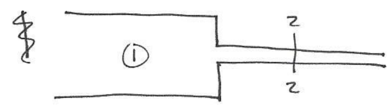
HW 2.1: CH10 - 20, 37, 39, 43, 46, 48 CH11 - 5, 13, 20

N Da Da N G Da

10 #20 Determine the energy loss for a sudden contraction from a DN 125 schedule 80 steel pipe to a DN 50 schedule 80 pipe for a flow rate of 500 L/min. = $0.5\,m^3/min$ = $0.008\,m^3/s$

→ sudden contraction $h_L = K\frac{V_2^2}{2g}$



→ cont. eqn.: $Q = V \cdot A$ $\quad V_1 = \frac{Q}{A_1} \quad V_2 = \frac{Q}{A_2}$

→ Bernoulli's: $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + \cancel{z_1} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + \cancel{z_2} + h_L$ ✓

→ $Q = 500\,L/min = 30\,m/s$

→ diameter of DN 125 : 141.3mm ϕ $\qquad \frac{D_2}{D_1} \approx 0.43$

→ diameter of DN 50 : 60.3mm ϕ

→

→ $V_2 = \frac{Q}{A_2} = \frac{.008\,m^3/s}{\frac{(0.0603\,m)^2\pi}{4}} = V_2 = 2.8\,m/s$

→ K is found from Figure 10.8:

$K = 0.45$

→ $h_L = K\frac{V_2^2}{2g} = (0.45)\frac{(2.8\,m/s)^2}{2(9.81\,m/s^2)}$

$h_L = 0.18\,m$

10.57) Bernoullis equation

$$\frac{P_1}{y} + z_1 + \frac{v_1^2}{2g} - h_f - h_L = \frac{P_2}{y} + z_2 + \frac{v_2^2}{2g}$$

energy in pipe

$$P_1 - P_2 = y\,(h_L + h_f)$$

energy loss because of bend

$$h_L = K\left(\frac{v^2}{2g}\right)$$

Given

temperature = 77 F

Q (flow rate) = 12.5 gal/min

use $Q = Av$ to get discharge of flow

A = area

v = velocity of flow

switch formula around to $v = \frac{Q}{A}$ $\frac{12.5}{(.0021)}$ change to ft/s = .0275

google says

$.0022 \times 12.5 = .0275$ ft/s

$v = 13.033$ ft/s

resistance coefficient closed bend

Moodys diagram gives $f_T = .26$

$K = f_T\,(L_e/D)$ $\quad L_e/D = 50$

$K = (.26)(50)$ $\quad E = 1.5 \times 10^{-4}$

$= 1.3$

next use energy loss formula

$$h_L = 1.3\left(\frac{(13.033)^2}{2(32.2}\right) = 3.43 \text{ ft}$$

next use h_L due to friction (guess what our R_N so we can get f from Moodys Diagram)

$$h_f = f \times \frac{8}{.0518} \times \frac{13.033^2}{2(32.2)}$$

$$= .04 \times \frac{8}{.518} \times \frac{(13.033)^2}{2(32.2)} = 16.31 \text{ ft}$$

fill in the $P_1 - P_2$ values

$$P_1 - P_2 = (68.5)(3.43 + 16.31) = \boxed{P_1 - P_2 = 1{,}352.19 \text{ lb/ft}^2}$$

10.39 $Q = .40\ ft^3/s$

$A = .05132\ ft^2$ (schedule 40 3" pipe)

$T = 50°$

$$h_L = f \frac{Le}{D} \frac{v^2}{2g} \qquad V = \frac{Q}{A} \quad \frac{.4\ ft^3/s}{.05132\ ft^2}$$

$V = 7.794\ ft/s$

Table 10.4 = Tee with flow through tee (run)

