HW 1.3

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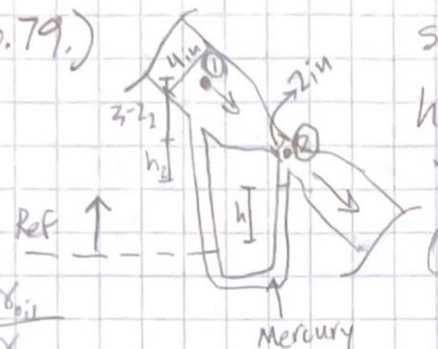
The group 1

6.79.)



Mercury sg=13.54

$sg_{oil}=0.9$

$h=28\,in$

$\gamma_{water}=9.81\,\frac{kN}{m^3}$

$Q=?$

$$\frac{P_1}{\gamma_{oil}}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\gamma_{oil}}+\frac{V_2^2}{2g}+z_2$$

$Q=V\cdot A$ $\quad \Delta P=\gamma_{oil}\cdot h$

$$\frac{Q^2}{2g}\left(\frac{1}{A_1^2}-\frac{1}{A_2^2}\right)=\frac{P_2-P_1}{\gamma}+(z_1-z_2)$$

$$Q=\sqrt{\frac{2g\left(\frac{P_2-P_1}{\gamma}+(z_1-z_2)\right)}{\frac{1}{A_1^2}-\frac{1}{A_2^2}}}$$

$$sg_{oil}=\frac{\gamma_{oil}}{\gamma_{water@4C}}$$

$$0.9=\frac{\gamma_{oil}}{9810\frac{N}{m^3}}$$

$$\gamma_{oil}=8829\,\frac{N}{m^3}$$

$$A_1=\frac{\pi}{4}D_1^2=\frac{\pi}{4}(0.33\,ft)^2=0.0873\,ft^2$$

$$A_2=\frac{\pi}{4}D_2^2=\frac{\pi}{4}(0.167\,ft)^2=0.0218\,ft^2$$

$$P_1+\gamma_{oil}((z_1-z_2)+h_2+h)-\gamma_{Hg}h-\gamma_{oil}h_2=P_2$$

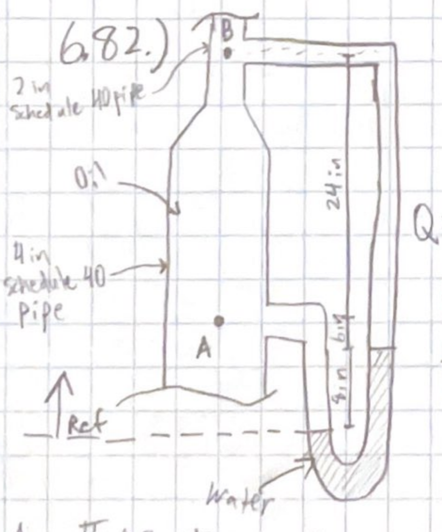
$$\frac{P_2-P_1}{\gamma_{Hg}}=(z_1-z_2)+\left(1-\frac{\gamma_{Hg}}{\gamma_{oil}}\right)h$$

$$\frac{P_2-P_1}{\gamma_{Hg}}=(z_1-z_2)+\left(1-\frac{sg_{Hg}}{sg_{oil}}\right)h$$

$$Q=\sqrt{\frac{2g\left(1-\frac{sg_{Hg}}{sg_{oil}}\right)h}{\frac{1}{A_1^2}-\frac{1}{A_2^2}}}$$

$$Q=\sqrt{\frac{2\cdot 32.2\frac{ft}{s^2}\left(1-\frac{13.54}{0.9}\right)\cdot 2.33\,ft}{\frac{1}{(0.0873\,ft^2)^2}-\frac{1}{(0.0218\,ft^2)^2}}}\Rightarrow\boxed{Q=1.034\,\frac{ft^3}{s}}$$

6.82.)



