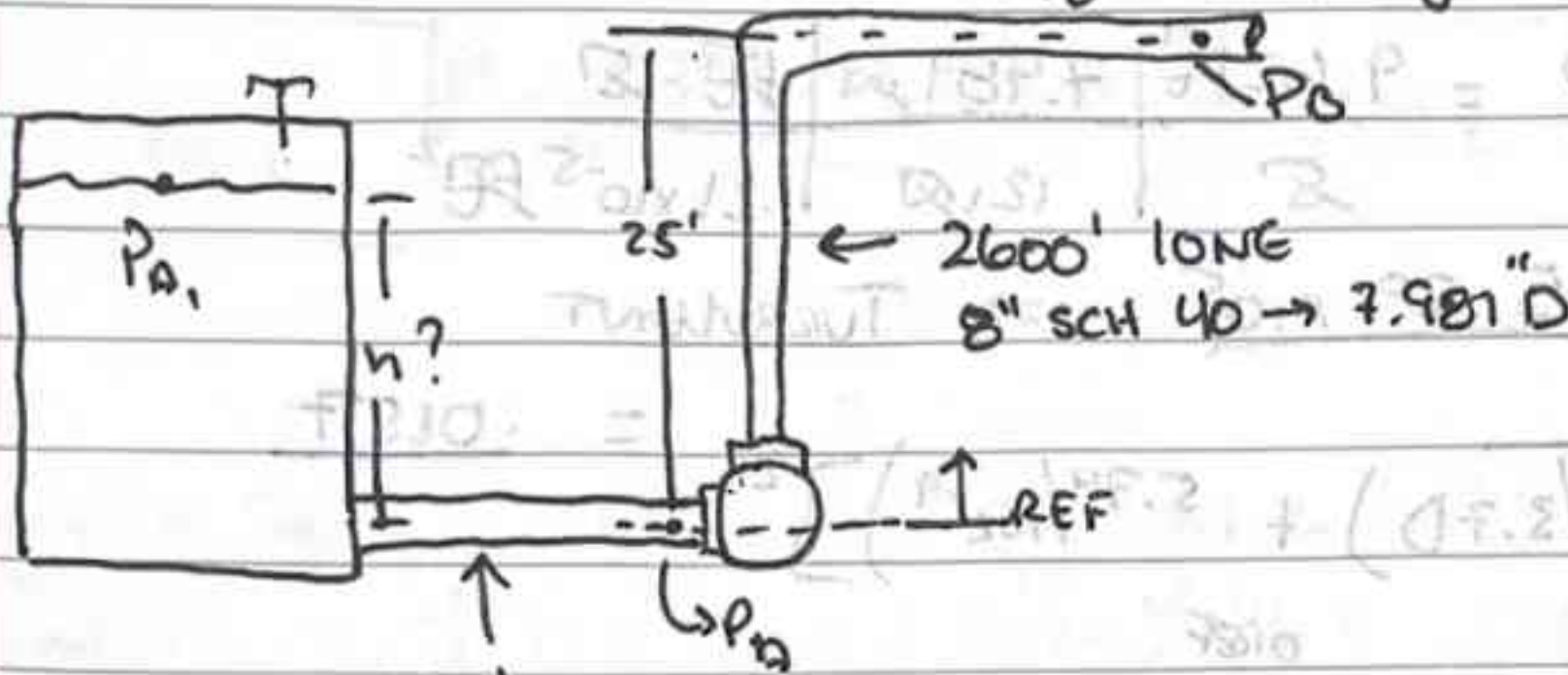


HW 2.2 ✓ 33, 38, 44, 46, 49, 62

JORDAN DAMS

33) FIND h IN TANK? GIVEN: WATER @ $60^\circ\text{F} \rightarrow \gamma = 62.4 \text{ lb/ft}^3$
 FIND P_A (PUMP)? $Q = 1500 \text{ gal/min}$ $\rho = 1.94 \text{ slugs/ft}^3$
 $P_A = 5 \text{ psig}$ $n = 2.35 \times 10^{-5} \frac{\text{lb}\cdot\text{s}}{\text{ft}^2}$
 $P_B = 85 \text{ psig}$



