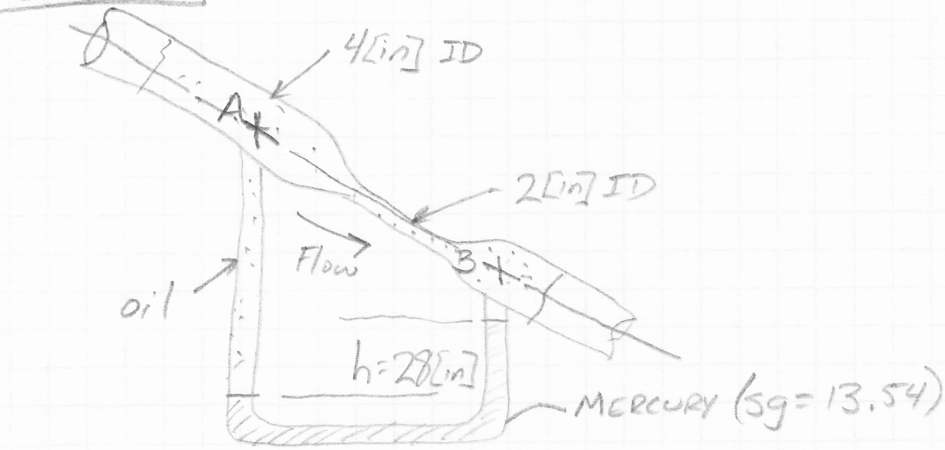
HW 2.1 | MET 330 | STEVEN BLEA

Problem 6.79: Calculate the volume flow rate of the oil.

Source: Applied fluid mechanics textbook/solutions Pearson

Given: $sg_{oil} = 0.90$, Manometer deflection $(h) = 28$ [in]

DRAWING



Solution: Rearrange continuity equation to find velocity relationship

$$A_B v_B = A_A v_A \Rightarrow v_B = v_A\left(\frac{A_A}{A_B}\right) \Rightarrow v_B = v_A\left(\frac{D_A}{D_B}\right)^2$$

$$v_B = \left(\frac{4}{2}\right)^2 * v_A \Rightarrow v_B = 4 * v_A$$

$$P_A - P_B = (\gamma_m \times h) - (\gamma_o \times h) - [\gamma_o * (z_A - z_B)]$$

multiply through by $\frac{1}{\gamma_o}$

$$\frac{P_A - P_B}{\gamma_o} = \frac{\gamma_m h}{\gamma_o} - h - (z_A - z_B)$$

, sub. $(sg)_m \gamma_w$ for γ_m and $(sg)_o \gamma_w$ for γ_o

$$\frac{P_A - P_B}{\gamma_o} = \frac{(sg)_m \times h}{(sg)_o} - h - (z_A - z_B) = \frac{P_A - P_B}{\gamma_o} = 14.04 \times h - (z_A - z_B)$$

USE Bernoulli's equation: $\frac{P_A}{\gamma_o} + z_A + \frac{v_A^2}{2g} = \frac{P_B}{\gamma_B} + z_B + \frac{v_B^2}{2g}$

Rearrange to:

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

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Problem 6.79 cont

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

we get: $\left[\left(14.04 * \frac{28}{12}\right) - \cancel{(z_A - z_B)}\right] \cancel{+ (z_A - z_B)} = \frac{(4V_A)^2 - V_A^2}{2(32.2)}$

$32.69 = \frac{15 V_A^2}{64.4} \Rightarrow V_A^2 = 140.349$

$\boxed{V_A = 11.86 \text{ ft/s}}$

Using $Q = A_A * V_A \Rightarrow Q = \left(\frac{\pi D_A^2}{4}\right) * V_A$

Subst. known values:

$Q = \left[\frac{\pi * \left(\frac{4}{12}\right)^2}{4}\right] \times 11.86 \Rightarrow \boxed{Q = 1.035 \text{ ft}^3/\text{s}}$

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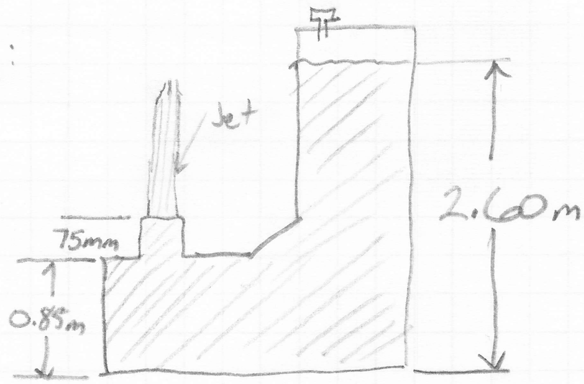
Problem 6.91: Find height jet of fluid will rise

Source: Chegg textbook solutions

Given: Dimensions as shown in drawing.

