CH.6 79, 82, 91
HW 2.1 CH.7 11, 16, 22, 30, 35, 42 Jordan Davis

79) FIND Q of oil. * ASSUME 60° F *

GIVEN: $sg_o = .9$, $sg_{Hg} = 13.54$, $h = 28''$

$A_1 = \frac{\pi 4^2}{4}$, $A_2 = \frac{\pi 2^2}{4}$, $\gamma_1 = \gamma_2 = \gamma_{oil}$

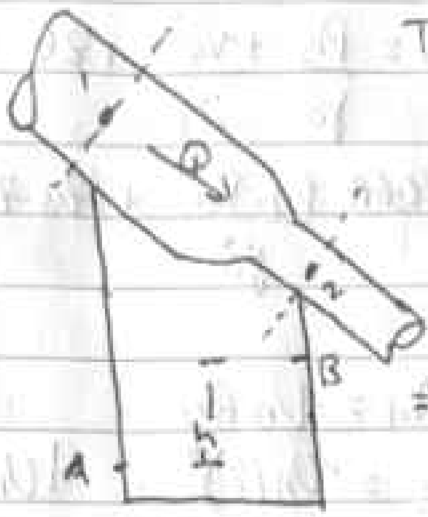


TABLE A.2 $\gamma_w = 62.4\ lb/ft^3$

$\Rightarrow \gamma_{oil} = 0.9(62.4\ lb/ft^3) = \underline{56.16\ lb/ft^3}$

$\gamma_{Hg} = 13.54(62.4\ lb/ft^3) = \underline{844.896\ lb/ft^3}$

$\Rightarrow$ if $Q_{IN} = Q_{OUT}$ $\Rightarrow A_1 v_1 = A_2 v_2$

$v_2 = \frac{A_1 v_1}{A_2} = \frac{(\pi D_1^2/4)v_1}{(\pi D_2^2/4)}$

$\Rightarrow v_2 = (D_1/D_2)^2 v_1$ $\Rightarrow \underline{v_2 = 4v_1}$

$\Rightarrow \frac{P_1}{\gamma_o} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma_o} + \frac{v_2^2}{2g} + z_2$ (1)

$\Rightarrow$ * MANOMETER * $P_A = P_B$

$\Rightarrow P_1 + \gamma_o z_A = P_2 + \gamma_o(z_B - h) + \gamma_{Hg} h$

$\Rightarrow P_1 - P_2 = \gamma_o(z_B - z_A - h) + \gamma_{Hg} h$

$\Rightarrow P_1 - P_2 = 56.16\ lb/ft^3 (z_B - z_A - (28''/12'')) + 844.896\ lb/ft^3 (28''/12'')$

$\Rightarrow P_1 - P_2 = 56.16\ lb/ft^3 (z_B - z_A) + 1840.384\ lb/ft^2$ (2)

$\Rightarrow$ FROM (1)

$\frac{P_1 - P_2 + \gamma_o(z_A - z_B)}{\gamma_o} = \frac{v_2^2 - v_1^2}{2g}$ $\Rightarrow \frac{(P_1 - P_2) + \gamma_o(z_A - z_B)}{\gamma_o} = \frac{(4v_1)^2 - v_1^2}{2g}$

$\Rightarrow v_1 = \underline{11.856\ ft/s}$

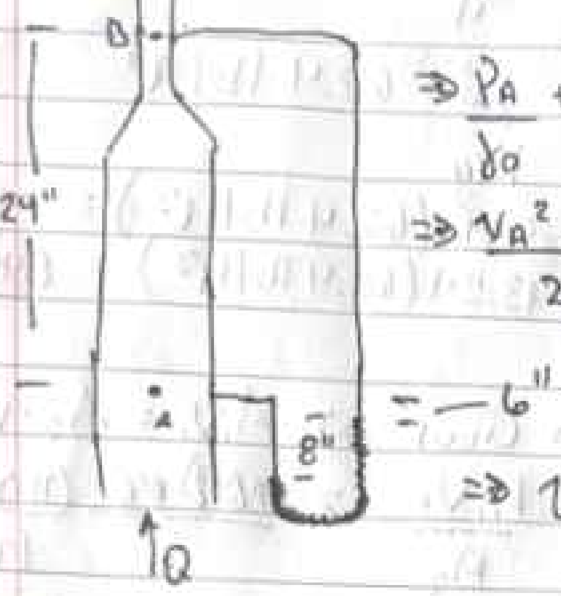
$\Rightarrow Q_{oil} = v_1 A_1 = 11.856\ ft/s\ (\pi/4\ (4''/12'')^2)$