$$\Rightarrow \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

$$\textcircled{1} h = \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \frac{f L_{10} V_A^2}{2Dg}$$

$$\Rightarrow Q = VA \Rightarrow V_A = \frac{Q}{A} = \frac{1500 \text{ gal/min}}{\pi (10.02 \text{ in})^2 / 4} = 6.101 \text{ ft/s}$$

$$\Rightarrow N_R = \frac{VD}{\nu} = \frac{6.101 \text{ ft/s} \cdot 10.02 \text{ in}}{1.21 \times 10^{-5} \text{ ft}^2/\text{s}} = 4.21 \times 10^5$$

$$\Rightarrow \text{Turbulent} \Rightarrow f = \frac{.25}{[\log(1/(3.7(D/\epsilon) + 5.74/N_R^{.9}))]^2}$$

$$\Rightarrow f = .0156$$

$$\Rightarrow h = \frac{5 \text{ lb}}{62.4 \text{ lb/ft}^3} + \frac{6.101^2 \text{ ft}^2/\text{s}^2}{2(32.17 \text{ ft/s}^2)} + \frac{.0156 \cdot 45 \text{ ft} \cdot 6.101^2 \text{ ft}^2/\text{s}^2}{2 \cdot 10.02 \text{ in} \cdot 12 \text{ in} \cdot 32.17 \text{ ft/s}^2}$$

$$\Rightarrow h = \frac{5 \text{ lb}}{62.4 \text{ lb/ft}^3} + \frac{6.101^2 \text{ ft}^2/\text{s}^2}{2(32.17 \text{ ft/s}^2)} + \frac{.0156 \cdot 45 \text{ ft} \cdot 6.101^2 \text{ ft}^2/\text{s}^2}{2 \cdot 10.02 \text{ in} \cdot 12 \text{ in} \cdot 32.17 \text{ ft/s}^2}$$

$$\Rightarrow h = 11.54 \text{ ft} + 0.58 \text{ ft} + .49 \text{ ft}$$

$$\Rightarrow \boxed{h = 12.61 \text{ ft}}$$

→ CONT

2NAD LAGAD

50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000

$$\Rightarrow V_B = Q/A = \frac{1500 \text{ gal} | \text{min} | \text{ft}^3}{\text{min} | 449 \text{ gal} | \text{s} | \pi | 7.981^2 | \text{ft}^2} = 9.62 \text{ ft/s}$$

$$\Rightarrow V_B = 9.62 \text{ ft/s}$$

$$\Rightarrow N_R = \frac{V_B D}{\nu} = \frac{9.62 \text{ ft} | 7.981 \text{ ft} | \text{ft}^2}{\text{s} | 12.1 \times 10^{-5} \text{ ft}^2} = 5.29 \times 10^5$$

$$\Rightarrow N_R = 5.29 \times 10^5 \Rightarrow \text{Turbulent}$$

$$\Rightarrow f = \frac{.25}{\left[\log \left(\frac{\epsilon}{3.7D} \right) + \frac{5.74}{N_R^{.9}} \right]^2} = .0157$$

$$\Rightarrow h_A + \frac{P_A}{\rho} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\rho} + \frac{V_B^2}{2g} + z_B + f L \frac{V_B^2}{2g}$$

$$\Rightarrow h_A = \frac{P_B - P_A}{\rho} + \frac{V_B^2 - V_A^2}{2g} + z_B + f L \frac{V_B^2}{2g}$$

$$\Rightarrow \left(\frac{85 \text{ lb} | 144 \text{ in}^2}{\text{in}^2 | \text{ft}^2} - \frac{5 \text{ lb} | 144 \text{ in}^2}{\text{in}^2 | \text{ft}^2} \right) \frac{1}{(2)(32.17 \text{ ft/s}^2)} + \frac{(9.62^2 - 6.101^2) \text{ ft}^2}{2(32.17 \text{ ft/s}^2)} + \frac{.0157 | 2600 \text{ ft} | 9.62^2 \text{ ft}^2}{2 | 7.981 \text{ ft} | \text{ft}^2} + 25 \text{ ft}$$

