Homework #1.3

Ch 6 Flow Fluids and Bernoulli's Equation

MET 330 Virginia Beach Distance Learning WC2 and Campus

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Due Date: 09/19/19

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HW 1.3

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9/19/19

HW1.3

We will be using Bernoulli's equation for the rest of semester. If we see temperature changes, we need to use thermodynamics. There is always an energy loss due to friction when a pump or a turbine is added to the 1st law of thermodynamics. (energy conversion) Remember that steady states must be equal. Way to control velocity in a pipe is playing with the area. To gain potential energy, pressure must increase. Energy losses depends on diameter, pressure, and area. Besides Bernoulli's equation, we need to ~~remember~~ flowrate ($Q = VA$) and $P = \gamma QH$ (Power).

When doing problems, [illegible] the [illegible].

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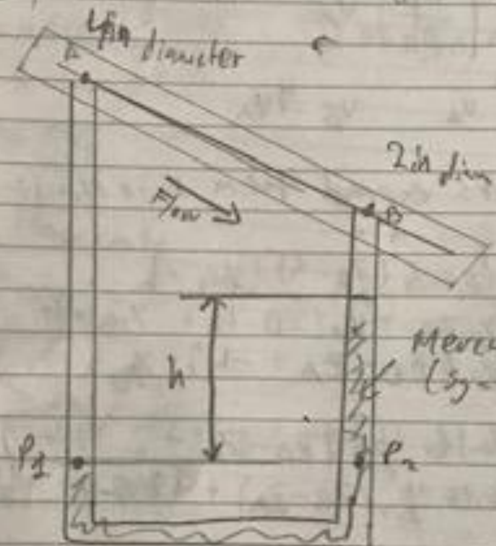
Problem 79 2/#

Oil with a specific gravity of 0.90 is flowing downward through the venturi meter shown in fig 6.33. If the manometer deflection h is 28 in, calculate the volume flow rate of oil.



Given specific weight of oil

$\gamma_o = sg_{oil} \times \gamma_{water}$

$= 0.9 \times 62.4 = 56.16 \ lb/ft^3$

$\gamma_{Hg} = sg_{Hg} \times \gamma_{water}$

$= 13.54 \cdot 62.4 = 844.896 \ lb/ft^3$

$h = 28 \text{ in} \left(\frac{1 ft}{12 in}\right) = 2.333 \ ft$

Have pressure points equal to each other

$P_A = P_B \quad P_1 = P_2$

Expand up on it

Nathaniel

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Relation between velocity of water

$A_B V_B = A_A V_A$

Area

Expand / break down A_A and A_B

$\frac{\pi D_B^2}{4} V_B = \frac{\pi D_A^2}{4} V_A$ =

Find $V_B = \left(\frac{D_B}{D_A}\right)^2 V_A$ Plug in diameters

$V_B = \left(\frac{4 in}{2 in}\right)^2 V_A$ $V_B = 4 V_A$

Pressure points expand them into equations

$P_1 = P_2$

$P_A + \gamma_0 z_A = P_B + \gamma_0 (z_B - h) + \gamma_{Hg} \times h$

$P_A - P_B = -\gamma_0 z_A + \gamma_0 (z_B - h) + \gamma_{Hg} \times h$

$P_A - P_B = \gamma_0 (z_B - z_A + -h) + \gamma_{Hg} h$

Plug in values

13.102 1971.424

$= 56.16 \frac{lb}{ft^3} (z_B - z_A - 2.333 ft) + 881.896 \frac{lb}{ft^3} (2.333 ft)$

$P_A - P_B = 56.16 \frac{lb}{ft^3} (z_B - z_A) + 1840.40 \frac{lb}{ft^3}$

Apply Bernoulli's equation between

$\frac{P_A}{\gamma_0} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma_0} + \frac{V_B^2}{2g} + z_B$

Combine like terms

$\frac{P_A - P_B + \gamma_0 (z_A - z_B)}{\gamma_0} = \frac{V_B^2 - V_A^2}{2g}$ =

$\frac{\left(56.16 \frac{lb}{ft^3} (z_B - z_A) + 1840.40 \frac{lb}{ft^3}\right) + 56.16 \frac{lb}{ft^3} (z_A - z_B)}{56.16 \frac{lb}{ft^3}} = \frac{(4 V_A)^2 - V_A^2}{2 (32.2 ft/s^2)}$

