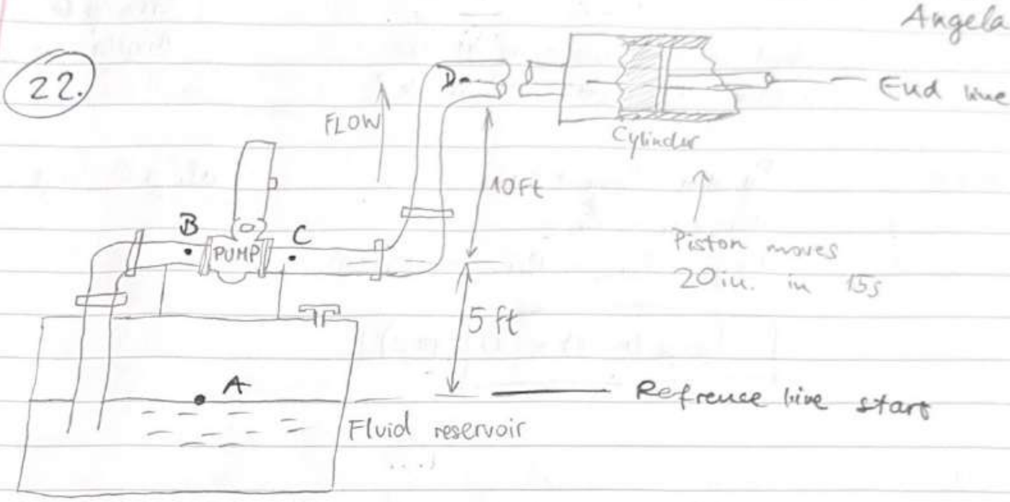
HW 1.3

02/01/2024
Angela Sicaja

22.



oil sg = 0.9
cylinder inside D = 5 in
t = 5s
F = 11 000 lb
E loss = 11.5 lb-ft/lb

$$A_{cylinder} = \frac{\pi d^2}{4} = \frac{\pi (5)^2}{4} = 19.64\, in^2$$

a) $Q = AV$

$$V = \frac{Distance}{time} \Rightarrow Q = \frac{A_{cyl} \cdot L}{t} = \frac{\left(19.64\, in^2 \cdot \left(\frac{1 ft^2}{144 in^2}\right)\right) \cdot \left(20 in \cdot \frac{1 ft}{12 in}\right)}{15 s}$$

$$\boxed{Q = 0.0152\ ft^3/s}$$

b) $P_{cyl} = \frac{F}{A_{cyl}} = \frac{11\,000 \text{ lb}}{19.64 \text{ in}^2} \cdot \left(\frac{144 \text{ in}^2}{1 \text{ ft}^2}\right)$

$$\boxed{P_{cyl} = 80\,672.3 \text{ lb/ft}^2}$$

c) $V_C = \frac{Q}{A_C} = \frac{0.0152 \text{ ft}^3/\text{s}}{0.000976 \text{ ft}^2} = 15.52 \text{ ft/s}$

$V_B = V_C = 15.52 \text{ ft/s}$

$V_D = \frac{L}{t} = \frac{20 \text{ in}}{15 \text{ s}} \cdot \left(\frac{1 \text{ ft}}{12 \text{ in}}\right) = 0.1111 \text{ ft/s}$

$\gamma_{oil} = sg(\gamma_{H_2O}) = 0.90(62.4 \text{ lb/ft}^3)$

$\gamma_{oil} = 56.16 \text{ lb/ft}^3$

$$\frac{P_C}{\gamma_{oil}} + \frac{V_C^2}{2g} + \cancel{z_C} - h_{LD} = \frac{P_D}{\gamma_{oil}} + \frac{V_D^2}{2g} + z_D$$

$$\frac{P_C}{\gamma_{oil}} = \frac{P_D}{\gamma_{oil}} + \frac{V_D^2}{2g} + z_D - \frac{V_C^2}{2g} - z_C + h_{LD}$$

$$P_C = P_{cyl} + \gamma_{oil}\left[\left(\frac{V_D^2 - V_C^2}{2g}\right) + (z_D - \cancel{z_C}) + h_{LD}\right]$$

$$P_C = 80\,672.3 + 56.16\left[\left(\frac{0.1111^2 - 15.52^2}{2(32.2)}\right) + 10 + 35\right]$$

$$\boxed{P_C = 82\,989.43 \text{ lb/ft}^2}$$

d) $\frac{\cancel{P_A}}{\gamma_{oil}} + \frac{\cancel{V_A^2}}{2g} + z_A - h_{LS} = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B$

$z_A - h_{LS} = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B$

$\frac{P_B}{\gamma_{oil}} = z_A - h_{LS} - \frac{V_B^2}{2g} - z_B$

$P_B = \gamma_{oil}\left[(z_A - z_B) - \frac{V_B^2}{2g} - h_{LS}\right]$

$P_B = 56.16\left[(-5-0) - \frac{(15.52)^2}{2(32.2)} - 11.5\right]$

$\boxed{P_B = -1136.69 \text{ lb/ft}^2}$

e) $\frac{\cancel{P_A}}{\gamma_{oil}} + \frac{\cancel{V_A^2}}{2g} + z_A + h_A - h_{LS} - h_{LD} = \frac{P_D}{\gamma_{oil}} + \frac{V_D^2}{2g} + z_D$

$h_A = \frac{P_{cyl}}{\gamma_{oil}} + \frac{V_D^2}{2g} + (z_D - z_A) + h_{LS} + h_{LD}$ $\qquad P_D = P_{cyl}$