$$\Rightarrow h_A = 184.62 \text{ ft} + 0.86 \text{ ft} + 25 \text{ ft} + 88.28 \text{ ft}$$

$$\Rightarrow h_A = 298.76 \text{ ft}$$

$$\Rightarrow P_A = \gamma_{H_2O} Q h_A = \frac{62.4 \text{ lb} | 1500 \text{ gal} | \text{min} | \text{ft}^3}{\text{ft}^3 | \text{min} | 449 \text{ gal} | \text{s} | 298.76 \text{ ft}}$$

$$\Rightarrow P_A = 62,280.5 \text{ ft} \cdot \text{lb} / \text{s} \quad \text{HP}$$

$$\Rightarrow P_A = 113.24 \text{ HP}$$

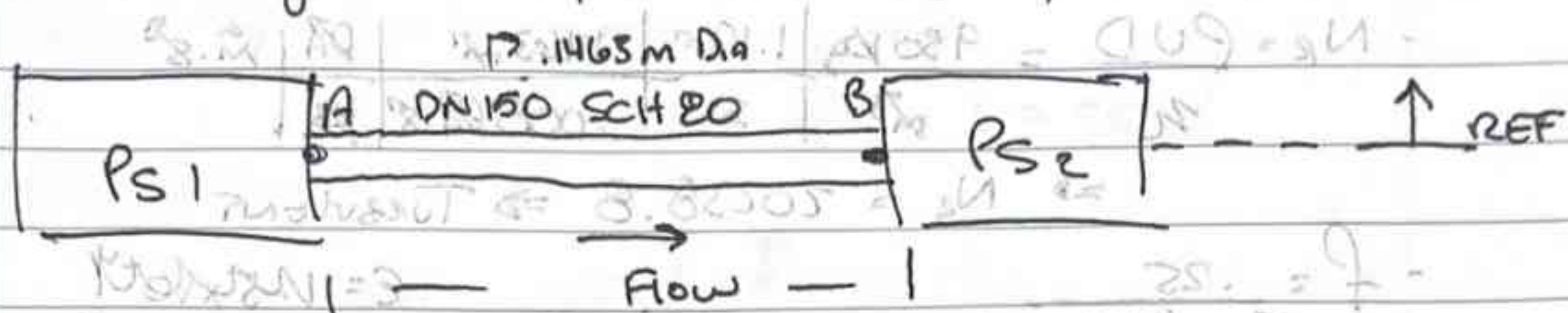
7.100

$$\Rightarrow N = 11.51$$

$$\Rightarrow N = 11.51$$

38) * FINDING #37 FIRST * FIND $P_A - P_B$? PWR REQ TO MAINTAIN INLET PRESSURE?

GIVEN: $S_{g.oil} = .93$, $Q = 1200 \text{ L/min}$, $Oil @ 10^\circ C$



$$\gamma_{oil} = S_{g.oil}(\gamma_w @ 4^\circ C) = .93(9.81 \text{ kN/m}^3) = 9.1233 \text{ kN/m}^3$$

$$Area = \pi(D^2)/4 = \pi(.1463 \text{ m})^2/4 = .0168 \text{ m}^2$$

$$\tau_{oil @ 10^\circ C} = .15 \text{ MPa}\cdot\text{s}, \quad \rho_{oil} = S_{g.oil}(\rho_w) = .93(1000 \text{ kg/m}^3) = 930 \text{ kg/m}^3$$

$$P_A + \frac{V_A^2}{2g} + z_A = P_B + \frac{V_B^2}{2g} + z_B + h_L \quad \text{and} \quad U_A = U_B$$

$$\Rightarrow P_A - P_B = h_L \gamma \quad (1)$$

$$V = Q/A = \frac{1200 \text{ L/min}}{60000 \text{ L/s}} \cdot \frac{1 \text{ m}^3}{1000 \text{ L}} \cdot \frac{1}{.0168 \text{ m}^2} = 1.19 \text{ m/s}$$

$$N_R = \frac{\rho V D}{\mu} = \frac{930 \text{ kg/m}^3 \cdot 1.19 \text{ m/s} \cdot .1463 \text{ m}}{.15 \text{ Pa}\cdot\text{s}} = 1079.4$$