= Le / D = 20

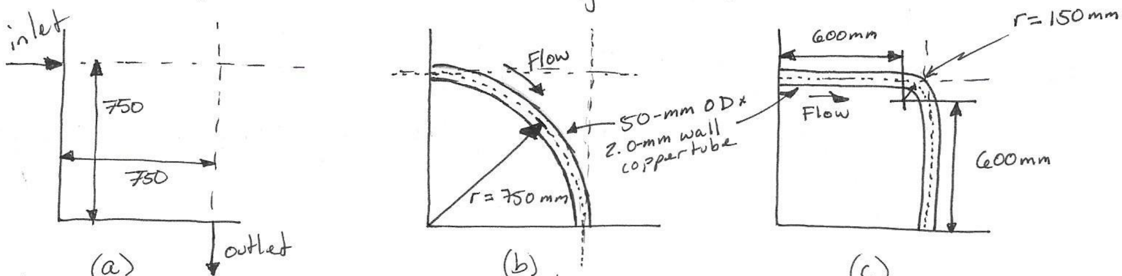
Table 10.5 = New schedule 40 pipe

$f = .017$

$$h_L = (.017) \cdot (20) \cdot \left(\frac{(7.794\ ft/s)^2}{2(32.2\ ft/s)} \right) = h_L = .32$$

$$\boxed{h_L = .32}$$

10 #43 | The inlet & outlet shown in (a) are to be connected w/ a 50mm OD × 2.0mm wall copper tube to carry 750 L/min of propyl alcohol @25°C. Evaluate the two schemes shown in parts (b) & (c) w/ regard to the energy loss. Include the losses due to both the bend and the friction in the straight tube.



(a) basic layout   (b) proposal 1   (c) proposal 2

→ (b) $Q = 750\ L/min = 0.75\ m^3/min = 0.0125\ m^3/s$

→ $h_L = K\frac{v^2}{2g}$

→ $K = f_T\left(\frac{Le}{D}\right)$ (for a pipe bend (figure 10.28))

inner ϕ

→ $\frac{D}{\varepsilon} = \frac{0.046m}{1.5 \times 10^{-6} m} = \boxed{30666.7}$

→ $V = Q/A$

→ $D = 50mm - 2(2.0\ mm) = 46mm = \boxed{0.046m}$

→ $\varepsilon = $ (table 8.2) $= 1.5 \times 10^{-6} m$

→ $\frac{Le}{D}$ (according to figure 10.28) ⇒ $\boxed{43}$

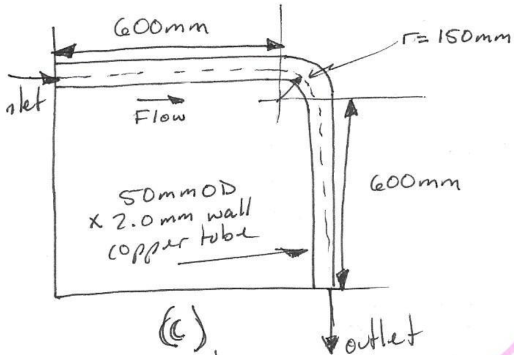
→ $\frac{r}{\text{inner } D} = \frac{.750m}{0.046m} = 16.3$ (now look @ figure 10.28)

→ $V = \frac{0.0125 m^3/s}{\frac{\pi(0.046m)^2}{4}} = \boxed{7.5m/s = V}$

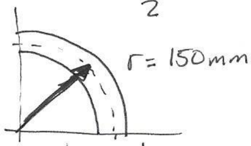
→ $f_T = 0.0095$ (according to moody's diagram on figure 8.7)

→ $K = f_T\left(\frac{Le}{D}\right) = 0.0095(43) = \boxed{0.4085 = K}$

→ $h_L = K\left(\frac{V^2}{2g}\right) = 0.4085\left(\frac{(7.5m/s)^2}{2(9.81m/s^2)}\right) = 1.17 = h_L$



(c)
proposal 2



analyze h_L

→ $h_L = K\frac{v^2}{2g}$

→ $k = f_T\left(\frac{Le}{D}\right)$

→ $V = Q/A = \dfrac{0.0125\,m^3/s}{\frac{\pi(0.046\,m/s)^2}{4}} = \boxed{7.5\,m/s = V}$

