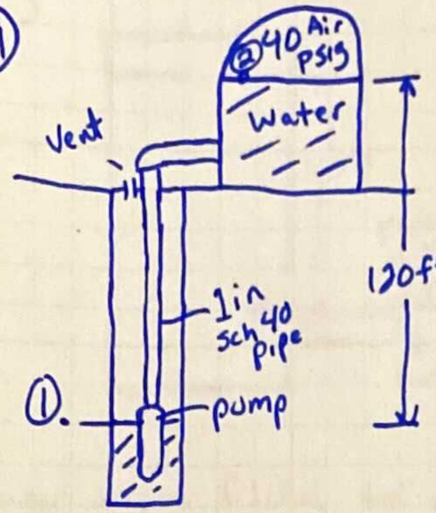
HW1.4

7.11)



Deep well pump $Q = 745 \frac{gal}{hr}$

Energy loss $h_L = 10.5 \, lb \cdot ft/lb$

a) calculate power delivered by pump to water. P_A

b) If pump draws 1 HP, what is the efficiency? e_M

Known → $Q = 745 \frac{gal}{hr}$

$h_L = 10.5 \, {}^{lb \cdot ft}/_{lb}$

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

$A = 0.006 \, ft^2$

$z_2 - z_1 = 120 ft$

$P_2 = 40 \, {}^{lb}/_{in^2}$

$P_A = h_A \gamma Q$

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

$$Q = Av \Rightarrow v = \frac{Q}{A}$$

$$v = \frac{745 \frac{\cancel{gal}}{\cancel{hr}} \times \frac{1 ft^3/s}{449 \cancel{gal}/\cancel{min}} \times \frac{1 \cancel{hr}}{60 \cancel{min}}}{0.006 \cancel{ft^2}}$$

$$v_2 = 4.609 \, ft/s = 4.61 \, ft/s$$

$$h_A = \frac{P_2}{\gamma} + z_2 - z_1 + \frac{v_2^2}{2g} + h_L$$

$$= \frac{40 \, {}^{lb}/_{in^2}}{62.4 \, {}^{lb}/_{ft^3}} + 120 ft + \frac{4.61 \, ft/s}{2(32.2 \, ft/s^2)} + 10.5 \frac{lb \cdot ft}{lb} \times \frac{1 in^2}{0.006944 ft^2}$$

$$40 \, {}^{lb}/_{in^2} \times \frac{1 in^2}{0.006944 ft^2} = 5760.37 \, {}^{lb}/_{ft^2}$$

$$h_A = \frac{5760 \, {}^{lb}/_{ft^2}}{62.4 \, {}^{lb}/_{ft^2}} + 120 ft + \frac{4.61 \, {}^{ft}/_{s}{}^2}{2(32.2 \, ft/s^2)} + 10.5 \frac{\cancel{lb \cdot ft}}{\cancel{lb}}$$

ft

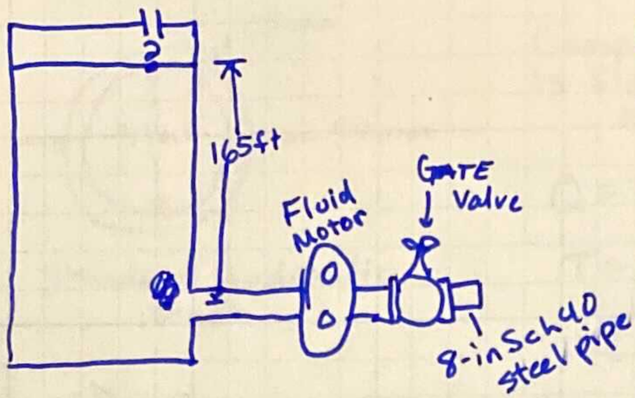
$$h_A = 223.14 ft \qquad P_A = (223.14)(62.4)(0.027654)$$

$$P_A = 385.05 \, \frac{lb \cdot ft}{s}$$

$$P_A = 385.05 \times \frac{1}{550 \, lb\text{-}ft/s} = \boxed{0.70 HP}$$

$$\text{b)} \; e_M = \frac{P_A}{P} = \frac{0.70}{1.00} = \boxed{70\%}$$

7.30



Water @ 60°F

$Q = 1000 \text{ gal/min}$

If motor removes 37 hp from fluid calculate energy losses in the system.