$\Rightarrow N_R = 1079.4 \Rightarrow \text{LAMINAR}$

$$f = 64/N_R = .059$$

$$h_L = f \left(\frac{L}{D} \right) \left(\frac{V^2}{2g} \right) = .059 \left(\frac{3200 \text{ m}}{.1463 \text{ m}} \right) \left(\frac{1.19^2 \text{ m}^2/\text{s}^2}{2(9.81 \text{ m/s}^2)} \right)$$

$$\Rightarrow h_L = 93.14 \text{ m}$$

$$\Delta P = P_A - P_B = \frac{93.14 \text{ m} \cdot 9.1233 \text{ kN/m}^3}{1 \text{ m}^3} = 849.74 \text{ kPa}$$

$$\Rightarrow P_{(pwr)} = \gamma Q h_L \quad \text{TO HAVE EQUAL PRESSURES}$$

THE PUMP HEAD = ENERGY LOSSES

$$\Rightarrow \frac{9.1233 \text{ kN/m}^3 \cdot 1200 \text{ L/min}}{60000 \text{ L/s}} \cdot \frac{1 \text{ m}^3}{1000 \text{ L}} \cdot 93.14 \text{ m} = 16.99 \text{ kW}$$

* $Q_A = Q_B \rightarrow \text{CONT}$

38) IF oil @ 100°C, FIND PUMP PWR REQ? (85)
 MAX DISTANCE w/ SAME ΔP?

- $\mu_{oil @ 100^\circ C} = 0.008 \text{ Pa}\cdot\text{s}$

- $N_R = \frac{\rho U D}{\mu} = \frac{950 \text{ kg/m}^3 \cdot 1.19 \text{ m} \cdot 1.1463 \text{ m/s}}{0.008 \text{ Pa}\cdot\text{s}} = 20238.8$

$\Rightarrow N_R > 20238.8 \Rightarrow \text{Turbulent}$

- $f = 0.25$

$\epsilon = 1.5 \times 10^{-4} \text{ m}$
 $4.6 \times 10^{-5} \text{ m}$

$\left[\log\left(\frac{\epsilon}{3.7D}\right) + \frac{5.74}{N_R^{0.9}} \right]^2$

$\Rightarrow f = 0.0265$

$\Rightarrow h_L = \frac{f L U^3}{12 D^5} = \frac{0.0265 \cdot 3200 \text{ m} \cdot 1.19^3 \text{ m}^3/\text{s}^3}{12 \cdot (0.1463 \text{ m})^5} = 41.84 \text{ m}$

$\Rightarrow P_{A(PWR)} = \rho g Q h_L = \frac{9.1233 \text{ kW} \cdot 1200 \text{ m}^3/\text{s}}{60000 \text{ s}} = 7.63 \text{ kW}$

$\Rightarrow \boxed{P_{WTR REQ} = 7.63 \text{ kW}} \quad \text{LESS PWR NEEDED}$

• USING h_L FROM #37

$h_L = \frac{f L U^3}{12 D^5} \Rightarrow L = \frac{20 g h_L}{f U^3}$

$\Rightarrow L = \frac{2 \cdot 9.81 \text{ m/s}^2 \cdot 41.84 \text{ m}}{0.0265 \cdot 1.19^3 \text{ m}^3/\text{s}^3} = 7124.3 \text{ m}$

$\Rightarrow \boxed{\text{MAX DISTANCE} = 7.1243 \text{ km}}$

* Proof *

$\frac{P_A}{\rho} + \frac{U_A^2}{2g} + z_A + h_A = \frac{P_B}{\rho} + \frac{U_B^2}{2g} + z_B + h_L$

• $U_A = U_B$ DUE TO SAME FLOW & AREA

• $P_A = P_B$ SAME INLET PRESSURES

$\Rightarrow h_A = h_L$ *

44) FIND PRESSURE @ PUMP OUTLET?