$g = 32.2 ft/s^2$

Nathaniel Yapnayo

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Problem 79 (con't)

$$\frac{1840.40\ \frac{lb}{ft^2}}{56.16\ \frac{lb}{ft^3}} = \frac{\overset{16V_A^2}{(4V_A)^2} - V_A^2}{64.4\ ft/s^2} = \frac{15\ V_A^2}{64.4\ ft/s^2}$$

$$V_A = \sqrt{\frac{64.4\ ft/s^2}{15}\ \frac{1840.40}{56.16}} = 11.8615\ ft/s$$

$V_A = 11.86\ ft/s$

Volume flow rate:

$Q = A_A V_A$

$= \left(\frac{\pi D_A^2}{4}\right) V_A$

From $D_A = 4in\left(\frac{1}{12in}\right) = 0.33\overline{3}$

$$Q = \left(\frac{\pi\left(\frac{4in}{12in}\right)^2}{4}\right)(11.86\ ft/s)$$

Volume flow rate

$$\boxed{Q = 1.0347\ ft^3/s \approx 1.035\ \frac{ft^3}{s}}$$

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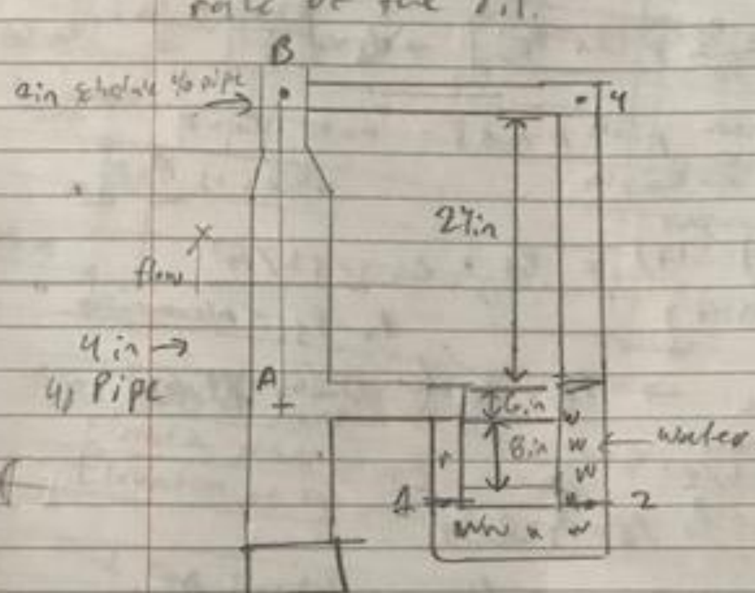
Problem 82

Oil with a specific weight of 55.0 lb/ft³ flows from A to B through the system shown in fig 6.35. Calculate the volume flow rate of the oil.



Given weight of oil $\gamma_o = 55\ lb/ft^3$

Point A = $D_A = 4in$

point B = $D_B = 2in$

Flow rate equation

$Q = AV$

Bernoulli's equation = $\frac{P_A}{\gamma_o} + z_A + \frac{V_A^2}{2g} = \frac{P_B}{\gamma_o} + z_B + \frac{V_B^2}{2g}$

Velocity of flow at points A and B $A_A V_A = A_B V_B$

$A = \frac{\pi D^2}{4} \rightarrow \left(\frac{\pi D_A^2}{4}\right) V_A = \left(\frac{\pi D_B^2}{4}\right) V_B$

Find V_B App'y diameters/numbers)

$\left(\frac{\pi (4)^2}{4}\right) V_A = \left(\frac{\pi (2)^2}{4}\right) V_B \rightarrow 12.57 V_A = 3.14 V_B$

$V_B = 4 V_A$

Use Bernoulli's equation

$$\frac{P_A}{\gamma_o} + z_A + \frac{V_A^2}{2g} = \frac{P_B}{\gamma_o} + z_B + \frac{(4V_A)^2}{2g} \leftarrow 16V_A^2$$

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Places in the values by solving for V_A

$$\frac{P_A - P_B}{\gamma_o} + z_A - z_B = \frac{16V_A^2 - V_A^2}{2g} \leftarrow \frac{15V_A^2}{2g}$$

$$V_A^2 = \left(\frac{2g}{15}\right)\left[\frac{P_A - P_B}{\gamma_o} + (z_A - z_B)\right] \rightarrow V_A = \sqrt{\left(\frac{2g}{15}\right)\left[\frac{P_A - P_B}{\gamma_o} + (z_A - z_B)\right]}$$