$h_A = \frac{30672.3}{56.16} + \frac{(0.1111)^2}{2(32.2)} + (10+5) + 11.5 + 35$

$h_A = 1497.97 \text{ ft}$

$P = h_A \gamma_{oil} \cdot Q$

$P = 1497.97 \text{ ft} \cdot 56.16 \text{ lb/ft}^3 \cdot 0.0152 \text{ ft}^3/\text{s}$

$P = 1274.509 \text{ lb} \cdot \text{ft/s}$

$\boxed{P = 2.317 \text{ hp}}$

HW 1.3

02/01/2024
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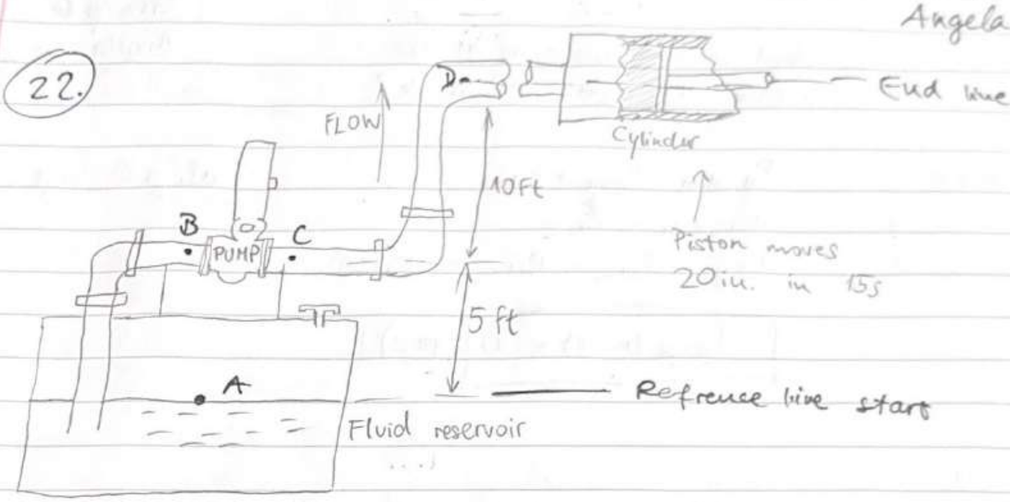
22.



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$$\boxed{Q = 0.0152\ ft^3/s}$$

b) $P_{cyl} = \frac{F}{A_{cyl}} = \frac{11\,000\ lb}{19.64\ in^2} \cdot \left(\frac{144\ in^2}{1\ ft^2}\right)$

$$\boxed{P_{cyl} = 80\ 672.3\ \ lb/ft^2}$$

c) $v_c = \frac{Q}{A_c} = \frac{0.0152\ ft^3/s}{0.000976\ ft^2} = 15.52\ ft/s$

$v_B = v_c = 15.52\ ft/s$

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$$P_c = P_{cyl} + \gamma_{oil}\left[\left(\frac{v_D^2 - v_c^2}{2g}\right) + (z_D - \cancel{z_c}) + h_{LD}\right]$$

$$P_c = 80\ 672.3 + 56.16\left[\left(\frac{0.1111^2 - 15.52^2}{2(32.2)}\right) + 10 + 35\right]$$

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$h_A = \frac{30672.3}{56.16} + \frac{(0.1111)^2}{2(32.2)} + (10+5) + 11.5 + 35$

$h_A = 1497.97 \text{ ft}$

$P = h_A \gamma_{oil} \cdot Q$

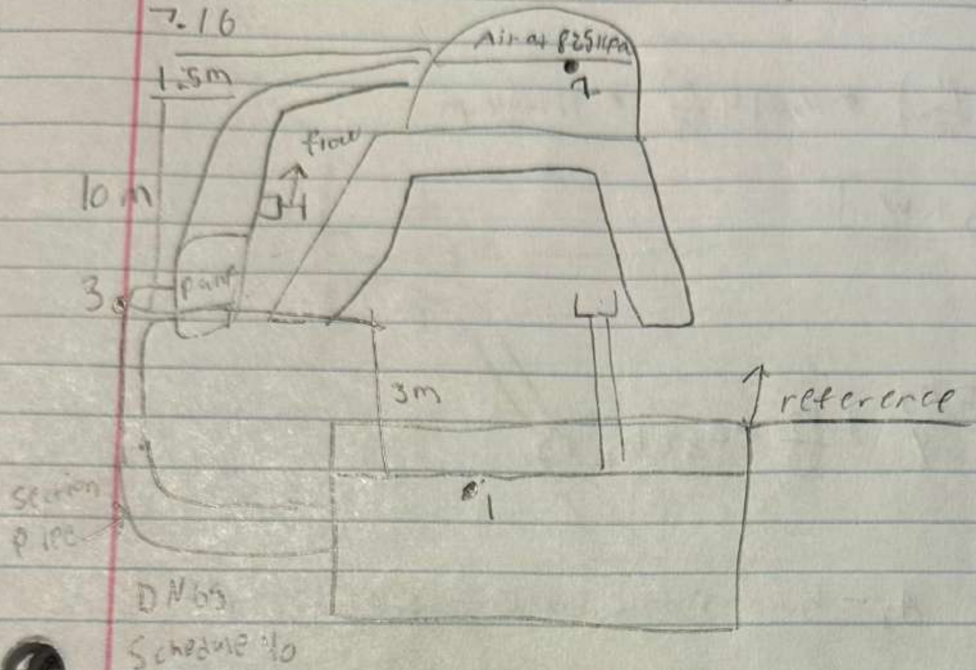
$P = 1497.97 \text{ ft} \cdot 56.16 \text{ lb/ft}^3 \cdot 0.0152 \text{ ft}^3/\text{s}$