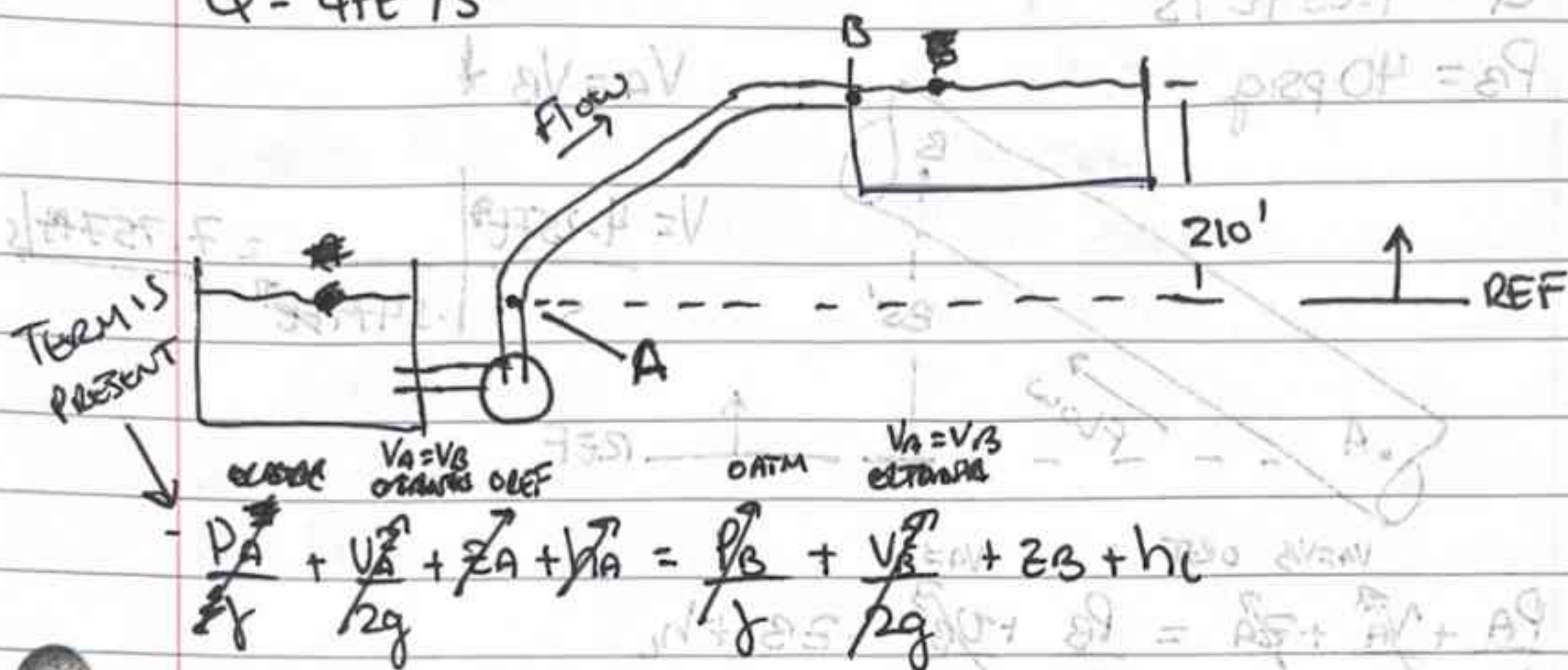
GIVEN: WATER @ 60°F → $\gamma_{H_2O} = 62.4 \text{ lb/ft}^3$

