Questions.

1. $e > b = d > a = c$

3. (a) $1 > 3 > 2$

(b) all tie.

(c) no. Water exerts force perpendicular to the walls of the container. And the vector sum of these forces are exerted on the scale via the walls.

5. $3 > 4 > 1 > 2$

7. (a) downward (b) downward (c) same

9. (a) same (b) same (c) lower (d) higher

Exercises & Problems

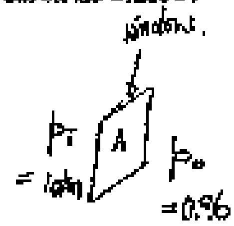
5. An office window has dimensions 3.4 m by 2.1 m. As a result of the passage of a storm, the outside air pressure drops to 0.96 atm, but inside the pressure is held at 1.0 atm. What net force pushes out on the window?

The air outside pushes inward $= F_o = p_o A$

The air inside pushes outward $= F_i = p_i A$

$\Rightarrow$ the net force acting on the window is

$F = (p_i - p_o)A$.



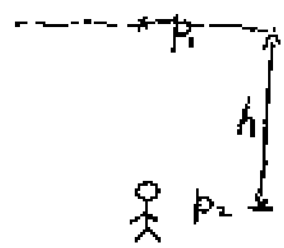
$F = (1.0\ \text{atm} - 0.96\ \text{atm})(1.013\times10^5\ \text{Pa/atm})(3.4\times2.1\ \text{m}^2)$

$= \boxed{2.9\times10^4\ \text{N}.}$

since 1atm $= 1.013\times10^5$ Pa.

13. The human lungs can operate against a pressure differential of up to about 1/20 of an atmosphere. If a diver uses a snorkel for breathing, about how far below water level can she or he swim?

human lungs can take : $\Delta p = P_{atm}/20$



$p_2 = p_1 + \rho g h$

$\Delta p = \rho g h$

P_{atm}

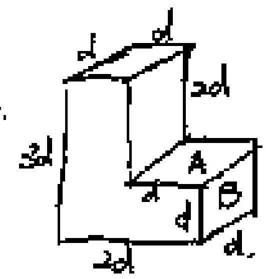
$h = \dfrac{\Delta p}{\rho g} = \dfrac{(1/20)(1.0\times10^5\ \text{Pa})}{(1.0)(10^3\ \text{kg/m}^3)(9.8\ \text{m/s}^2)}$

$\boxed{h = 0.52\text{m}}$

24. The L-shaped tank shown in Fig 15-33 is filled with water and is open at the top. If d = 5.0 m, what are (a) the force on face A and (b) the force on face B due to the water?

ρ of water $= 1\times10^{3}\,kg/m^3$

a) The force on A is



$$F_A = p_A A = \rho g h_A A = 2\rho g d^3$$

$$= 2(1.0\times10^3\,kg/m^3)(9.80\,m/s^2)(5.0\,m)^3$$

$$\boxed{F_A = 2.5\times10^6\,N}$$

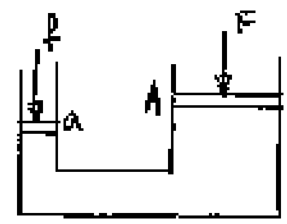
b) The force on B is.

$$F_B = \overline{p_B}\,B = \rho g\left(\frac{5d}{2}\right)d^2 = \frac{5}{2}\rho g d^3$$

$$= \frac{5}{2}(1.0\times10^3\,kg/m^3)(9.80\,m/s^2)(5.0\,m)^3 = \boxed{3.1\times10^6\,N}$$

29. A piston of small cross-sectional area a is used in a hydraulic press to exert a small force f on the enclosed liquid. A connected pipe leads to a larger piston of cross-sectional area A (Fig. 15-35).
(a) What force F will the larger piston sustain?
(b) If the small piston has a diameter of 1.5 in. and the large piston one of 21 in., what weight on the small piston will support 2.0 tons on the large piston?

a) since $\Delta p = \frac{F}{A} = \frac{f}{a}$ (Pascal's)



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

b) The weight on the small piston:

$$\frac{a}{A} = \frac{\pi r^2}{\pi R^2} = \left(\frac{d}{D}\right)^2$$

$$f = \frac{aF}{A} = \left(\frac{d}{D}\right)^2 F$$

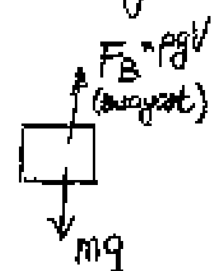
20 lb

$$= \left(\frac{1.5\,in}{21\,in}\right)^2(2.0\,ton) = \boxed{1.0\times10^{-2}\,ton}$$

43. An iron casting containing a number of cavities weighs 6000 N in air and 4000 N in water. What is the volume of the cavities in the casting? The density of iron is 7.87 g/cm³.

$$V_{cav} = V_{cast} - V_{iron} \quad ①$$

$$V_{iron} = \frac{W}{g\rho_{iron}}$$ where W is the weight (mg) of the casting



$$\text{Weight in water} = W_{H_2O} = W - F_B$$
$$= W - g\rho V_{cast}$$
$$\Rightarrow V_{cast} = (W - W_{H_2O}) / g\rho \quad ②$$