$Q = 1000 \text{ gal/min}$

$\gamma = 62.4 \text{ lb/ft}^3$

$z_2 - z_1 = 165 \text{ ft}$

$A = 0.3472 \text{ ft}^2$

Power from fluid to motor.

$$P_R = h_R W = h_R \gamma Q$$

$$Q = 1000 \frac{\text{gal}}{\text{min}} \times \frac{1 \text{ ft}^3/\text{s}}{449 \frac{\text{gal}}{\text{min}}} = 2.227 \text{ ft}^3/\text{s}$$

$$P_R = 37 \text{ HP} \times \frac{550 \text{ lb}\cdot\text{ft/s}}{1 \text{ HP}}$$

$$P_R = 20350 \text{ lb}\cdot\text{ft/s}$$

$$h_R = \frac{P_R}{\gamma Q} = \frac{20350 \cancel{\text{lb}}\,\text{ft}/\cancel{\text{s}}}{(62.4 \cancel{\text{lb}}/\cancel{\text{ft}^3})(2.227 \cancel{\text{ft}^3}/\cancel{\text{s}})} = 146.44 \text{ ft}$$

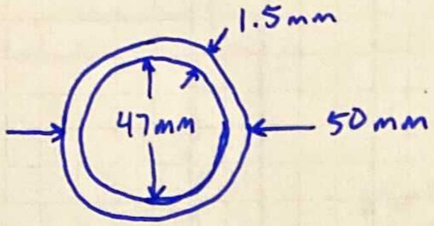
$$v = \frac{Q}{A} = \frac{2.227 \text{ ft}^3/\text{s}}{0.3472 \cancel{\text{ft}^2}} = 6.41 \text{ ft/s}$$

$$h_L = (z_2 - z_1) - \frac{v^2}{2g_2} - h_R$$

$$165 - \frac{6.41^2}{2 \times 32.2} - 146.44$$

$$h_L = 17.92 \text{ ft}$$

8.8)



Standard Hydraulic Steel

Compute Reynolds number. Is flow laminar or turbulent?

$Q = 325\ L/min$

$T = 10°C$

Table G.2

$A = 1.735 \times 10^{-3}\ m^2$

$ID = 47\ mm = 0.047\ m$

Table A.1

@ $T = 10°C$

$\nu = 1.30 \times 10^{-6}\ m^2/s$

$$N_R = \frac{vD}{\nu}$$

$$v = \frac{Q}{A}$$

$$Q = 325\left(\frac{L}{min}\right)\left(\frac{1\,min}{60\,s}\right)\left(\frac{1\,m^3}{1000\,L}\right)$$

$$Q = 0.005417\ m^3/s$$

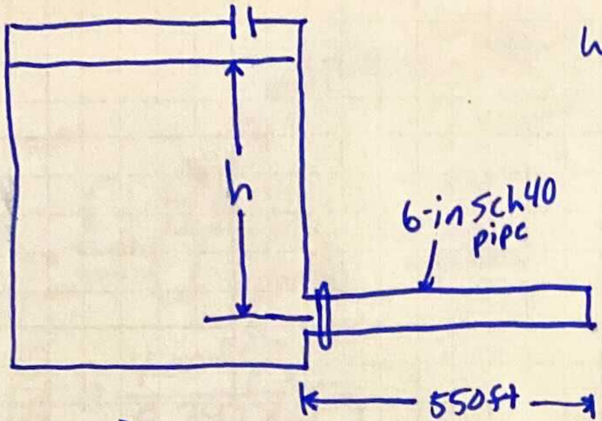
$$v = \frac{0.005417\ m^3/s}{1.735 \times 10^{-3}\ m^2} = 3.12\ m/s$$

$$N_R = \frac{(3.12\ \cancel{m/s})(0.047\ \cancel{m})}{1.30 \times 10^{-6}\ \cancel{m^2/s}} = \underline{112800}$$