$$\nu = 1.21 \times 10^{-5} \text{ ft}^2/\text{s}$$

8" SCH. 40 PIPE → 0.6651 ft DIAMETER

$$A = 0.3472 \text{ ft}^2 \quad L = 2500'$$

$$Q = 4 \text{ ft}^3/\text{s}$$



$$\Rightarrow \cancel{P_A/\gamma} + \cancel{V_A^2/2g} + \cancel{z_A} + \cancel{h_A} = \cancel{P_B/\gamma} + \cancel{V_B^2/2g} + \cancel{z_B} + h_L$$

$$- V = Q/A = \frac{4 \text{ ft}^3/\text{s}}{0.3472 \text{ ft}^2} = 11.521 \text{ ft/s}$$

$$- N_R = \frac{VD}{\nu} = \frac{11.521 \text{ ft/s} \cdot 0.6651 \text{ ft} \cdot 8}{1.21 \times 10^{-5} \text{ ft}^2/\text{s}} = 633274.1 \Rightarrow \text{TURBULENT}$$

$$- f = \frac{.25}{\left(\log \left(\left(\frac{\epsilon}{3.7D} \right) + \frac{5.74}{N_R^{.9}} \right) \right)^2} \Rightarrow f = .0155$$

$$\Rightarrow h_L = \frac{.0155 \cdot 2500 \text{ ft} \cdot 11.521^2 \text{ ft}^2/\text{s}^2}{2 \cdot (32.17) \text{ ft/s}^2} = 120.19 \text{ ft}$$

$$\Rightarrow \cancel{210'} + 120.19' = 330.19 \text{ ft}$$

$$\Rightarrow P_A = \gamma(z_B + h_L) = \frac{62.4 \text{ lb}}{\text{ft}^3} (210' + 120.19') = 20603.9 \text{ lb/ft}^2$$

$$\Rightarrow \frac{20603.9 \text{ lb}}{\text{ft}^2} = 143.1 \text{ psi}$$

Two ←

46) Find Press @ A?

Given: GAS @ 50°F → $\rho = 1.32 \text{ slugs/ft}^3$
 $\gamma_{\text{gas}} = 42.4 \text{ lb/ft}^3$

$$\mu = 7 \times 10^{-6} \text{ lb.s/ft}^2$$

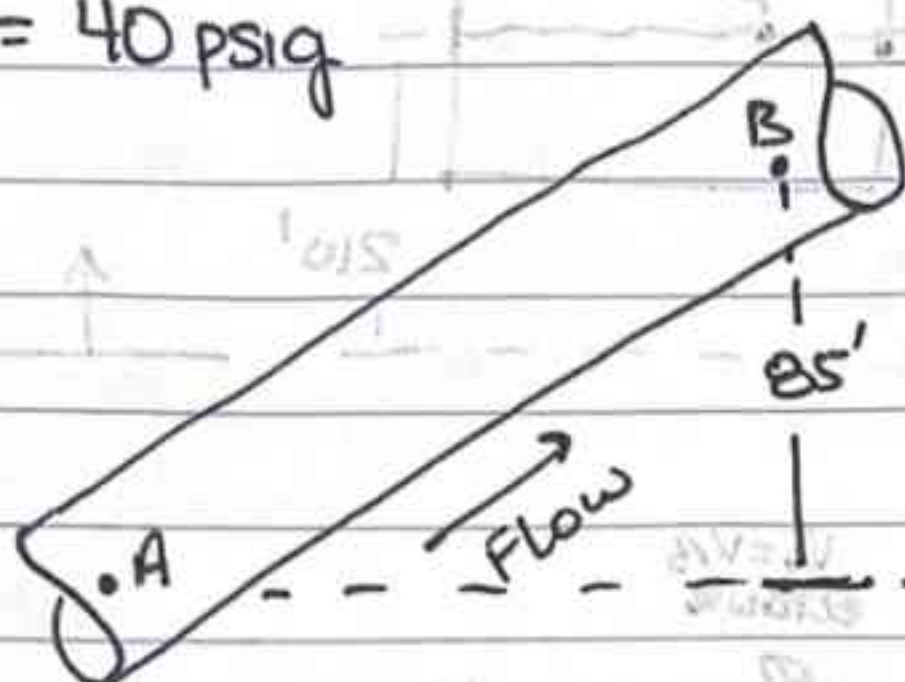
10" SCH 40 PIPE = DIA: 8.350 ft, L = 3200'