$\gamma_{oil}=55.0\,\frac{lb}{ft^3}$

$\gamma_{water}=62.4\,\frac{lb}{ft^3}$

$Q=?$

$$\frac{P_A}{\gamma_{oil}}+\frac{V_A^2}{2g}+\underset{14\,in}{z_A}=\frac{P_B}{\gamma_{oil}}+\frac{V_B^2}{2g}+\underset{38\,in}{z_B}$$

$Q=V_A A_A$ $\quad \Delta p=\gamma_{oil}\cdot h$

$$P_A-\gamma_{oil}\cdot\frac{14\,in}{12\,in}ft+\gamma_{water}\cdot\frac{8\,in}{12\,in}ft+\gamma_{oil}\cdot\frac{30\,in}{12\,in}ft=P_B$$

$$P_B-P_A=550\frac{lb}{ft^3}\cdot\frac{14}{12}ft+62.4\frac{lb}{ft^3}\cdot\frac{8}{12}ft+550\frac{lb}{ft^3}\cdot\frac{30}{12}ft=\frac{P_B-P_A}{\gamma_{oil}}=\frac{2058.3\frac{lb}{ft^2}}{\gamma}$$

$$\frac{P_B-P_A}{\gamma}=\frac{2058.3\frac{lb}{ft^2}}{62.43\frac{lb}{ft^3}}$$

$$\frac{P_B-P_A}{\gamma}=32.97\,ft$$

$$\frac{P_A-P_B}{\gamma}+z_A-z_B=\frac{V_B^2-V_A^2}{2g}$$

$$A_A=\frac{\pi}{4}D_A^2=\frac{\pi}{4}(0.33\,ft)^2=0.0873\,ft^2$$

$$A_B=\frac{\pi}{4}D_B^2=\frac{\pi}{4}(0.167\,ft)^2=0.0218\,ft^2$$

$$z_A-z_B=\frac{14}{12}ft-\frac{38}{12}ft=-2\,ft$$

$A_A V_A=A_B V_B$ $\quad V_B=V_A(A_A/A_B)$ $\quad V_B=V_A(4)$ $\quad V_B^2=16V_A^2$

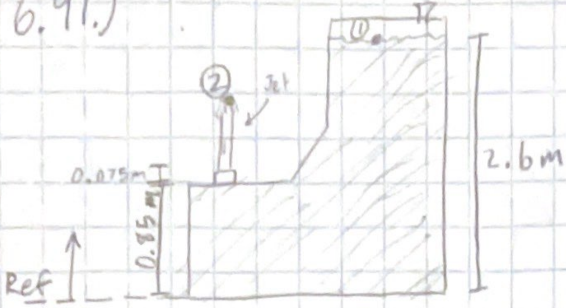
$$V_B^2-V_A^2=16V_A^2-V_A^2=15V_A^2$$

$$32.97\,ft-2\,ft=\frac{15V_A^2}{2g}$$

$$V_A=\sqrt{\frac{2g(30.97\,ft)}{15}}=11.53\,\frac{ft}{s}$$

$$Q=V_A A_A=11.53\,\frac{ft}{s}\cdot 0.0873\,ft^2=\boxed{1.006\,\frac{ft^3}{s}=Q}$$

6.91.)



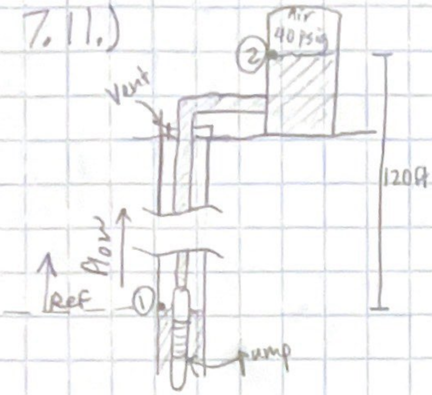
$h_{jet} = ? = z_2$ $\quad V_1 =$ negligible $\quad V_2 = 0\ m/s$

$P_1 = P_2 =$ ATM pressure

$$z_2 = \frac{P_1 - P_2}{\gamma} + \frac{V_1^2 - V_2^2}{2g} + z_1$$

$$z_2 = \frac{\cancel{P_1 - P_2}}{\gamma} + z_1 \qquad z_2 = z_1 = \boxed{2.6\,m}$$

7.11.)



