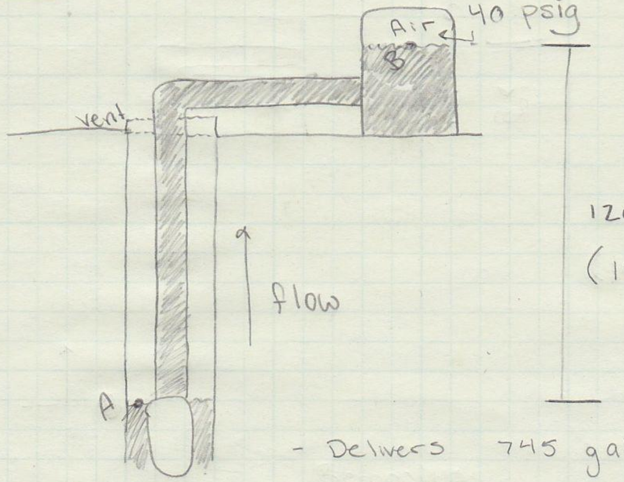
MET 330 | HW 1.4

7.11



- Delivers 745 gal/h of water
- 1 in. schedule 40 pipe
  flow area 0.006 ft²
- Energy loss 10.5 lb-ft/lb

Calc power delivered by pump

$$h_A = \frac{P_B - \cancel{P_A}}{\gamma} + (z_B - z_A) + \frac{v_B^2 - v_A^2}{2g} + h_L$$

* P_A is @ gauge pressure

Pressure Difference

$$\Rightarrow \frac{40\,\frac{lb}{in^2} \times 144\,\frac{in^2}{ft^2}}{62.4} = \frac{P_B}{\gamma} = 92.31$$

$$\Rightarrow (z_B - z_A) = 120\text{ ft}$$

$$\Rightarrow Q = 745\,\frac{gal}{hr} \times \frac{1\text{ ft}^3/s}{26929.9\text{ gal/hr}} = 0.0277\text{ ft}^3/s$$

$$\Rightarrow v_A = v_B = \frac{Q}{A} \longrightarrow \frac{0.0277\text{ ft}^3/s}{0.006\text{ ft}^2} = 4.62\text{ ft/s}$$

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$$h_A = \frac{40 \frac{\cancel{lb}}{\cancel{in^2}} \times 144 \frac{\cancel{in^2}}{ft^2}}{62.4 \frac{\cancel{lb}}{ft^{\cancel{3}}}} + 120\ ft + \frac{\cancel{4.62^2 - 4.62^2}}{32.2 \times 2} + 10.5 \frac{\cancel{lb} \cdot ft}{\cancel{lb}}$$

$\cancel{4.62^2 - 4.62^2} = 0$

$$h_A = 222.8 \quad ft$$

$$\Rightarrow Power = h_A \gamma Q$$

$$222.8\ ft \left(62.4 \frac{lb}{\cancel{ft^3}}\right)\left(0.0277 \frac{\cancel{ft^3}}{s}\right)$$

$$= 385.11 \frac{lb \cdot ft}{s} \times \frac{1\ hp}{550 \frac{lb \cdot ft}{s}}$$

$$\boxed{P_{pump} = 0.7\ hp} = P_A$$

$$e_m = P_A / P_I = \frac{0.7\ hp}{1\ hp}$$

$$\boxed{e_M = 0.7 \text{ or } 70\%}$$

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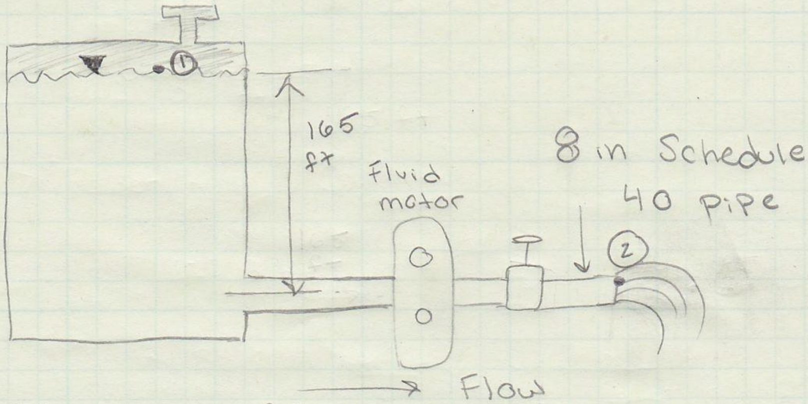

- Water at 60° F
- 1000 gal/min
- $P_R = 37$ hp (power removed)
- $A = 0.3472$ in²

Calculate energy loss

Bernoulli's eqn:

$$\cancel{h_A} + \cancel{\frac{p_1}{\gamma}} + \cancel{\frac{v_1^2}{2g}} + z_1 = \cancel{\frac{p_2}{\gamma}} + \frac{v_2^2}{2g} + z_2 + h_R + h_L$$

=> $h_A = 0$, no pump

=> $P_1 = 0$ gage

=> $v_1 = 0$, large tank ∴ no velocity

=> $P_2 = 0$ gage

solve for h_L

$$h_L = (z_1 - z_2) - \frac{v_2^2}{2g} - h_R$$

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$$h_L = (z_1 - z_2) - \frac{v_2^2}{2g} - h_R$$

$$P_R = h_R \gamma Q$$

$$\hookrightarrow h_R = \frac{P_R}{\gamma Q}$$

$$Q = 1000 \ \frac{\cancel{gal}}{\cancel{min}} \times \frac{0.0022 \ \frac{ft^3}{s}}{1 \ \frac{\cancel{gal}}{\cancel{min}}}$$

$$Q = 2.2 \ \frac{ft^3}{s}$$

$$\Rightarrow P_R = 37 \ \cancel{hp} \times \frac{550 \ \frac{lb \cdot ft}{s}}{1 \ \cancel{hp}} = 20350 \ \frac{lb \cdot ft}{s} = P_R$$

$$\Rightarrow h_R = \frac{20350 \ \frac{\cancel{lb} \cdot ft}{\cancel{s}}}{62.4 \ \frac{\cancel{lb}}{\cancel{ft^3}} \times 2.2 \ \frac{\cancel{ft^3}}{\cancel{s}}} \ ; \quad h_R = 148.24 \ ft$$

$$\Rightarrow v_2 = \frac{Q}{A} = \frac{2.2}{0.3472} = 6.34 \ ft/s = v_2$$

All unknowns found

$$h_L = (165) - \frac{6.34^2}{(32.2)2} - 148.24$$

Energy loss $\boxed{h_L = 16.14 \ ft}$