Put ② → ①

$$\Rightarrow V_{cav} = \frac{W - W_{H_2O}}{g\rho} - \frac{W}{g\rho_{iron}} = \frac{(6000-4000)N}{(9.8\,m/s^2)(0.998\times10^3\,kg/m^3)} - \frac{6000N}{(9.8\,m/s^2)(7.87\times10^3\,kg/m^3)}$$

$$\boxed{V_{cav} = 0.127\,m^3}$$

57. A river 20 m wide and 4.0 m deep drains a 3000 km² land area in which the average precipitation is 48 cm/y. One – fouth of this rainfall returns to the atmosphere by evaporation, but the remainder ultimately drains into the river. What is the average speed of the river current?

The volume of the rain water that drains back into river is

$$\text{Volume} = \frac{3}{4}\,(\underbrace{3000\times10^6\,m^2}_{\text{Area}})(\underbrace{0.48\,m}_{\text{precipitation}})$$

($\frac{1}{4}$ will returns to atmosphere.)

$$= 1.1\times10^9\,m^3$$

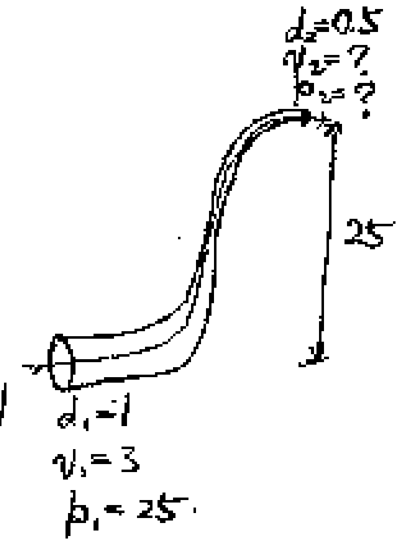
the speed of the river is

$$v = \frac{\text{Length}}{\text{time}} = \frac{\text{Volume}}{\text{AREA}} \times \frac{1}{\text{time}}$$

$$= \frac{1.1\times10^9\,m^3}{(20m)(4.0m)} \times \frac{1}{(1\,year)(3.17\times10^7\,s/year)}$$

$$\boxed{v = 0.43\,m/s}$$

61. A water pipe having a 1.0 in. inside diameter carries water into the basement of a house at a speed 3.0 ft/s and a pressure of 25 lb/in^2. If the pipe tapers to 0.50 in. and rises to the second floor 25 ft above the input point, what are (a) the speed and (b) the water pressure at the second floor?



a) $A_1 v_1 = A_2 v_2$ (conservation of mass)

$$\Rightarrow v_2 = \frac{A_1 v_1}{A_2} = \frac{(1.0\,\text{in})^2 (3.0\,\text{ft/s})}{(0.50\,\text{in})^2}$$

$$= \boxed{12\,\text{ft/s}}$$

b) Apply Bernoulli's equation (assume Ideal flow with no work).

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

$$\Rightarrow p_2 = p_1 + \rho g (h_1 - h_2) + \frac{1}{2}\rho (v_1^2 - v_2^2)$$

$$= 25\,\frac{\text{lb}}{\text{in}^2} + (62\,\text{lb/ft}^3)(-25\,\text{ft}) + \frac{(62\,\text{lb/ft}^3)}{2(32\,\text{ft/s}^2)}\left[(3\,\text{ft/s})^2 - (12\,\text{ft/s})^2\right]$$

$$= \boxed{13\,\text{lb/in}^2}$$

Note: When using Bernoulli's equation:

① assume Ideal Flow with No work.

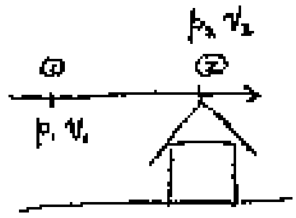
② pick 2 points; usually ① is upstream, ② is downstream.

③ plug in the known values & solve for the unknown

④ only works with a Flow, that is "moving-fluid"

If it is static, you can use $p_1 = p_2 + \rho g h$ to get pressure.

71. In hurricane, the air (density 1.2 kg/m^3) is blowing over the roof of a house at a speed of 110 km/h.
(a) What is the pressure difference between inside and outside that tends to lift the roof?
(b) What would be the lifting force on a roof of area 90 m^2?



a). Apply Bernoulli's equation
(Assume ideal flow with no work)

