo, then

$$A_p v_p = (A_p - A_t) v_t \,,$$

where v_p in the water speed in the unconstricted portion of the pipe and v_t is the water speed past the torpedo. Use $A = \pi r^2$ to calculate the areas, then solve for v_p.

(b) Since the pipe is horizontal the Bernoulli equation becomes

$$\frac{1}{2}\rho v_1^2 + p_1 = \frac{1}{2}\rho v_2^2 + p_2 \,.$$

Solve for the magnitude of $p_2 - p_1$. The density of water is $0.998 \times 10^3\,\mathrm{kg/m^3}$.

Chapter 15 Hint for Exercise 46

Use Bernoulli's equation. Let v_1 represent the water speed at the intake and v_2 represent the water speed at the outlet. Let h be the height of the intake above the outlet. Also let p_1 be the pressure at the intake and p_2 be the pressure at the outlet. Then

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h = p_2 + \frac{1}{2}\rho v_2^2$$

Solve for $p_1 - p_2$.

CHAPTER 15 HINT FOR EXERCISE 48

The lift force is given by $(p_u - p_t)A$, where p_u is the pressure at the underside of the wing and p_t is the pressure at the top of the wing. Neglect the gravitational terms in Bernoulli's equation and write

$$p_u + \frac{1}{2}\rho v_u^2 = p_t + \frac{1}{2}\rho v_t^2 \,.$$

Solve for $p_u - p_t$ and substitute into the expression for the force.

(a) The stream starts at a height of $H - h$ from the floor. Let v be the initial speed, as the water leaves the tank. Use constant acceleration kinematics to show that

$$x = \sqrt{\frac{2v^2(H-h)}{g}}\,.$$

Now use Bernoulli's equation to find the speed v: take one point on a streamline to be at the water surface at the top of the tank and the other to be at the hole. The pressures at the top of the tank and at the hole are both atmospheric pressure. Assume the speed of the water at the top of the tank is negligible. Then, Bernoulli's equation becomes

$$\rho g H = \rho g(H-h) + \frac{1}{2}\rho v^2\,.$$

Solve for v^2 and substitute into the expression for x.

(b) Solve $x = 2\sqrt{h(H-h)}$ for h. The equation is quadratic so there are two solutions. One is h. You want the other.

(c) Differentiate $x^2 = 4h(H-h)$ with respect to h, set the derivative equal to zero, and solve for h.

Chapter 15 Hint for Problem 58

Refer to Fig. 15–43. Since the speed of the air at point A is zero and point A is at the height as point B, Bernoulli's equation becomes

$$p_A = p_B + \frac{1}{2}\rho v_B^2 \,,$$

where p_A is the pressure at point A, p_B is the pressure at point B and v_B is the air speed at point B. Set $p_A - p_B$ equal to $180\,\mathrm{Pa}$ and solve for v_B.