$112800 > 400$

<u>Turbulent</u>

8.33



Water @ 80°F

Taking energy loss due friction into account, calculate required head h above pipe inlet to produce volume flow rate of 2.50 ft³/s

Pipe 6-in Sch40

$D = 0.5054\,ft$
$A = 0.2006\,ft^2$

$Q = 2.50\,ft^3/s$

$N_R = \frac{vD}{\nu}$

Water @ 80°F

Table A.2 $\nu = 9.15 \times 10^{-6}\,(ft^2/s)$

$$v = \frac{Q}{A} = \frac{2.50\,ft^3/s}{0.2006\,ft^2} = 12.46\,ft/s$$

$$N_R = \frac{(12.46\,ft/s)(0.5054\,ft)}{9.15 \times 10^{-6}\,(ft^2/s)} = 688228 = 6.88 \times 10^5$$

$\frac{D}{\epsilon} \rightarrow$ Table 8.2 $\epsilon = 1.5 \times 10^{-4}\,ft$

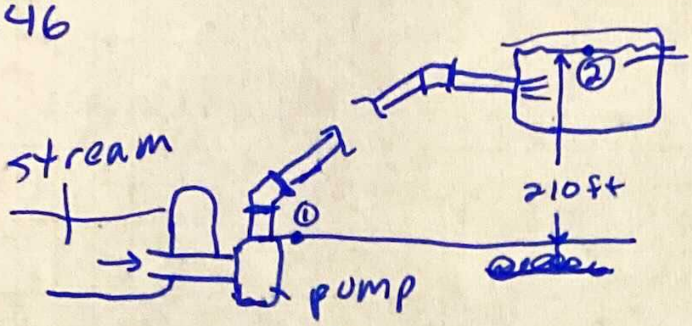
$$\frac{0.5054\,ft}{1.5 \times 10^{-4}\,ft} = 3369.3$$

From Moody Chart $N_R : \frac{D}{\epsilon}$, $f = 0.0145$

$$h_L = f \cdot \frac{L}{D} \cdot \frac{v^2}{2g} = (0.0145)\left(\frac{550}{0.5054}\right)\left(\frac{12.46^2}{2 \times 32.2}\right)$$

$$h_L = 38.04\,ft$$

8.46



Water @ 60°F

pipe Sch40 8-in

$L = 2500\ ft$

$Q = 4.00\ ft^3/s$

Table A.2
$\nu = 1.21 \times 10^{-5} (ft^2/s)$

Pipe Sch40 8-in

$D = 0.6651\ ft$

$A = 0.3472 (ft^2)$

$\epsilon = 1.5 \times 10^{-4}\ ft$

$$v = \frac{Q}{A} = \frac{4.00\ ft^3/s}{0.3472 (\cancel{ft^2})}$$

$$v = 11.52\ ft/s$$

$$N_R = \frac{vD}{\nu} = \frac{(11.52\ \cancel{ft/s})(0.665\ \cancel{1ft})}{1.21 \times 10^{-5} (\cancel{ft^2/s})}$$

$$N_R = 633219 = 6.33 \times 10^5$$

$$\frac{D}{\epsilon} = \frac{0.6651}{1.5 \times 10^{-4}} = 4434$$

Moody chart $f = 0.016$

$$H_L = (f)\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (0.016)\left(\frac{2500}{0.6651}\right)\left(\frac{11.52^2}{2 \times 32.2}\right)$$

$$H_L = 123.93\ ft$$

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

$$p_1 = [(z_2 - z_1) + h_L]\,\gamma$$

$$[\underset{ft}{(210)} + \underset{ft}{(123.93)}]\underset{lb/ft^3}{(62.4)}$$

$$p_1 = (20837.2\ lb/ft)\frac{1\ ft}{144\ in^2}$$

$$p_1 = 144.7\ psia$$