$P = 1274.509 \text{ lb}\cdot\text{ft/s}$

$\boxed{P = 2.317 \text{ hp}}$

Fluid Mechanics HW 1.3 Ben Smithson

7.16



sg oil = 0.85

Q = 840L/min = 0.014 m^3/s

h_L = 4.2

h_L suction = 1.4 m

bernoulli's $h_a + \frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_{L12}$

$P = \gamma Q h_A$

$h_A = \frac{p_2 - \cancel{p_1}^{0}}{\gamma} + \frac{\cancel{v_2^2}^{0} - \cancel{v_1^2}^{0}}{2g} + z_2 - \cancel{z_1}^{0} + h_{L12}$

$h_A = \frac{p_2}{\gamma} + z_2 + h_{L12}$

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

Power Pump

$$P\ (0.85 \cdot 9810 \tfrac{N}{m^3}) \cdot 0.014 \tfrac{m^3}{s} \cdot 117.64\ m$$

$$\boxed{P = 13.733\ KW}$$

0 kPa gage

$$\frac{\cancel{p_1}^{0}}{\gamma} + \frac{\cancel{v_1^2}^{0}}{2g} + \cancel{z_1}^{0} = \frac{p_3}{\gamma} + \frac{v_3^2}{2g} + z_3 + h_{L\,13}$$

$\frac{p_3}{\gamma}$, $V_3 = \frac{Q}{A_3}$ A_3 - back of the book $= 3.09 \cdot 10^{-3}\ m^2$

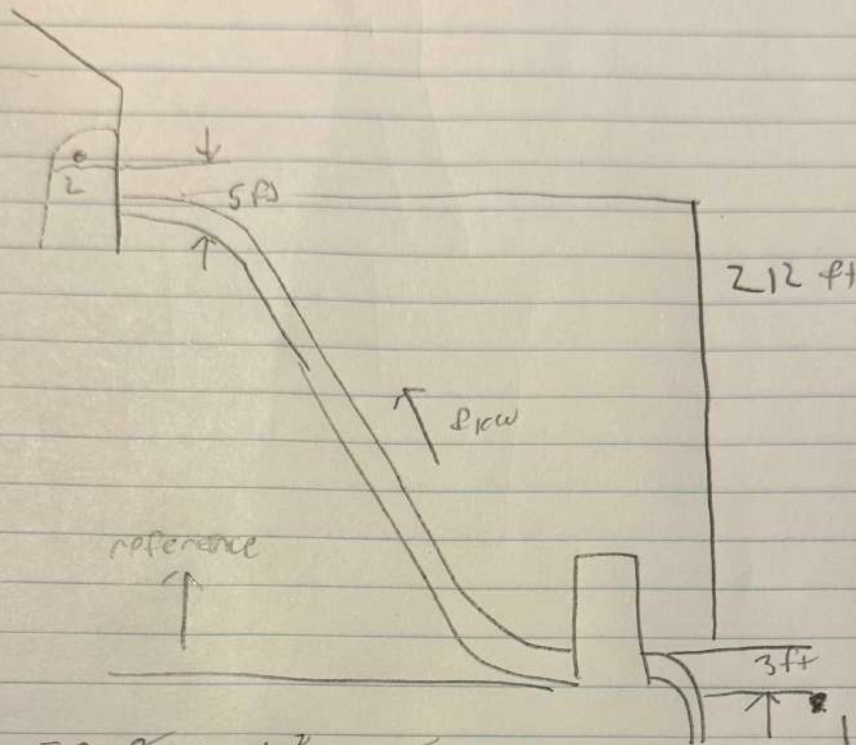
$$V_3 = \frac{0.014\ m^3/s}{3.09 \cdot 10^{-3}\ m^2} = 4.531\ m/s$$

$$p_3 = (0.85 \cdot 9810 \tfrac{N}{m^3})\left(-\frac{(4.531 \tfrac{m}{s})^2}{2 \cdot 9.81 \tfrac{m}{s^2}} - 3m - 1.4m\right)$$

$$\boxed{p_3 = -45.41\ kPa}$$

Fluid Mechanics HW 1.3 Ben Smithson

7.42



$$h_A = \frac{p_2 - \cancel{p_1}}{\gamma} + \frac{\cancel{v_2^2 - v_1^2}}{2g} + \cancel{z_2} - z_1 + h_{L\,12}$$