$$A = 1.5479 \text{ ft}^2$$

$$Q = 4.25 \text{ ft}^3/\text{s}$$

$$P_B = 40 \text{ psig}$$

$$V_A = V_B$$



$$V = \frac{Q}{A} = \frac{4.25 \text{ ft}^3/\text{s}}{1.5479 \text{ ft}^2} = 2.75 \text{ ft/s}$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

$$\Rightarrow P_A = \gamma (P_B/\gamma + z_B + h_L) \quad (1)$$

$$- \text{Nr} = \frac{\rho V D}{\mu}, \quad \rho = 1.32 \text{ slugs/ft}^3, \quad V = 2.75 \text{ ft/s}, \quad D = 8.350 \text{ ft}, \quad \mu = 7 \times 10^{-6} \text{ lb.s/ft}^2$$

$$\Rightarrow \text{Nr} = \frac{42.46 \text{ lb/ft}^3}{\text{ft}^3} \cdot \frac{4.25 \text{ ft}^3/\text{s}}{\text{s}} \cdot \frac{8.350 \text{ ft}}{\text{ft}^2} \cdot \frac{\text{ft}^2}{7 \times 10^{-6} \text{ lb.s/ft}^2} \cdot \frac{\text{s}^2}{32.17 \text{ ft}} = 1221251$$

⇒ TURBULENT

$$- f = \frac{0.25}{\left[\log\left(\frac{\epsilon}{3.7D}\right) + \frac{5.74}{\text{Nr}^{0.9}} \right]^2} = 0.014$$

$$\Rightarrow h_L = \frac{0.014}{2} \cdot \frac{3200 \text{ ft}}{\text{ft}} \cdot \frac{7.75^2 \text{ ft}^2/\text{s}^2}{\text{s}^2} \cdot \frac{\text{s}^2}{8.35 \text{ ft}} \cdot \frac{\text{ft}}{32.17 \text{ ft}} = 6.47 \text{ ft}$$

$$\Rightarrow h_L = \frac{0.014}{2} \cdot \frac{3200 \text{ ft}}{\text{ft}} \cdot \frac{7.75^2 \text{ ft}^2/\text{s}^2}{\text{s}^2} \cdot \frac{\text{s}^2}{8.35 \text{ ft}} \cdot \frac{\text{ft}}{32.17 \text{ ft}} = 6.47 \text{ ft}$$

→ CONT

46) (cont) $P_A = \frac{40 \text{ lb}}{\text{in}^2} + \frac{85 \text{ ft} \cdot 42.4 \text{ lb}}{144 \text{ in}^2} + \frac{6.47 \text{ ft} \cdot 42.4 \text{ lb}}{144 \text{ in}^2}$
 $\Rightarrow P_A = 106.93 \text{ psig}$

49) FIND $P_A - P_B$?