$\Rightarrow \boxed{Q_{oil} = 1.035\ ft^3/s}$

82) FIND Q_{oil} *ASSUME 60° F*

GIVEN: $\gamma_{oil} = 55 \text{ lb/ft}^3$, $D_A = 4''$, $D_B = 2''$

TABLE A.2 $\Rightarrow \gamma_w = 62.4 \text{ lb/ft}^3$



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

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

$$\Rightarrow V_A A_A = V_B A_B$$

$$\Rightarrow V_B = \frac{V_A A_A}{A_B} = V_A (2)^2 = 4V_A$$

$$\Rightarrow P_A + \gamma_o(14''/12'') - \gamma_w(8''/12'') - \gamma_o(24''/12'') = P_B$$

$$\Rightarrow P_A - P_B = \gamma_w(8/12) + \gamma_o(2) - \gamma_o(14/12)$$

$$\Rightarrow P_A - P_B = 41.6 \text{ lb/ft}^2 + 110 \text{ lb/ft}^2 - 64.167 \text{ lb/ft}^2$$

$$\Rightarrow P_A - P_B = 87.433 \text{ lb/ft}^2 \checkmark$$

$$\Rightarrow \frac{P_A - P_B}{\gamma_o} = 1.59 \text{ ft} \checkmark$$

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

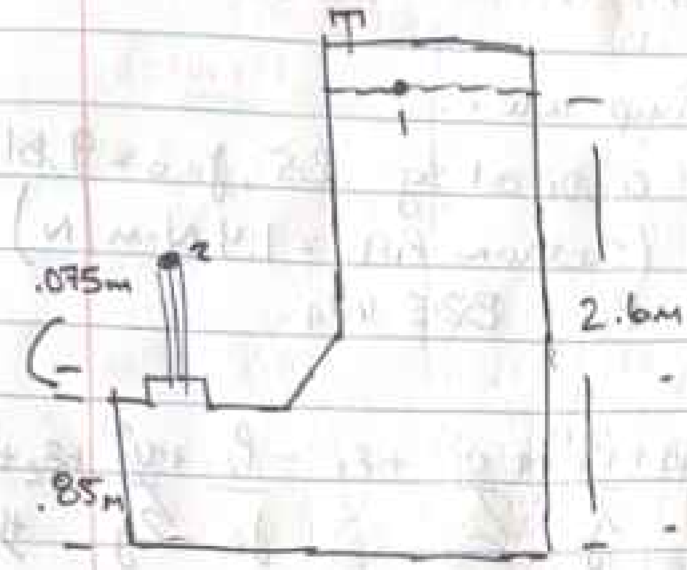
$$\Rightarrow \frac{-15V_A^2}{2g} = -1.59 \text{ ft} + (2 \text{ ft})$$

$$\Rightarrow -15V_A^2 = 26.3794 \text{ ft}^2/\text{s}^2 \longrightarrow (?)$$

* CONFUSED ON WHERE I WENT WRONG!? THAT LAST EQ CANNOT BE NEGATIVE SINCE I HAVE TO $\sqrt[2]{\ }$ THE ANSWER TO FIND V_A. THEN $Q = V_A A_A$. *

I) Find height of jet? * Assume water @ 5°C *

Given: $\gamma_{H_2O} = 9.81\ kN/m^3$



Bernoulli's:

$$\frac{P_2}{\gamma_{H_2O}} + \frac{V_2^2}{2g} + z_2 = \frac{P_1}{\gamma_{H_2O}} + \frac{V_1^2}{2g} + z_1$$

- V_1 & $V_2 = 0$. V_1 large tank & V_2 is assumed @ rest @ peak
- P_1 & $P_2 = 0$ due to being @ atm pressure

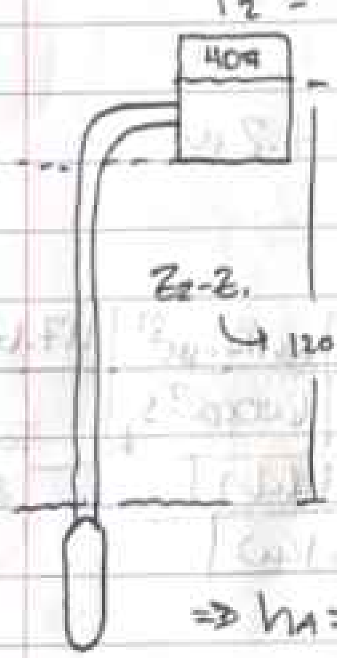
$\Rightarrow z_2 = z_1 \Rightarrow$ **Jet will rise 2.6m** if we assume that there are no friction losses.