$$h_A = \frac{p_2}{\gamma} + z_2 + h_{L\,12}$$

$$P_A = 62.4\ \frac{lb}{ft^3} \cdot 0.089\ \frac{ft^3}{s} \cdot 304.73\ ft$$

$$P_A = 1692.35\ lb \cdot ft/s$$

$$1\ Hp = 550\ lb \cdot ft/s$$

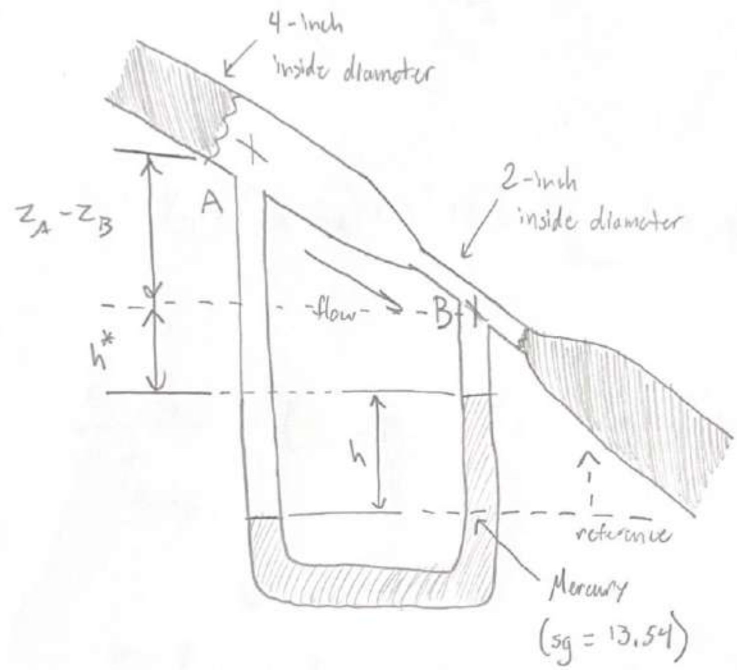
$$\boxed{P_A = 3.077\ Hp}$$

HW 1.3

Chapter 6 – 79, 82, 91

Chapter 7 – 11, 16, 22, 30, 35, 42

6-79) 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.



Need: volume flow rate

Diameter A = 4 in.

Diameter B = 2 in.

h = 28 in.

$sg_{oil} = 0.90$

$sg_{Mercury} = 13.54$

$\gamma_{water} = 9.81 \text{ kN/m}^3$

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

$$Q = VA \ ; \ V = Q/A$$

$$\Delta p = \gamma h$$

$$\frac{Q^2}{2g}\left(\frac{1}{A_A^2} - \frac{1}{A_B^2}\right) = \frac{P_B - P_A}{\gamma} + (Z_A - Z_B)$$

(over →)

6-79)

$$Q = \sqrt{\frac{2g\left(\frac{P_B - P_A}{\gamma} + (z_A - z_B)\right)}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$

$$P_A + \gamma_{oil}\left((z_A - z_B) + h^* + h\right) - \gamma_{Mercury} h - \gamma_{oil} h^* = P_B$$

$$\frac{P_B - P_A}{\gamma_{Mercury}} = (z_A - z_B) + \left(1 - \frac{\gamma_{Mercury}}{\gamma_{oil}}\right)h$$

$$\downarrow$$

$$\frac{P_B - P_A}{\gamma_{Mercury}} = (z_A - z_B) + \left(1 - \frac{sg_{Mercury}}{sg_{oil}}\right)h$$

$$\therefore \quad Q = \sqrt{\frac{2g\left(1 - \frac{sg_{Mercury}}{sg_{oil}}\right)h}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$

$$A_A = \frac{\pi}{4}\left(\frac{4}{12}\right)^2 = 0.0873 \text{ ft}^2$$

$$A_B = \frac{\pi}{4}\left(\frac{2}{12}\right)^2 = 0.0218 \text{ ft}^2$$

$$Q = \sqrt{\frac{2\left(32.2 \text{ ft/s}^2\right)\left(1 - \frac{13.54}{0.90}\right)(28 \text{ in})\left(\frac{1 \text{ ft}}{12 \text{ in}}\right)}{\frac{1}{(0.0873 \text{ ft}^2)^2} - \frac{1}{(0.0218 \text{ ft}^2)^2}}}$$

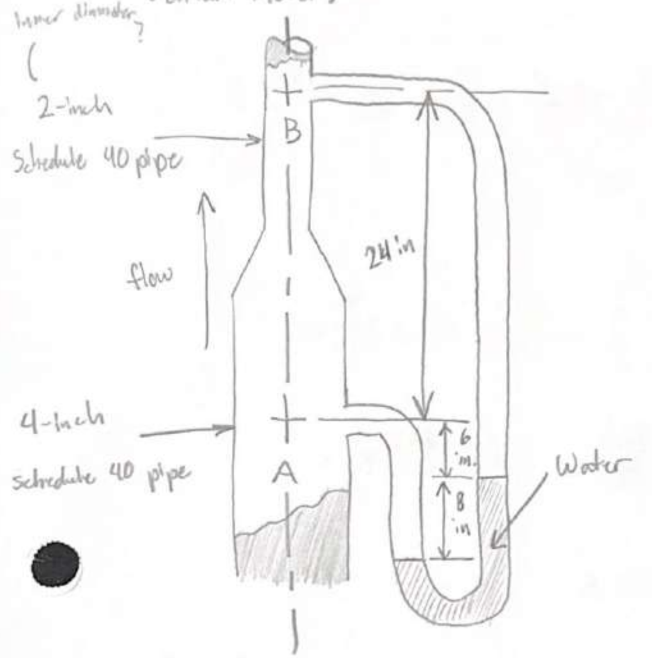
$$\rightarrow \sqrt{\frac{\left[\frac{ft}{s^2}\right]\left[ft\right]}{\frac{1}{ft^4}}} = \frac{\sqrt{\frac{ft^2}{s^2}}}{\sqrt{\frac{1}{ft^4}}} = \frac{\left[\frac{ft}{s}\right]}{\frac{1}{ft^2}} = \frac{ft}{s} \times ft^2 = \frac{ft^3}{s}$$

$$\boxed{Q = 1.034 \text{ ft}^3/\text{s}}$$

1/29/2024 Pg 3
MET 330
HW 1.3

6-82) Oil with a specific weight of 55.0 lb/ft^3 flows from A to B through the system. Calculate the volume flow rate of the oil.