Drawing:



75mm = 0.075 m

Solution: Height of jet is found using the equation:

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

h = total height of tank = 2.6m

h_1 = base of outlet = 0.85m

h_2 = height of outlet = 0.075m

$$h_j = 2.6[m] - (0.85[m] + 0.075[m])$$

$$h_j = 2.6[m] - 0.925[m]$$

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

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Problem 7.11: A submersible deep-well pump delivers water through a pipe.

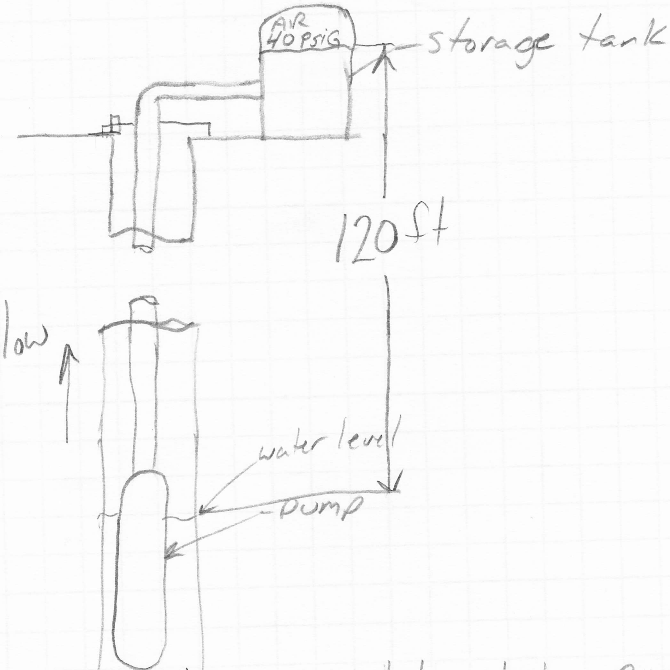
Given: flow rate $(Q) = 745 [gal/h]$, pipe = 1[in] sch 40

Energy loss = 10.5 lb-ft/lb

Find: a) power delivered by the pump

b) Efficiency of pump if it uses 1hp of energy

Drawing:



Solution: To find power delivered by pump we use $P_A = h_A \gamma Q$ (1)

h_A = energy added to the pump

γ = specific weight of water

Q = volume flow rate

To find h_A (energy added to system) we need to use the general energy equation.

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

Rearranging equation and removing zero terms we have:

$$h_A = \frac{P_2}{\gamma} + (z_2 - z_1) + \frac{V_2^2}{2g} + h_L \quad (3)$$

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Problem 7.11 cont.

to find the velocity of flow at point 2 we use

$$V_2 = \frac{Q}{A} \quad (4) \quad Q = 745\,[\text{gal/h}]$$

A for 1in sch 40 pipe is 0.006 ft²

$$V = \frac{745\,\text{gal/h} * \frac{1\,\text{gal}}{449\,\text{ft}} * \frac{1\text{hr}}{60\text{s}}}{0.006\,\text{ft}^2} = \frac{\frac{745}{449 * 60}}{0.006\,\text{ft}} = 4.61\ \text{ft/s}$$

Substitute known values into eq (3):

$$h_A = \frac{5760.36}{62.4} + 120 + \frac{4.61^2}{2 * 32.18} + 10.5 = 223.13\ \text{ft}$$

now subst. known values into eq. (1)

$$P_A = 223.13\,[\text{ft}] * 62.4 * \frac{745}{449 \times 60} = 385.04\ \frac{\text{lb-ft}}{\cancel{s}} * \frac{1\text{hP}}{550\,\cancel{\frac{\text{lb-ft}}{s}}}$$

$$\boxed{P_A = 0.70\ hp}$$

for pump efficiency $e_m = \frac{P_A}{P_I} = \frac{0.70\,hp}{1\,hp}$

$$\boxed{e_m = 0.70\ (70\%)}$$