$Q = 745\ \frac{gal}{h}$ $\quad \gamma = 62.4\ \frac{lb}{ft^3}$ $\quad p_1 = 40\ psig = 5760\ \frac{lb}{ft^2}$

$h_L = 10.5\ \frac{lb \cdot ft}{lb}$ $\quad P = \gamma Q h_A$

$Q = 745\ \frac{gal}{h}\left(\frac{1\,hr}{3600\,s}\right)\left(\frac{0.1336\,ft^3}{1\,gal}\right) = 0.0277\ \frac{ft^3}{s}$

a.) $P = ?$ b.) $\varepsilon = ?$

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{\cancel{V_2^2 - V_1^2}}{2g} + z_2 - \cancel{z_1} + h_L$$

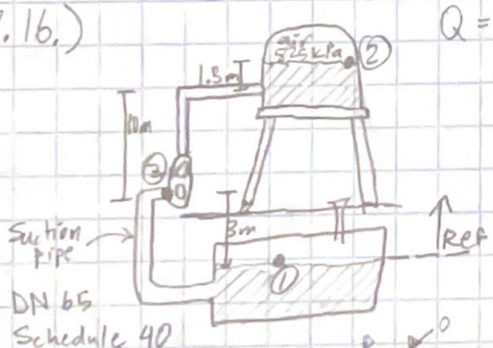
$$h_A = \frac{P_2}{\gamma} + z_2 + h_L = \frac{5760\ \frac{lb}{ft^2}}{62.4\ \frac{lb}{ft^3}} + 120\,ft + 10.5\ \frac{lb \cdot ft}{lb} = 222.81\,ft$$

$P = \gamma Q h_A$

$$P = 62.4\ \frac{lb}{ft^3}\left(0.0277\ \frac{ft^3}{s}\right)(222.81\,ft) = 385.12\ \frac{lb \cdot ft}{s}\left(\frac{1\,hp}{550\ \frac{lb \cdot ft}{s}}\right) = \boxed{0.700\ hp = P}$$

b.) $\varepsilon_A = \frac{P_A}{P_{input}} = \frac{0.700\ hp}{1\,hp} = \boxed{70\%}$

7.16.)



$Q = 840\ \frac{L}{min} = 0.014\ \frac{m^3}{s}$ $\quad sg_{oil} = 0.85$

$$h_A + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L12}$$

$P = \gamma Q h_A$ $\quad \gamma_{oil} = sg_{oil} \cdot \gamma_{H_2O}$ $\quad Q = V \cdot A$

calculate power delivered to pump, $h_L = 4.2\ \frac{N \cdot m}{N}$

calculate pump inlet pressure, $h_{Lsuc} = 1.4\ \frac{N \cdot m}{N}$

$$h_A = \frac{P_2 - \cancel{P_1}}{\gamma} + \frac{\cancel{V_2^2 - V_1^2}}{2g} + z_2 - \cancel{z_1} + h_{L12} \qquad h_A = \frac{P_2}{\gamma} + z_2 + h_{L12}$$

$$h_A = \frac{825\ kPa}{0.85 \times 9810\ \frac{N}{m^3}} + 14.5\,m + 4.2\ \frac{N \cdot m}{N} = 117.64\,m$$

$$P = \left(0.85 \times 9810\ \frac{N}{m^3}\right) \cdot 0.014\ \frac{m^3}{s} \cdot 117.64\,m \Rightarrow \boxed{P = 13.733\ kW}$$

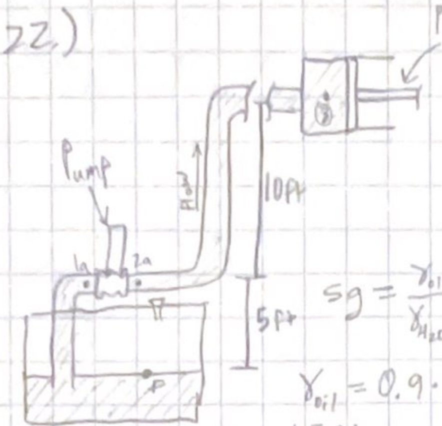
$\frac{P_3}{\gamma} = -\frac{V_3^2}{2g} - z_3 - h_{L13}$ $\quad V_3 = \frac{Q}{A_3}$ $\quad$ from tables $\Rightarrow A_3 = 3.09 \times 10^{-3}\ m^2$

$$V_3 = \frac{0.014\ \frac{m^3}{s}}{3.09 \cdot 10^{-3}\ m^2} = 4.531\ \frac{m}{s}$$

$$P_3 = \left(0.85 \times 9810\ \frac{N}{m^3}\right)\left(-\frac{(4.531\ \frac{m}{s})^2}{2 \cdot 9.81\ \frac{m}{s^2}} - 3\,m - 1.4\,m\right)$$

$$\boxed{P_3 = -45.41\ kPa}$$

7.22)