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

$$\Rightarrow \quad p_1 - p_2 = \frac{1}{2}\rho v_2^2 \quad \left(\text{since } \begin{matrix} h_1 = h_2 \\ v_1 = 0 \end{matrix}\right)$$

for for any where the air is "still"

$$\Delta p = \frac{1}{2}(110\times10^3\,\text{m}/3600\,\text{s})^2$$

$$= \boxed{5.6\times10^2\ \text{Pa.}}$$

$1\ \text{Pa} = 1\ \text{N/m}^2$

b) $$\Delta p = \frac{F}{A} \Rightarrow F = \Delta p \cdot A$$

$$= (5.6\times10^2\ \text{N/m}^2)(90\,\text{m}^2)$$

$$= \boxed{5.0\times10^4\ \text{N}}$$

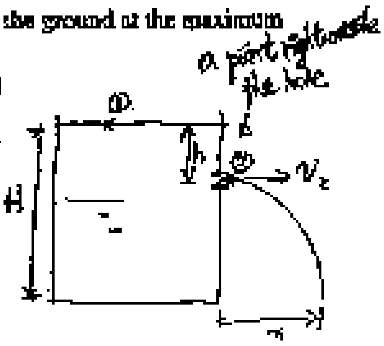
NOTE: Why don't we pick a point inside the house?
— cause the problem states that "...the air is blowing OVER the roof ..." so, from ① to ② is over the roof.
— so we should pick a point with $v=0$ for easier calculation.

75. A tank is filled with water to a height H. A hole is punched in one of the walls at a depth h below the water surface (Fig. 15-46).

(a) Show that the distance x from the base of the tank to the point at which the resulting stream strikes the floor is give by $x = 2[h(H-h)]^{1/2}$.

(b) Could a hole be punched at another depth to produce a second stream that would have the same range? If so, at what depth?

(c) At what depth should the hole be placed to make the emerging stream strike the ground at the maximum distance from the base of the tank?



a). apply Bernoulli's Equation (Assume ideal Flow with NO work)

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

since $v_1 = 0$ (the point we pick on surface).

$$v_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho} + 2g(h_1 - h_2)}$$

$$= \sqrt{2g(h_1 - h_2)} = \sqrt{2gh}. \quad \text{since } P_1 = P_2 = P_{atm}$$

also $\frac{1}{2}gt^2 = H - h$ (vertical direction) + $x = v_2 t$ (horizontal direction)

$$\Rightarrow x = v_2 t = \sqrt{2gh}\sqrt{\frac{2(H-h)}{g}} \Rightarrow \boxed{x = 2\sqrt{h(H-h)}} \quad ①.$$

b) YES! for a hole at $\boxed{h' = H - h}$ below the surface.

range $x' \Rightarrow x' = 2\sqrt{h'(H-h')}$

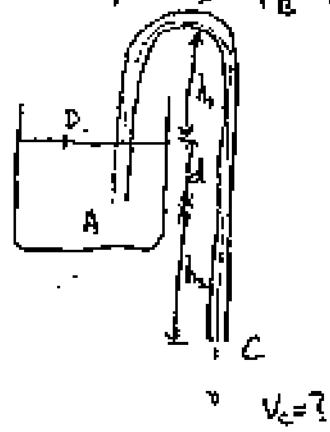
$$= 2\sqrt{(H-h)h} = x$$

c). We want to maximize $f(h) = h(H-h)$

$$\Rightarrow \frac{df}{dh} = h - 2H$$

$\frac{df}{dh} = 0$ when $\boxed{h = H/2}$ which is the max

76. A siphon is a device for removing liquid from a container. It operates as shown in Fig 15-47. Tube ABC must initially be filled, but once this has been done, liquid will flow through the tube until the liquid surface in the container is level with the tube opening at A. The liquid has density ρ and negligible viscosity.
(a) What speed does the liquid emerge from the tube at C? v_c
(b) What is the pressure in the liquid at the topmost point B? P_B
(c) Theoretically, what is the greatest possible height h_1 that a siphon can lift water? h_1 $\quad$ B $\quad P_B = ?$



a) Apply Bernoulli's Equation from D to C.

$$p_D + \frac{1}{2}\rho v_D^2 + \rho g h_D = p_c + \frac{1}{2}\rho v_c^2 + \rho g h_c$$

$$\Rightarrow v_c = \sqrt{\frac{2(p_D - p_c)}{\rho} + 2g(h_D - h_c) + v_D^2}$$

$$\boxed{v_c \approx \sqrt{2g(d+h_2)}} \qquad \text{where } p_D = p_c = p_{air}, \quad v_D = 0$$

b). Apply Bernoulli's Equation from B to C.

$$\Rightarrow p_B + \frac{1}{2}\rho v_B^2 + \rho g h_B = p_c + \frac{1}{2}\rho v_c^2 + \rho g h_c \quad \text{—— ①}$$

since $v_B = v_c$ (by equation of continuity)
& $p_c = p_{air}$.

① becomes $p_B = p_c + \rho g(h_c - h_B) = \boxed{p_{air} - \rho g(h_1 + d + h_2)}$

c) Since $p_B \geq 0$. $\Rightarrow \underbrace{p_{air} - \rho g(h_1 + d + h_2)}_{\text{part (b)}} \geq 0$

$$\therefore h_1 \leq h_{max} = \frac{p_{air}}{g\rho} - d - h_2 \leq \frac{p_{air}}{g\rho} \Rightarrow \boxed{h_{1,max} \leq \frac{p_{air}}{g\rho}} \sim 10.3m$$

(ρ: density of H_2O)