Venturi Meter:



Need: volume flow rate of oil

$SW_{oil} = 55.0\ lb/ft^3$; $\gamma_{oil} = 55\ lb/ft^3$

$L_{A\to B} = 24\text{ inch} = 2\text{ ft}$

$\gamma_{water} = 9.81\ kN/m^3$; $\gamma_{water} = 62.4\ lb/ft^3$

Diameter A = 4 in.

Diameter B = 2 in.

Appendix A

$A_A = 8.727E{-2}\ ft^2$

$A_B = 2.182E{-2}\ ft^2$

$g = 32.2\ ft/s^2$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B$$

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

$Z_A - Z_B = -24\text{ inch} = -2\text{ ft}$

$\gamma_{oil} = 55\ lb/ft^3$

$$P_A + \cancel{\gamma(6in)} + \gamma(8in) - \gamma_{oil}(8in) - \cancel{\gamma(6in)} - \gamma(24in) = P_B$$

$$P_A - P_B = \gamma(24in - 8in) + \gamma_{oil}(8in)$$

$$P_A - P_B = \gamma(16in) + \gamma_{oil}(8in)$$

(over →)

1/29/2024 Pg 4
MET 330
HW 1.3

6-82)

$$P_A - P_B = \gamma_{oil}(16\text{ in}) + \gamma_{water}(8\text{ in})$$

$$\frac{P_A - P_B}{\gamma_{oil}} = (16\text{ in}) + \frac{\gamma_{water}(8\text{ in})}{\gamma_{oil}}$$

$$= (16\text{ in})\left(\frac{1\text{ ft}}{12\text{ in}}\right) + \left(\frac{(62.4\text{ lb/ft}^3)(8\text{ in})\left(\frac{1\text{ ft}}{12\text{ in}}\right)}{55\text{ lb/ft}^3}\right)$$

$$= (1.33\text{ ft}) + \left(\frac{(62.4)(0.67\text{ ft})}{55}\right)$$

$$= (1.33\text{ ft}) + (0.76\text{ ft})$$

$$\frac{P_A - P_B}{\gamma_{oil}} = 2.09\text{ ft}$$

$$A_A v_A = A_B v_B$$

$$v_B = v_A\left(\frac{A_A}{A_B}\right)$$

$$= v_A\left(\frac{8.727E\text{-}2\text{ ft}^2}{2.182E\text{-}2\text{ ft}^2}\right)$$

$$v_B = 3.99\, v_A$$

$$v_B^2 = 15.92\, v_A^2$$

$$v_B^2 - v_A^2 = 15.92\, v_A^2 - v_A^2$$

$$v_B^2 - v_A^2 = 14.92\, v_A^2$$

$$\frac{P_A - P_B}{\gamma_{oil}} + (z_A - z_B) = \frac{v_B^2 - v_A^2}{2g}$$

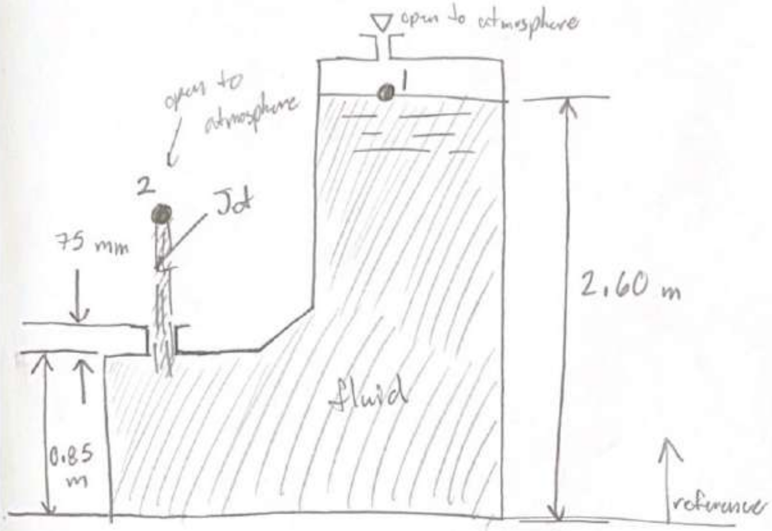
$$(2.09\text{ ft}) + (-2\text{ ft}) = \frac{14.92\, v_A^2}{2g}$$

$$\sqrt{\frac{(0.09\text{ ft})(2)(32.2\text{ ft/s}^2)}{14.92}} = v_A \quad ; \quad v_A = 0.62\text{ ft/s}$$

$$Q = A_A v_A$$

$$Q = (8.727E\text{-}2\text{ ft}^2)(0.62\text{ ft/s}) \quad ; \quad \boxed{Q = 0.054\text{ ft}^3/\text{s}}$$

6-91) To what height will the jet of fluid rise for the conditions shown?



$P = 0.0$ psig

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

$Z_1 = 2.60$ m

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

$$Z_2 = \frac{P_1 - P_2}{\gamma} + \frac{\cancel{V_1^2}^{0} - \cancel{V_2^2}^{0}}{2g} + Z_1$$

$V_1 \to$ assume negligible (large tank)

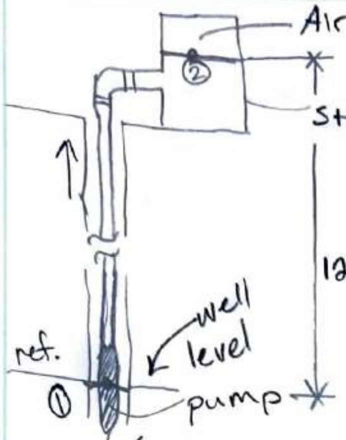
$V_2 \to 0$

$$Z_2 = \frac{\cancel{P_1}^{0} - \cancel{P_2}^{0}}{\gamma} + Z_1$$

$\therefore\ Z_2 = Z_1$

$$\boxed{Z_2 = 2.60\ m}$$

7 - 11 Noel T



40psig $Q = 745\,gal/h$

• 1in-Schedule 40 pipe

$h_L = 10.5\ lb\text{-}ft/lb$

$$h_A + \cancel{\frac{p_1}{\gamma}}^{0} + \cancel{\frac{v_1^2}{2g}}^{0} + \cancel{z_1}^{0} = \frac{P_2}{\gamma} + \cancel{\frac{v_2^2}{2g}}^{0} + z_2 + h_L$$