Pipe: $\frac{3}{8}$ in schedule 80 steel pipes

$sg_{oil} = 0.9$

$d = 5.0\,in$ $\qquad h_A = 35.0\,\frac{lb\cdot ft}{lb}$

$F = 11000\,lbf$ $\qquad h_L = 11.5\,\frac{lb\cdot ft}{lb}$

$sg = \frac{\gamma_{oil}}{\gamma_{H_2O @ 4°C}}$ $\qquad \frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_A = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + \cancel{h_R}^{0} + h_L$

$\gamma_{oil} = 0.9 \cdot 9810\,\frac{N}{m^3} \cdot \left(\frac{1m}{3.2814}\right)^3 \cdot \left(\frac{1\,lbf}{4.408N}\right) = 56.7089\,\frac{lbf}{ft^3}$ $\qquad P_f = 0\,psi$

$z_3 = 15\,ft$

$Q_3 = \frac{\frac{\pi \cdot (5in)^2}{4} \cdot 20in}{15s} = 26.17994\,\frac{in^3}{s} \cdot \frac{1ft^3}{1728\,in^3} = 0.01515\,\frac{ft^3}{s}$

$Q_2 = Q_3 = \boxed{0.01515\,\frac{ft^3}{s} = Q_2}$ (a) $\qquad V_3 = \frac{0.01515\,\frac{ft^3}{s}}{\frac{(5in)^2 \cdot \pi}{4} \cdot \frac{1ft^2}{144}} = 0.1111\,\frac{ft}{s}$ $\qquad z_2 = 5ft$

$A_2 = 0.00133\,ft^2$

$Q_2 = A_2 V_2$ $\qquad \frac{Q_2}{A_2} = V_2 = \frac{0.1515\,\frac{ft^3}{s}}{0.000976\,ft^2} = 15.523\,\frac{ft}{s}$

$P_3 = \frac{11000\,lbf}{\frac{(5in)^2 \cdot \pi}{4} \cdot \frac{1ft^2}{144\,in^2}} = \boxed{80672.46\,\frac{lbf}{ft^2} = P_3}$ (b.)

$\cancel{h_A}^{0} + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3 + \cancel{h_L}^{0} + \cancel{h_r}^{0}$ $\qquad P_2 = \left(\frac{P_3}{\gamma_{oil}} + \frac{V_3^2}{2g} + z_3 - z_2 - \frac{V_2^2}{2g}\right)\gamma_{oil}$

$P_2 = \left(\frac{80672.46\,\frac{lbf}{ft^2}}{56.7089\,\frac{lbf}{ft^3}} + \frac{(0.1111\,ft/s)^2}{2 \cdot 32.2\,\frac{ft}{s^2}} + 15ft - 5ft - \frac{(15.523\,\frac{ft}{s})^2}{2 \cdot 32.2\,\frac{ft}{s^2}}\right) = \boxed{P_2 = 81027.37\,\frac{lbf}{ft^2}}$ (c.)

$Q_1 = Q_2 = Q_3 = 0.01515\,\frac{ft^3}{s}$ $\qquad \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + h_A = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L + \cancel{h_R}^{0}$