Pressure between points A and B — make $P_A = P_1$

$P_1 = P_A + \gamma_o h_1 \leftarrow$ height, which is $P_1 = P_2$

$\gamma_o \leftarrow$ oil weight

$= P_A + (55)(1.17) = P_A + 64.35\ \text{lb/ft}^2$

At pressure point 3 — $P_2 = P_3 \leftarrow$ elevation

values

$P_3 = P_2 - \gamma_w h_2 \rightarrow P_3 = P_A + (64.35 - (62.4)(0.67))$

$\gamma_w \leftarrow$ water

$P_3 = P_A + 22.54\ \text{lb/ft}^2$

Pressure point B, $P_B = P_3 - \gamma_o h_3$

Plug in P_3

$P_B = P_A + (22.54\ \text{lb/ft}^2 - (55)(2.4))$

$P_B = P_A - 107.94\ \text{lb/ft}^2$

$P_A - P_B = 114.96\ \text{lb/ft}^2$

Put back in V_A

$$V_A = \sqrt{\left(\frac{2 \times 32.2\ \text{ft/s}^2}{15}\right)\left[\frac{114.96}{55} + (0 - 2)\right]}$$

$$= \sqrt{4.29 \times 0.09} = 0.621\ \text{ft/s}$$

Pipe at Point A $\quad A_A = \frac{\pi D_A^2}{4} = \frac{\pi (0.33)^2}{4}$

$= 0.0855$

Flow rate

$Q = 0.086 \times 0.621$

$$\boxed{Q = 0.0531\ \text{ft}^3/\text{s}}$$

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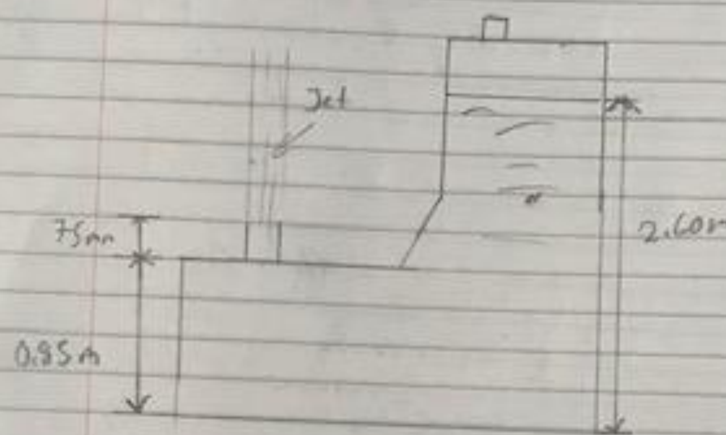
Problem 91

To what height will the jet of fluid rise for the conditions shown in Figure 6.39



Given height tank $h = 2.6m$

Elevation of base of outlet, $h_1 = 0.85m$

Elevation of tip of outlet, $h_2 = 75mm = 0.075m$

Find the height of the jet of fluid

$$h_j = h - (h_1 + h_2)$$

$$= 2.6m - (0.85 + 0.075)$$

$$\boxed{h_j = 1.675\ m}$$

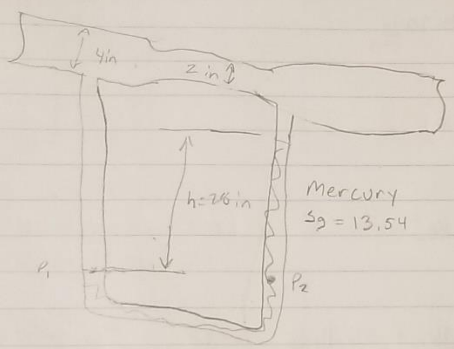
Aaron Jackson

Hw 1,3 Question: 1 ; chp 6: 79, 82, 91

1 We learned about Bernoulli's equation and flow rate which is equal to $Q = VA$. When it comes to velocity in a pipe, the way to control it is by changing the area. An example of this was changing a hose area to make the water come out faster. When a pump or turbine is added there is always an energy loss due to friction. Gaining potential energy is a result of pressure being increased

Chapter 6

79



Mercury
$S_g = 13.54$

$28\text{in} \; \frac{1}{12} = 2.33 \; ft$

$\gamma_o = S_{g_{oil}} \times \gamma_{water} = 0.9 \times 62.4 = 56.16 \; lb/ft^3$