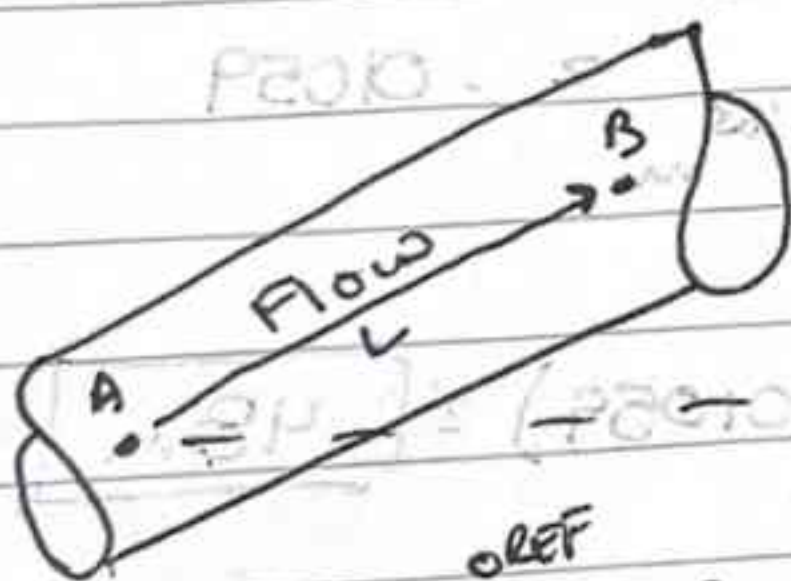
GIVEN: GLYCERIN @ $25^\circ\text{C} \rightarrow \gamma = 12.34 \text{ kN/m}^3$
 $\nu = 7.63 \times 10^{-4} \text{ m}^2/\text{s}$

COPPER PIPE $\rightarrow .0744 \text{ m}$ DIAMETER
 $4.347 \times 10^{-3} \text{ m}^2$ AREA

$Q = \frac{180 \text{ L/min}}{60000 \text{ L/min}} = \frac{\text{m}^3/\text{s}}{.003 \text{ m}^3/\text{s}}$

$L = 25.8 \text{ m}$

$U = Q/A = \frac{.003 \text{ m}^3/\text{s}}{4.347 \times 10^{-3} \text{ m}^2} = .69 \text{ m/s}$



$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A^{\text{REF}} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$

$V_A = V_B$, SAME Q & A

$\Rightarrow P_A - P_B = \gamma(z_B + h_L)$

$Re = \frac{VD}{\nu} = \frac{.69 \text{ m/s} \cdot .0744 \text{ m}}{7.63 \times 10^{-4} \text{ m}^2/\text{s}} = 67.28 \Rightarrow \text{LAMINAR}$

$f = 64/67.28 = .95$

$h_L = \frac{.95}{8} \cdot \frac{25.8 \text{ m}}{.0744 \text{ m}} \cdot \frac{.69^2 \text{ m}^2/\text{s}^2}{2(9.81) \text{ m/s}^2} = 7.99 \text{ m}$

$\Rightarrow \Delta P_{A-B} = \frac{12340 \text{ N}}{\text{m}^3} \cdot 8.67 \text{ m} = 106.988 \text{ kPa}$

62) Find h_L ?

GIVEN: Hydraulic Copper Tube $\rightarrow$ DIA: .113 m

$$A: 1.003 \times 10^{-2} \text{ m}^2$$

WATER $\rightarrow V=2$

$$Q = \frac{1000 \text{ L}}{\text{min}} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{60 \text{ s}}{1 \text{ min}} = .0167 \text{ m}^3/\text{s}$$

$$L = 45 \text{ m}, C_H = 140, R = .0565 \text{ m}$$

$$\Rightarrow V = Q/A = \frac{.0167 \text{ m}^3/\text{s}}{1.003 \times 10^{-2} \text{ m}^2} = 1.67 \text{ m/s}$$

$$\Rightarrow V = .85 C_H R^{.63} S^{.54}$$

$$\Rightarrow V = Q/A = \frac{.0167 \text{ m}^3/\text{s}}{1.003 \times 10^{-2} \text{ m}^2} = 1.67 \text{ m/s}$$

$$\Rightarrow S^{.54} = \frac{V}{.85 C_H R^{.63}} \Rightarrow S = \sqrt[.54]{\frac{V}{.85 C_H R^{.63}}}$$

$$\Rightarrow S = \sqrt[.54]{\frac{1.67 \text{ m/s}}{.85 (140) (.0565)^{.63} \text{ m}}} = .01059$$

$$\Rightarrow h_L = L(S) = 45 \text{ m} (.01059) = \boxed{.48 \text{ m}}$$