$P = \gamma Q h_A$ $Q = V \cdot A$ $\gamma_W = 62.4\ lb/ft^3$

(A-F) $A = 0.006 ft^2$

$$V = \frac{745\,\cancel{gal}/\cancel{h}}{0.006\,\cancel{ft^2}}\left(\frac{\cancel{1h}}{60\,\cancel{min}}\right)\left(\frac{1\,\cancel{min}}{60\,s}\right)\left(\frac{1\,ft^3}{7.48\,\cancel{gal}}\right)$$

$V = 4.61\ ft/s$

$$h_A = \frac{P_2}{\gamma_W} + z_2 + h_L$$

$$= \frac{40\,psig}{62.4\,\cancel{lb}/ft^3}\ \cancel{lb}/\cancel{in^2}\left(\frac{12\,in}{1\,ft}\right)^2 + 120ft + 10.5\,\cancel{lb}-ft/\cancel{lb}$$

$h_A = 222.8 ft$

$$P = \left(62.4\frac{lb}{\cancel{ft^3}}\right)\left(0.028\frac{\cancel{ft^3}}{s}\right)(222.8\ ft)$$

$P = 384.6\ lb\text{-}ft/s$

Input = 1 hp

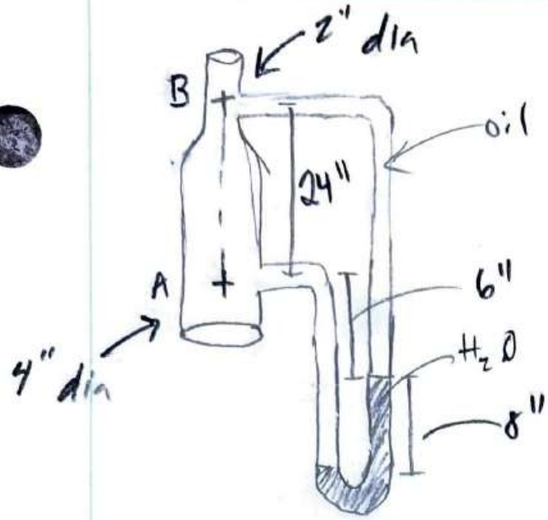
$$\eta_{pump} = \frac{Output}{Input}$$

$$384.6\,\cancel{lb\text{-}ft}/\cancel{s}\left(\frac{1.843 \times 10^{-3}\ hp}{1\,\cancel{\frac{lb\text{-}ft}{s}}}\right) = 0.7088\ hp$$

$$= \frac{0.7088\,\cancel{hp}}{1\,\cancel{hp}} = 0.7088$$

$\eta_{pump} = 0.7088$
or
70.88%

6-82 Noel T 1/2



$\gamma_{oil} = 55.0\ lb/ft^3$ $Q = ?$

$\gamma_w = 62.4\ lb/ft^3$

$$\frac{p_A}{\gamma} + \frac{v_A^2}{2g} + z_A = \frac{p_B}{\gamma} + z_B + \frac{v_B^2}{2g}$$

$$\frac{p_A - p_B}{\gamma} + (z_A - z_B) = \frac{v_B^2 - v_A^2}{2g}$$

$$z_A - z_B = -24\ in = -2\ ft$$

$$p_A + \cancel{\gamma(y)} + \gamma_{oil}(8in) - \gamma_w(8in) - \cancel{\gamma(y)} - \gamma_{oil}(24in) = p_B$$

$$p_A - p_B = \gamma(24-8)_{in} + \gamma_w(8in)$$

$$p_A - p_B = \gamma_{oil}(16in) + \gamma_w(8in)$$

$$\frac{p_A - p_B}{\gamma_{oil}} = 16in + \frac{\gamma_w(8in)\left(\frac{1ft}{12in}\right)}{\gamma_{oil}}$$

$$\frac{62.4\ \cancel{lb/ft^3}\ (8/12)\ ft}{55.0\ \cancel{lb/ft^3}} = 0.7564\ ft$$