$\gamma_{Hg} = S_{g_{Hg}} \times \gamma_{water} = 13.59 \times 62.4 = 884.29 \; lb/ft^3$

$P_A \; P_B \quad P_1 = P_2$

$A_B V_B = A_A V_A$

$\frac{\pi D_B^2 V_B}{4} = \frac{\pi D_A^2}{4} V_A \qquad V_B = \left(\frac{D_B}{D_A}\right)^2 V_A$

$$V_B = \left(\frac{4\,in}{2\,in}\right)^2 V_A$$

$$V_B = 4 V_A$$

$$P_1 = P_2$$

$$P_A + \gamma_o z_A = P_B + \gamma_o (z_B - h) + \gamma_{Hg} * h$$

$$P_A - P_B = -\gamma_o z_A + \gamma_o (z_B - h) + \gamma_{Hg} * h$$

$$P_A - P_B = \gamma_o (z_B - z_A + -h) + \gamma_{Hg} h$$

$$36.16 \frac{lb}{ft^3} (z_B - z_A - 2.333\,ft) + 889.846 \frac{lb}{ft^3} \cdot 2.333\,ft$$

$$= 36.16 \frac{lb}{ft^3}\ z_B - z_A + 1840.90 \frac{lb}{ft^3}$$

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

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

$$\frac{56.16 \frac{lb}{ft^2}\ z_B - z_A + 1890.48 \frac{lb}{ft} + 56.16 \frac{lb}{ft^3}\ z_A - z_B}{56.16 \frac{lb}{ft}} \quad (4 V_A)^2$$

$$= 32.2\ ft/s^2$$

$$\frac{1840.40 \frac{lb}{ft^3}}{36.16 \frac{lb}{ft^3}} = \frac{\overset{16 V_A^2}{(4V_A)^2} - V_A^2}{64.4\ ft/s^2} = \frac{15\ V_A^2}{64.4\ ft/s^2}$$

$$V_A = \sqrt{\frac{64.4\ ft/s^2}{15} \frac{1840.40}{36.16}} = 11.86190\ ft/s$$

$Q = A_A V_A = \frac{\pi D_A^2}{4} \cdot V_A$

$Q = \frac{\pi \cdot \left(\frac{4in}{12in}\right)^2}{4} \cdot 11.86\ ft/s$

$Q = 1.0347\ ft^3/s$

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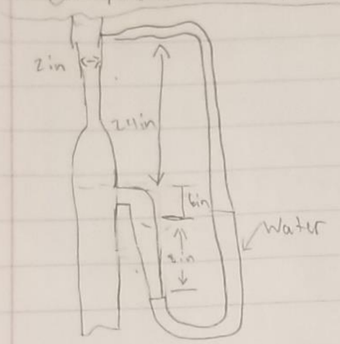


$\gamma_o = 55\ lb/ft^3$

point A = $D_A = 4in$

Point B = $D_B = 2in$

$Q = AV$

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

$$A = \frac{\pi D_A^2}{4} V_A = \frac{\pi D_B^2}{4} V_B$$

$$\frac{\pi(4)^2}{4} V_A^2 \cdot \frac{\pi(2)^2}{4} V_B = 12.57\ V_A = 3.14\ V_B \qquad V_B = 4V_A$$

$$\frac{P_A - P_B}{\gamma_o} + z_A - z_B = \frac{16 V_A^2 - V_A^2}{2g} = \frac{15 V_A^2}{2g}$$

$$V_A^2 = \frac{2g}{15}\left[\frac{P_A - P_B}{\gamma_o} + z_A - z_B\right) \quad V_A = \sqrt{\frac{2g}{15}\left(\frac{P_A - P_B}{\gamma_o} + (z_A - z_B)\right)}$$

$$P_1 = P_A + \gamma_o h_1$$

$$= P_A + 55 \cdot 1.17 = P_A + 64.35 \text{ lb/ft}^3$$

$$P_3 = P_2 - \gamma_w h_2 = P_A = P_A + (64.35 - 62.4 \cdot 0.67)$$

$$P_A + 22.54 \frac{\text{lb}}{\text{ft}^2}$$

$$P_B = P_3 - \gamma_o h_3$$

$$P_B = P_A + 22.54 \text{ lb/ft}^2 - 33 \cdot 2.1$$

$$= P_A - 107.96 \text{ lb/ft}^2$$

$$= 114.96 \text{ lb/ft}^2$$

$$V_A = \sqrt{\frac{2 \times 32.2 \frac{\text{lb}}{\text{ft}^3}}{13} \frac{114.96}{55} + 10 - 2}$$