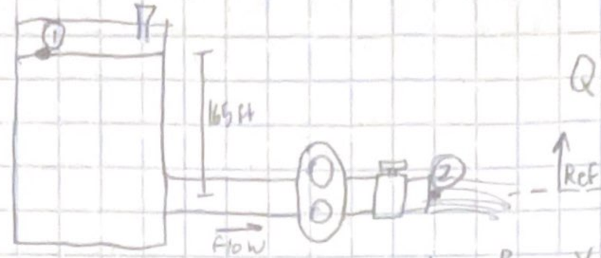
$V_1 = \frac{Q_1}{A} = \frac{0.01515\,\frac{ft^3}{s}}{0.000976\,ft^2} = 15.223\,\frac{ft}{s}$ $\qquad z_1 = z_2 \qquad V_1 = V_2$ $\qquad P_1 = \left(\cancel{\frac{V_2^2}{2g} - \frac{V_1^2}{2g}}^{0} + \cancel{z_2 - z_1}^{0} - h_A + h_L + \frac{P_2}{\gamma}\right)\gamma$

$P_1 = \left(h_L - h_A + \frac{P_2}{\gamma}\right)\gamma = \left(11.5\,\frac{lb\,ft}{lb} - 35.0\,\frac{lb\,ft}{lb} + \frac{81027.37\,\frac{lbf}{ft^2}}{56.7089\,\frac{lbf}{ft^3}}\right) 56.7089\,\frac{lbf}{ft^3}$

$\boxed{P_1 = 79694.71\,\frac{lbf}{ft^2}}$ (d)

$P_A = \gamma Q h_A = 56.7089\,\frac{lbf}{ft^3} \cdot 0.01515\,\frac{ft^3}{s} \cdot 35.0\,\frac{lb\,ft}{lbf} \Rightarrow \boxed{P_A = 30.07074\,W}$ (e)

7.30.)



H_2O @ 60°F

$Q = 1000 \frac{gal}{min} = 2.23 \frac{ft^3}{s}$

Motor removes 37 hp from fluid

$h_L = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 - \frac{P_2}{\gamma} - \frac{V_2^2}{2g} - Z_2 - h_r$

$Q = V \cdot A \qquad P_r = h_r \gamma Q \qquad P_r = 37\,hp$

$h_L = \cancel{\frac{P_1}{\gamma}}^{0} + \cancel{\frac{V_1^2}{2g}}^{0} + \underbrace{Z_1}_{165ft} - \cancel{\frac{P_2}{\gamma}}^{0} - \frac{V_2^2}{2g} - \cancel{Z_2}^{0} - h_r \qquad h_L = 165ft - \frac{V_2^2}{2g} - h_r$

$P_r = h_r \gamma Q \qquad 37hp = h_r \gamma Q \qquad \gamma Q = (62.4 \frac{lb}{ft^3} \cdot 2.23 \frac{ft^3}{s}) = 139.15 \frac{lb}{s}$

$37hp = h_r (139.15 \frac{lb}{s})$

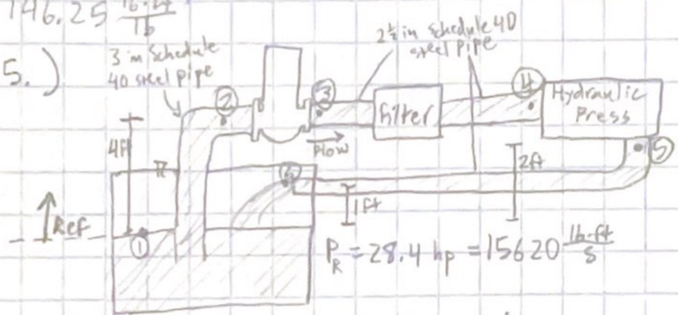
$h_r = \frac{37hp \cdot 550 (\frac{lb \cdot ft}{s})/hp}{139.15 \frac{lb}{s}}$

$h_r = 146.25 \frac{lb \cdot ft}{lb}$

$Q = V \cdot A \qquad V_2 = \frac{Q}{A} = \frac{2.23 \frac{ft^3}{s}}{0.3472 ft^2}$

$h_L = 165ft - \frac{6.423 \frac{ft}{s}}{2(32.2 ft/s^2)} - 146.25 \frac{lb \cdot ft}{lb} \Rightarrow \boxed{h_L = 18.65\ ft}$

7.35.)