II) Find pump power & E if pump draws 1Hp.

Given: $\gamma_{H_2O} = 62.4\ lb/ft^3$, $Q = 745\ gal/hr$

$h_L = 10.5\ ft/lb$, Pipe Dia $= 1''$, $P_1 = 0$ @ atm

$P_2 = 40\ psig$



$$\Rightarrow h_A + \frac{P_1}{\gamma_{H_2O}} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma_{H_2O}} + \frac{V_2^2}{2g} + z_2 + h_R + h_L$$

$\Rightarrow P_1 = 0$ @ atm, V_1 & $V_2 = 0$ @ well & tank

$h_R = 0$ no turb, non moving assumed

$$\Rightarrow h_A = \frac{P_2}{\gamma_{H_2O}} + (z_2 - z_1) + h_L$$

$$\Rightarrow h_A = \left(\frac{40\ lb}{in^2}\Big|\frac{144\ in^2}{ft^2}\Big|\frac{ft^3}{62.4\ lb}\right) + 120\ ft + 10.5\ ft = \underline{222.21\ ft}$$

$$\Rightarrow Q = \frac{745\ gal}{hr}\Big|\frac{min}{449\ gal}\Big|\frac{ft^3}{sec}\Big|\frac{hr}{60\ min} = \underline{.0277\ ft^3/sec}$$

$$\Rightarrow P_A = \gamma_{H_2O}(Q)h_A = \frac{62.4\ lb}{ft^3}\Big|\frac{.0277\ ft^3}{sec}\Big|\frac{222.21\ ft}{}\Big|\frac{sec}{550\ ft\ lb}\Big|HP$$

$\Rightarrow$ **$P_A = .7\ Hp$**

→ cont

9(cont) $\varepsilon_A = P_{ACT} / P_{REAL} = .7\ HP / 1\ HP$

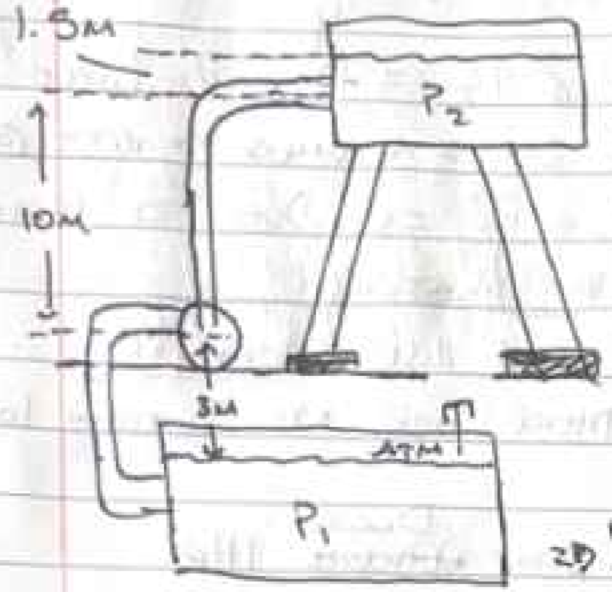
$\Rightarrow \boxed{e_A = 70\%}$

16) FIND P_A & PRESSURE @ PUMP INLET.

GIVEN: $Q = 840\ L/min$, CRUDE OIL sg = .85, $\gamma_{H_2O} = 9.81\ kN/m^3$

$h_L = 4.2\ N \cdot m/N$ (SUCTION PIPE = $1.4\ N \cdot m/N$)

$P_2 = 825\ kPa$



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

$\Rightarrow$ NO TURB $\Rightarrow h_R = 0$

$P_1 = 0$ @ ATM

v_1 & $v_2 = 0$ STAGNANT H_2O

$\Rightarrow h_A = \frac{P_2}{\gamma_o} + (z_2 - z_1) + h_L$ ①

$\gamma_o = .85(9810\ N/m^3) = \underline{8338.5\ N/m^3}$

$P_2 = \underline{825000\ N/m^2}$

$\Rightarrow h_A = \left(\frac{825000\ N}{m^2} \cdot \frac{m^3}{8338.5\ N}\right) + 14.5\ m + 4.2\ m$

$\Rightarrow h_A = \underline{117.64\ m}$

(a) $P_A = \gamma_o Q h_A = \frac{8338.5\ N}{m^3} \cdot \frac{840\ L}{min} \cdot \frac{min \cdot m^3}{60000\ L \cdot s} \cdot 117.64\ m$