$$= \sqrt{4.29 * 0.09}$$

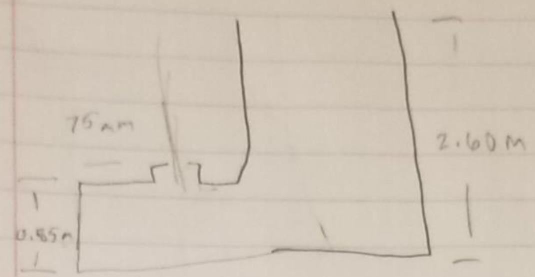
$$= 0.621 \text{ ft/s}$$

$$= \frac{\pi \cdot (0.33)^2}{4}$$

$$= 0.0455$$

$$Q = 0.086 \cdot 0.621 = 0.0531 \text{ ft}^3/3$$

91



$h = 2.6m$

$h_1 = 0.85$

$h_2 = 75\,mm = 0.075\,m$

$h_j = h - h_1 + h_2$

$2.6m - 0.85 + 0.075$

$h_j = 1.673m$

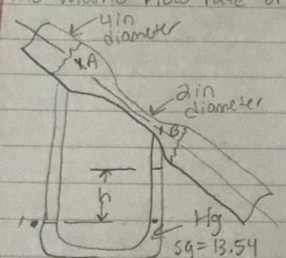
Zach Hollifield

Zach Hollifield

Homework 1.3

1) During chapter 6, we will learn to use Bernoulli's equation to analyze and build fluid flow systems. Bernoulli's equation is based on the principle of conservation of energy. Steady flow is referred to as fluid flowing past any section in a given amout of time is constent. We as learned about volumetric flow rate. If mass increases the dm/dt is positive. $\dot{m}_{in} = \dot{m}_{out}$ if no weight is gained. $dm/dt = 0$ in a steady state. Within Bernoulli's equation, a pump, turbine, and loss due to friction can be included into the problem

79) Oil with a specific gravity of 0.90 is flowing downward through the venturi meter. If the manometer deflection h is 28 in. calculate the volume flow rate of oil.



$$A_A V_A = A_B V_B \rightarrow \frac{\pi D_A^2}{4} V_A = \frac{\pi D_B^2}{4} V_B$$

$$\left(\frac{D_A}{D_B}\right)^2 V_A = V_B$$

$$V_B = \left(\frac{4}{2}\right)^2 V_A \rightarrow 4V_A$$

$$P_A + \gamma_{oil} Z_A = P_B + \gamma_{oil}(Z_B - h) + \gamma_{Hg} \times h$$

$$P_A - P_B = \gamma_o (Z_B - Z_A - h) + \gamma_{Hg} h$$

$$\gamma_{oil} = S_{g\,oil} \times \gamma_{H_2O} = 0.9 \times 62.4 = 56.16 \text{ lb/ft}^3$$

$$\gamma_{Hg} = S_{g\,Hg} \times \gamma_{H_2O} = 13.54 \times 62.4 = 844.896 \text{ lb/ft}^3$$

$$P_A - P_B = 56.16\left(Z_B - Z_A - 28\left(\tfrac{1}{12}\right)\right) + 844.896 \times 28 \times \tfrac{1}{12} = 56.16(Z_B + Z_A) + 1840.38$$

$$\frac{P_A}{\gamma_o} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma_o} + \frac{V_B^2}{2g} + Z_B \rightarrow \frac{P_A - P_B}{\gamma_o} + Z_A - Z_B = \frac{V_B^2 - V_A^2}{2g} \rightarrow \frac{P_A - P_B + \gamma_o (Z_A - Z_B)}{\gamma_o} = \frac{V_B^2 - V_A^2}{2g}$$

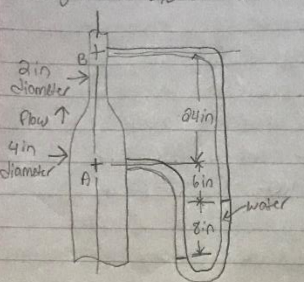
$$\frac{(56.16(Z_B - Z_A) + 1840.38) + 56.16(Z_A - Z_B)}{56.16} = \frac{(4V_A)^2 - V_A^2}{2 \times 32.2}$$

$$\frac{1840.38}{56.16} = \frac{15 V_A^2}{64.4} \rightarrow V_A = 11.86 \text{ ft/s}$$