$\gamma = 58.032 \frac{lb}{ft^3}$

$175 \frac{gal}{min} = 0.38976 \frac{ft^3}{s}$

$A_{3in} = 0.05132 ft^2 \qquad P_R = h_A \gamma Q$

$A_{2\frac{1}{2}in} = 0.03326 ft^2$

$P_R = 28.4\,hp = 15620 \frac{lb \cdot ft}{s}$

$h_A = \frac{P_R}{\gamma Q} = \frac{15620}{(58.032)(0.38976)}$

$h_A = 552.47\ ft$

$h_{1\to2} = 2.8 \frac{lb\,ft}{lb}$

$h_{3\to4} = 28.5 \frac{lb\,ft}{lb}$

$h_{5\to6} = 3.5 \frac{lb\,ft}{lb}$

$h_A = h_{1\to2} + h_{3\to4} + h_{4\to5} + h_{5\to6}$

$h_{4\to3} = h_A - h_{1\to2} - h_{3\to4} - h_{5\to6}$

$h_{4\to5} = h_A - 34.8 \frac{ft\,lb}{lb}$

$h_{4\to5} = 690.58 - 34.8 \frac{ft\,lb}{lb}$

$h_{4\to5} = 655.78\ ft$

$P_R = (517.67)(58.032)(0.38976)$

$P_R = 11708.94598 \frac{lb\,ft}{s} \cdot \frac{1hp}{550 \frac{lb\,ft}{s}} = 21.29\ hp$

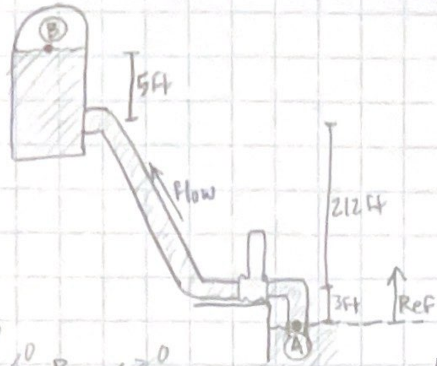
$\boxed{P_R = 21.29\ Hp}$

$h_{4\to5} = h_A - h_{1\to2} - h_{3\to4} - h_{5\to6}$

$h_{4\to5} = 552.47 - 2.8 - 28.5 - 3.5$

$h_{4\to5} = 517.67 ft$

7.42.)



$P = 30\ psi$

$h_{1\to2} = 15.5\ \frac{lb\,ft}{lb}$

$Q = \frac{40\,gal}{min} \cdot \frac{1\,ft^3}{7.48\,gal} \cdot \frac{1\,min}{60\,sec} \approx 0.089\ \frac{ft^3}{sec}$

$Q = 0.089\ \frac{ft^3}{sec}$

$$h_A + \cancel{\frac{P_1}{\gamma}}^{0} + \cancel{\frac{v_1^2}{2g}}^{0} + \cancel{z_1}^{0} = \frac{P_2}{\gamma} + \cancel{\frac{v_2^2}{2g}}^{0} + z_2 + h_{1\to2}$$

$$h_A = \frac{P_2}{\gamma} + z_2 + h_{1\to2}$$

$$h_A = \frac{30\,\frac{lb}{in^2} \cdot \frac{144\,in^2}{1\,ft^2}}{62.4\,\frac{lb}{ft^3}} + 220\,ft + 15.5\,ft$$

$h_A = 304.73\ ft$

$P_A = \gamma Q h_A$

$$P_m = \frac{P_A}{\eta_A} = \frac{\gamma Q h_A}{\eta_A}$$

$P_m = (62.4)(0.089)(304.73)$

$P_m = 1692.35\ \frac{lb\,ft}{s} = \boxed{3.077\ Hp = P_m}$

Practice Problems Reflection

We learned Professor Ayala's specific method for solving problems last week. The first step is to draw a sketch to help visualize the problem. This helps to establish scale for the problem so that distances can be determined. The next step is to plot points on the sketch based on points that you have the most information about. The next step is to establish a reference height. This allows every equation used on the problem to relate to a single point so that they can be set equal. The next step is to gather any relevant equations and solve the problem.

We also learned that pressure at the opening of a tank must be equal to atmospheric pressure. If it was less, air would be forced into the opening. If the pressure were larger, the fluid would blossom out of the opening in all directions. Therefore, since neither of these occur, the pressure must be equal to the atmosphere.