~~$\Rightarrow P_A = 1373318.75\ N \cdot m/s$ = [crossed out]~~ ← FORGOT A ZERO

$\Rightarrow P_A = 13733.18\ Nm/s = \boxed{13.733\ kW}$

→ CONT

(16 CONT) $Q = v_p A_{sp}$, DIA SCH 40 = 62.7 mm , $v_2 = v_p$

$\Rightarrow v_p = \frac{840 \ell}{min} \cdot \frac{min \cdot m^3}{60000 \ell \cdot s} \cdot \frac{4}{\pi} \cdot \frac{1}{(.0627 m)^2} = \underline{4.53\ m/s}$

ATM STAGNANT REF

$\Rightarrow \frac{P_1}{\gamma_o} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma_o} + \frac{v_2^2}{2g} + z_2 + h_L$

$\Rightarrow P_2 = \left(-\frac{v_2^2}{2g} - z_2 - h_L\right)\gamma_o$ * P_2 = P @ PUMP *

$= \left(\left(\frac{-4.53 m}{s}\right)^2 \frac{s^2}{2 \cdot 9.81 m} - 3m - 1.4m\right) \frac{8338.5 N}{m^3}$

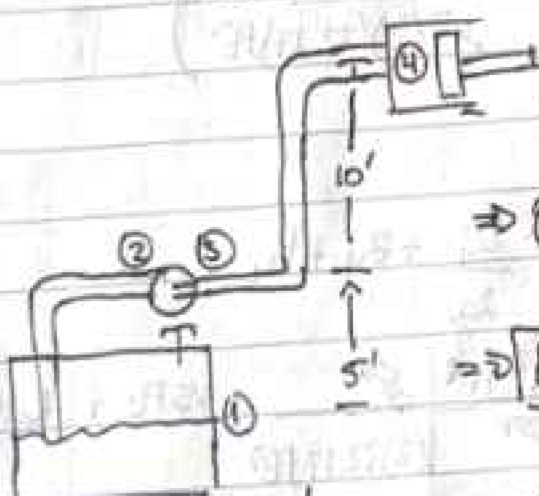
$= -27968\ N/m^2$ $\Rightarrow$ **PRESS pump = -27.968 kPA**

22) FIND Q, $P_{cylinder}$, PRESS pump out, PRESS pump inlet, P_A

GIVEN: Oil sg = .9   cylinder D = 5", t = 15s, L = 20"

F = 11,000 lb, $h_{L suc}$ = 11.5 ftlb/lb, $h_{L disch}$ = 35 ftlb/lb

PIPES ARE 3/8" SCH. 80 ⇒ DIA = .423"



$A_{cyl} = \frac{\pi(5^2)}{4} = \underline{19.635\ in^2}$

$\Rightarrow Q_{pump} = \frac{19.635 in^2}{144 in^2} \cdot ft^2 \cdot \frac{20 in}{15 s} \cdot \frac{ft}{12 in}$

$\Rightarrow$ **Q_{pump} = .015 ft³/s**

$\Rightarrow$ Press cyl = F/A = 11000 lb / 19.635 in² = **560.22 psi**

$\Rightarrow v_3 = Q/A_3 = \frac{.015 ft^3}{s} \cdot \frac{4}{.423 in} \cdot \frac{144 in^2}{.423 in} \cdot \frac{1}{\pi} \cdot \frac{1}{ft^2} = \underline{15.37\ ft/s}$

$Q_2 = Q_3$ & $A_2 = A_3$ ⇒ $v_3 = v_2$

$\Rightarrow v_4 = \frac{20 in}{15 s} \cdot \frac{ft}{12 in} = \underline{.111\ ft/s}$

→ CONT

22 cont) $\gamma_o = .9(62.4 lb/ft^3) = \underline{56.16 lb/ft^3}$ ✓ $P_4 = P_{oil}$

$\frac{5600 lb}{in^2} \Big| \frac{144 in^2}{ft^2} = \underline{80671.7 lb/ft^2}$

$\Rightarrow \frac{P_3}{\gamma_o} + \frac{v_3^2}{2g} + z_3 = \frac{P_4}{\gamma_o} + \frac{v_4^2}{2g} + z_4 + h_{LD}$

$\Rightarrow P_3 = \left(\frac{P_4}{\gamma_o} + \frac{v_4^2}{2g} + z_4 + h_{LD} - \frac{v_3^2}{2g} - z_3\right)\gamma_o$

$\Rightarrow P_3 = P_4 + \gamma_o\left(\frac{v_4^2 - v_3^2}{2g} + z_4 - z_3 + h_{LD}\right)$