Volume flow rate $= Q = A_A V_A \rightarrow \left(\frac{\pi D_A^2}{4}\right) \times V_A$

$$Q = \frac{\pi \times (4(\frac{1}{12}))^2}{4} \times 11.86 \quad \boxed{Q = 1.07 \text{ ft}^3/\text{s}}$$

82) Oil with a specific weight of 55.0 lb/ft³ flows from A to B through the system shown. Calculate the volume flow rate of oil



$$\frac{P_A}{\gamma_o} + z_A + \frac{V_A^2}{2g} = \frac{P_B}{\gamma_o} + z_B + \frac{V_A^2}{2g}$$

$$\left(\frac{\pi D_A^2}{4}\right)V_A = \left(\frac{\pi D_B^2}{4}\right)V_B$$

$$\left(\frac{\pi(4)^2}{4}\right)V_A = \left(\frac{\pi(2)^2}{4}\right)V_B$$

$$12.56\,V_A = 3.14\,V_B$$

$$V_B = 4\,V_A$$

$$P_1 = P_A + \gamma_o h_1$$

$$= P_A + (55\ \text{lb/ft}^3)(1.17) = P_A + 64.35\ \text{lb/ft}^3$$

$$P_3 = P_2 - \gamma_w h_2 \rightarrow P_3 = P_A + 64.35 - (62.4 \times 0.67) = P_A + 22.54\ \text{lb/ft}^3$$

$$P_B = P_3 - \gamma_w h_3 \rightarrow P_A + 22.54 - (55 \times 2.5) = P_A - 114.96\ \text{lb/ft}^3$$

$$\frac{16V_A^2 - V_A^2}{2g} + \frac{V_A^2}{2g} = \frac{P_B}{\gamma_o} + z_B + \frac{14V_A^2}{2g} \rightarrow V_A^2 = \left(\frac{2g}{15}\right)\left(\frac{P_A - P_B}{\gamma_o} + (z_A - z_B)\right)$$

$$V_A = \sqrt{\left(\frac{2g}{15}\right)\left(\frac{P_A - P_B}{\gamma_o} + (z_A - z_B)\right)}$$

$$V_A = \sqrt{\left(\frac{2 \times 32.2}{15}\right)\left(\frac{114.96}{55} + (0-2)\right)} = 0.621\ \text{ft/s}$$

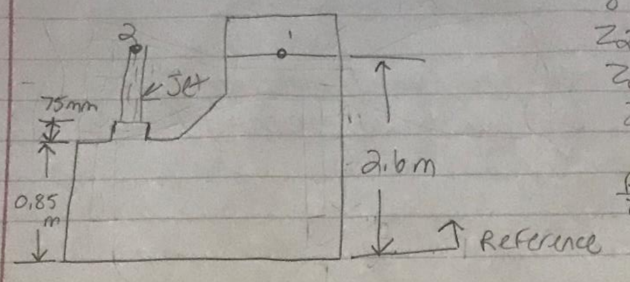
$$A_A = \frac{\pi D_A^2}{4} \rightarrow \frac{\pi(0.33)^2}{4} = 0.086\ \text{ft}^2$$

$$Q = AV \rightarrow Q = 0.086\ \text{ft}^2 \times 0.621\ \text{ft/s}$$

$$\boxed{Q = 0.053\ \text{ft}^3/\text{s}}$$

Zach Hollifield

91) To what height will the jet of fluid rise for the conditions.



$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_3$$

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

$$z_2 = \frac{P_1 - P_2}{\gamma} + z_1$$

$$z_2 = z_1$$

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$h_1 = \frac{P_1 - P_2}{\gamma} + \frac{v_1^2 - V_2^2}{2g} + z_1 - z_2$$

$$V_2 = \frac{Q}{A} > \frac{4Q}{\pi D^2}$$

$$V_2 = \frac{4 \times 0.085\ m^3/s}{\pi \times 0.1541 m^2}$$

$V_2 = 4.5575$ m/s

$D_1 = 0.1541$ m

$$h_L = 10m - \frac{4.5575}{2 \times 9.81 m/s^2}$$

$$\boxed{h_1 = 8.9413\ m}$$