$$\frac{p_A - p_B}{\gamma_{oil}} = \left(\frac{16in}{12in}\right) + 0.75\ ft$$

$$\frac{p_A - p_B}{\gamma_{oil}} = 2.1\ ft$$

6-82

Noel T

2/2

$A_A v_A = A_B v_B$

$A_A = 12.57 \cancel{in^2} \left(\frac{1\,ft}{12\,\cancel{in}}\right)^2 = 0.0$

$A_B = 3.14\ in^2$

$v_B = \frac{A_A v_A}{A_B}$

$v_B = 3.99\, v_A$

$v_B^2 = 15.99\, v_A^2$

$v_B^2 - v_A^2 = 15.99\, v_A^2 - v_A^2 = 14.99\, v_A^2$

$2.1ft - 2ft = 14.99\, v_A^2 / 2g$

$0.1ft = \frac{14.99\, v_A^2}{2g}$

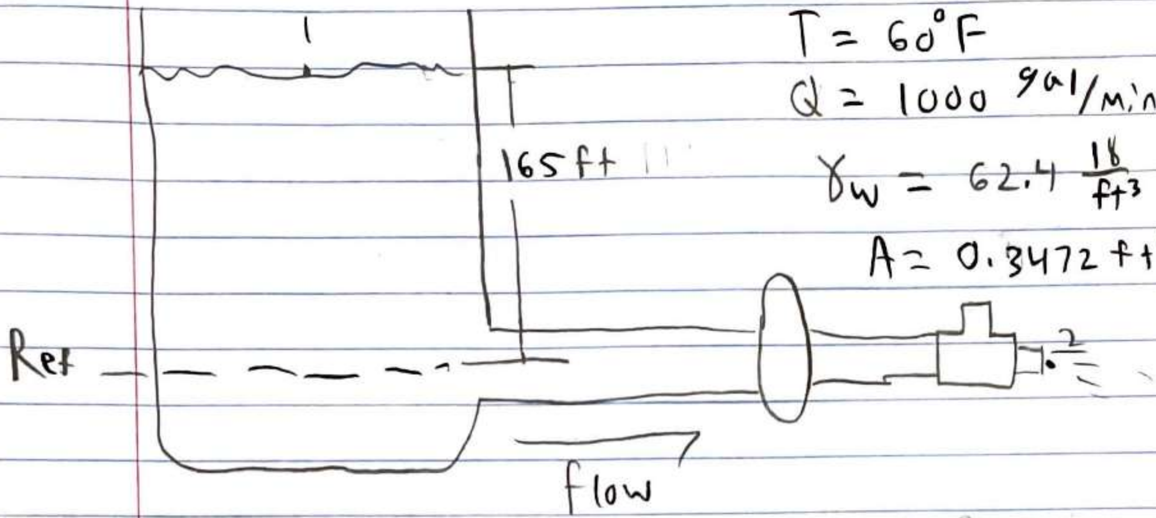
$v_A = \sqrt{\frac{2g(0.1\ ft)}{14.99}}$

$v_A = 0.65\ ft/s$

$(0.087\ ft^2)(0.65\ ft/s)$

$Q = 0.57$

7.30)



$T = 60°F$

$Q = 1000\ gal/min$

$\gamma_w = 62.4\ \frac{lb}{ft^3}$

$A = 0.3472\ ft^2$

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

$1.843E\text{-}3\,hp = 1\ \frac{lb\text{-}ft}{s}$

$P_R = h_R \gamma Q$

$$h_R = \frac{P_R}{\gamma Q} = \frac{37\ hp}{\left(62.4\ \frac{lb}{ft^3}\right)\left(1000\ \frac{gal}{min}\right)} = \frac{20076\ \frac{lb\text{-}ft}{s}}{\left(62.4\ \frac{lb}{ft^3}\right)\left(2.23\ \frac{ft^3}{s}\right)} = 144.3\ \frac{lb\,ft}{lb}$$

$$Q = VA \rightarrow V = \frac{Q}{A} = \frac{2.23\ \frac{ft^3}{s}}{0.3472\ ft^2} = 6.42\ \frac{ft}{s}$$

$$h_L = -\frac{V_2^2}{2g} - h_R + z_1 = \frac{6.42^2}{2(32.2)} - 144.3 + 165 = 21.34\ \frac{lb\ ft}{lb}$$

<u>Valve</u>

$$h_L = K\frac{V^2}{2g}$$

$f_T = 0.014$ (from slides)

$K = 8 f_T = 8(0.014)$

$K = 0.112$

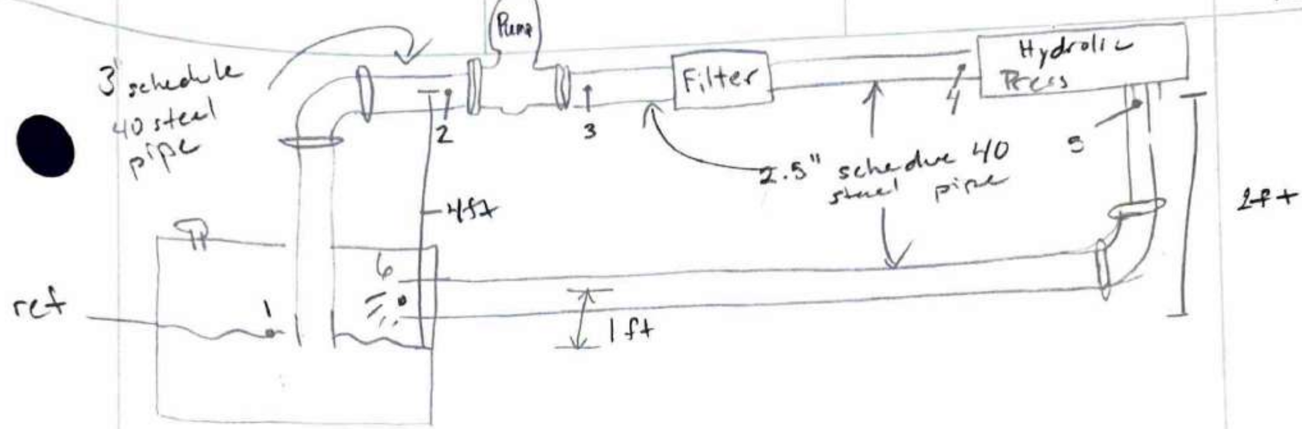
$$h_L = (0.112)\left(\frac{6.42}{2 \times 32.2}\right)$$

$h_L = 0.011165$

Total: $\boxed{h_L = 21.35\ \frac{lb\ ft}{lb}}$

HW 1.3 REFLECTION PARAGRAPH

This week we have learned about the formula for inclined surfaces, and force acting on a submerged curved surface. In one of the problems in the video lecture, we saw that for the decomposed surfaces we have to split them into two parts. Vertical which is equal to weight W, and Horizontal which is equal to the projected area that computes it. Furthermore, we went over on how to obtain the location of the weight for the Vertical surfaces. We just use the centroid of the volume in this case. One of the problems we did had a connection with the force on a curbed surface with fluid below it. We talked about buoyancy and pressure and said that the center of buoyancy is the center of displaced volume. Lastly, the condition for stability of bodies completely submerged in a fluid is that the center of gravity of the body must be below the center of buoyancy.