$\Rightarrow P_3 = \frac{80671.7 lb}{ft^2} + \frac{56.16 lb}{ft^3}\left(\frac{.111^2 - 15.37^2 ft^2/s^2}{2(32.17 ft/s^2)} + 10 ft + 35\right)$

$\Rightarrow P_3 = P_{pump\,out} = \boxed{82992.7 lb/ft^2}$

(ATM, STAG, $-h_{LS}$)

$\Rightarrow \frac{P_1}{\gamma_o} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma_o} + \frac{v_2^2}{2g} + z_2$

$\Rightarrow P_2 = \left((z_1 - z_2) - h_{LS} - \frac{v_2^2}{2g}\right)\gamma_o$

$\Rightarrow \frac{56.16 lb}{ft^3}\left((-5 ft) - 11.5 ft - \frac{15.37^2 ft^2 \cdot s^2}{s^2 (2)(32.17) ft}\right)$

$\Rightarrow \boxed{P_2 = -1132.8 lb/ft^2}$

(ATM, STAG, REF)

$\Rightarrow h_A + \frac{P_1}{\gamma_o} + \frac{v_1^2}{2g} + z_1 = \frac{P_4}{\gamma_o} + \frac{v_4^2}{2g} + z_4 + h_L$

$\Rightarrow h_A = \frac{80671.7 lb}{ft^2}\Big|\frac{ft^3}{56.16 lb} + \frac{.111^2 ft^2}{s^2}\Big|\frac{s^2}{(2)32.17 ft} + 15 ft + 46.5 ft$

$\Rightarrow h_A = \underline{1497.96 ft}$ ✓

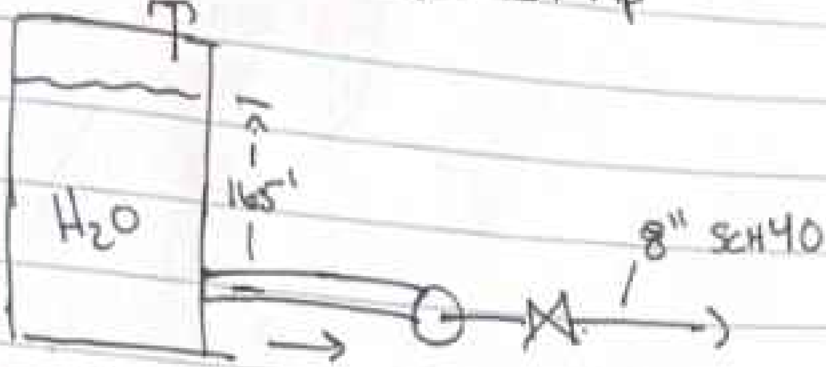
$\Rightarrow P_A = \gamma_o Q h_A = \frac{56.16 lb}{ft^3}\Big|\frac{.015 ft^3}{s}\Big| 1497.96 ft$

$\Rightarrow P_A = 1261.88\, ft\,lb/s \Big| \frac{HP}{550\, ft\,lb/s}$ $\Rightarrow \boxed{P_A = 2.29\, Hp}$

30) FIND ENERGY LOSSES IN SYSTEM

GIVEN: H_2O @ 60°F , Q = 1000 gal/min

MOTOR h_L = 37 hp



$\Rightarrow P_A = \gamma_{H_2O} Q h_A = \frac{62.4 \text{ lb}}{ft^3} \Big| \frac{1000 \text{ gal}}{min} \Big| \frac{min \cdot ft^3}{449 \text{ gal} \cdot s} \Big| 165 \text{ ft}$

$\Rightarrow P_A = \frac{22930.96 \text{ ft lb}}{s} \Big| \frac{HP \cdot s}{550 \text{ ft lb}} = \underline{41.69 \text{ HP}}$

$\Rightarrow$ w/ TOTAL PWR = 41.69 Hp + PUMP REMOVES 37 Hp

$\Rightarrow$ **4.69 Hp ENERGY LOSSES**

35) FIND P_R

GIVEN: $sg_o = .93$, Q = 175 gal/min , $P_{R_{in}}$ = 28.4 Hp

ε_{pump} = 80%.

$$\Rightarrow \frac{P_4}{\gamma_o} + \frac{v_4^2}{2g} + z_4 + h_A = \frac{P_5}{\gamma_o} + \frac{v_5^2}{2g} + z_5 + h_R + h_L$$

$$\Rightarrow h_R = \frac{P_4 - P_5}{\gamma_o} + (z_4 - z_5)$$