1. fluid is oil $(sg = 0.93)$
2. $Q = 175\ gal/min = 0.39\ ft^3/s$
3. Power input to the pump is 28.4 hp
4. Pump efficiency is 80%
5. h_L @ 1-2 $= 2.8\ lb\text{-}ft/lb$
6. h_L @ 3-4 $= 28.5\ lb\text{-}ft/lb$
7. h_L @ 5-6 $= 3.5\ lb\text{-}ft/lb$

$$P_R = \gamma Q h_R$$

4-5

$$\frac{P_4}{\gamma} + \cancel{\frac{v_4^2}{2g}} + z_4 = \frac{P_5}{2g} + \cancel{\frac{v_5^2}{2g}} + z_5 + h_R$$

$$h_R = \frac{P_4 - P_5}{\gamma} + z_4 - z_5$$

1-2

$$\cancel{\frac{P_1}{\gamma}} + \cancel{\frac{v_1^2}{2g}} + \cancel{z_1} + \cancel{h_A} = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + \cancel{h_R} + h_L$$

$$P_2 = \gamma\left(-\frac{v_2^2}{2g} - z_2 - h_L\right)$$

$$sg = \frac{\gamma_s}{\gamma_w} \qquad Q = V \cdot A$$

$$\gamma_s = 0.93(62.4)\ lb/ft^3$$

$$\gamma_s = 58.032\ lb/ft^3$$

$$= (58.032\ lb/ft^3)\left(-\frac{(7.6\ ft/s)^2}{2g} - 4 - 2.8\right) ft$$

$$V_2 = \frac{175\ gal/min}{0.05132\ ft^2}\left(\frac{1\ min}{60\ s}\right)\left(\frac{0.133681\ ft^3}{1\ gal}\right)$$

$$v_2 = 7.6\ ft/s$$

$$P_2 = 446\ lb/ft^2$$

2-3

$P = 28.4\ hp = 15620\ lb\cdot ft/s$

$P = \gamma h_A Q$

$$\frac{P_2}{\gamma} + \frac{v_2^2}{2g} + \cancel{z_2}^{0} + h_A = \frac{P_3}{\gamma} + \frac{v_3^2}{2g} + \cancel{z_3}^{0}$$

$$P_3 = \gamma\left(\frac{P_2}{\gamma} + \frac{v_2^2 - v_3^2}{2g} + h_A\right)$$

$$h_A = \frac{15620\ lb\cdot ft/s}{(58.032\ lb/ft^3)(0.39\ ft^3/s)}$$

$$h_A = 690.2\ lb\cdot ft/lb$$

$$v_3 = \frac{0.39\ ft^3/s}{0.03326\ ft^2}$$

$$v_3 = 11.7\ ft/s$$

$$P_3 = (58.032\ lb/ft^3)\left(\frac{446\ lb/ft^2}{58.032\ lb/ft^3} + \frac{(7.6\ ft/s)^2 - (11.7\ ft/s)^2}{2g} + 690.2\ \frac{lb\cdot ft}{lb}\right) ft$$

$$P_3 = 39{,}536.4\ lb/ft^2$$

3-4

$$\frac{P_3}{\gamma} + \cancel{\frac{v_3^2}{2g}}^{0} + \cancel{z_3}^{0} = \frac{P_4}{\gamma} + \cancel{\frac{v_4^2}{2g}} + \cancel{z_4}^{0} + h_L$$

same

$$P_4 = \gamma\left(\frac{P_3}{\gamma} - h_L\right)$$

$$= 58.032\ lb/ft^3\left(\frac{39{,}536.4\ lb/ft^2}{58.032\ lb/ft^3} - 28.5\ \frac{lb\cdot ft}{lb}\right) ft$$

$$P_4 = 37{,}882.49\ lb/ft^2$$

5-6

$$\frac{P_5}{\gamma} + \cancel{\frac{v_5^2}{2g}}^{0} + z_5 = \cancel{\frac{P_6}{\gamma}}^{0} + \cancel{\frac{v_6^2}{2g}}^{0} + h_L + z_6$$

$$P_5 = (h_L + z_6 - z_5)\gamma$$

$$P_5 = (3.5\ lb\cdot ft/lb + 1 - 2)\ 58.032\ lb/ft^3$$

$$P_5 = 145.8\ lb/ft^2$$

$$h_R = \frac{P_4 - P_5}{\gamma} + z_4 - z_5$$

$$= \frac{37{,}882.49\ \cancel{lb}/\cancel{ft^2} - 145.08\ lb/\cancel{ft^2}}{58.032\ \cancel{lb}/ft^{\cancel{3}}} + 2\ ft$$

$$h_R = 652.3\ ft$$

$$P_R = (58.032\ lb/\cancel{ft^3})(0.39\ \cancel{ft^3}/s)(652.3\ ft)$$

$$P_R = 14152.1\ lb \cdot ft/s$$

$$P_R = 25.7\ hP$$