→ $\varepsilon = 1.5\times10^{-6}\,m$

→ $D = 0.046\,m$

→ $\frac{D}{\varepsilon} = \frac{0.046\,m}{1.5\times10^{-6}\,m} = 30{,}666.7 \quad \therefore \boxed{f_T = 0.0095}$

→ $\frac{Le}{D} \Rightarrow \frac{r}{D} = \frac{.150\,m}{0.046\,m} = 3.26 \quad \therefore \boxed{\frac{Le}{D} = 12 \text{ (according to figure 10.28)}}$

→ $k = f_T\left(\frac{Le}{D}\right) = 0.0095(12) = \boxed{0.114 = K}$

→ $h_L = (0.114)\left(\frac{(7.5\,m/s)^2}{2(9.81\,m/s^2)}\right) = 0.327\,m = h_{L,1}$

energy loss in 90° bend. add this to the loss in the straightened pipe lengths.

→ to get h_L for a straight pipe: $h_L = f \times \frac{L}{D} \times \frac{V^2}{2\times g}$

→ to find friction factor f, calculate Reynold's ~~number and divide into it~~; use in turbulent eqn

→ $R_e = \frac{\rho \cdot V \cdot D}{\eta} = \frac{(802\,kg/m^3)(7.5\,m/s)(0.046\,m)}{1.92\times10^{-3}\left(\frac{kg\cdot m/s^2}{m^2}\right)(s)}$

→ $R_e = 144109$

→ $f =$ Done in Excel calculator $= 0.0168$

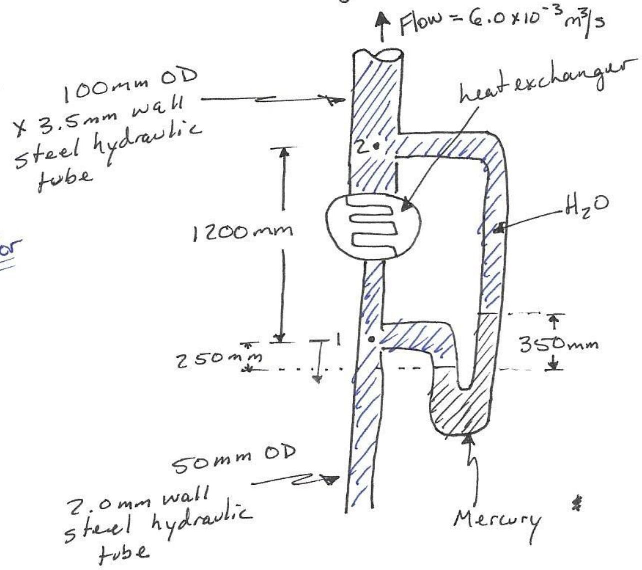
→ $h_L = (0.0168)(0.6\,m / 0.046\,m)((7.5\,m/s)^2 / (2\times9.81\,m/s^2))$

$h_{L,2} = 0.628\,m$

Total $h_L = h_{L,1} + h_{L,2} + h_{L,2} = 0.327 + (0.628)2$

$h_L = 1.58\,m$

10#46 The figure shows a test setup for determining the energy loss due to a heat exchanger. Water @ 50°C is flowing vertically upward @ 6.0×10^{-3} m^3/s. Calculate the energy loss between points 1 & 2. Determine the resistance coefficient for the heat exchanger based on the velocity in the inlet tube.



Step 1: write continuity & Bernoulli's

→ $Q = V\cdot A \quad V_1\cdot A_1 = V_2\cdot A_2$

→ $\dfrac{P_1}{\gamma} + \dfrac{V_1^2}{2g} + z_1 = \dfrac{P_2}{\gamma} + \dfrac{V_2^2}{2g} + z_2 + h_L$

solve for

step 2: minor loss using resistance coefficient

→ $h_L = K(v^2/2g)$

velocity of flow in pipe BEFORE heat exchanger (so, it's V_1)

Step 3: solve for K using the whole of Bernoulli's Eqn

→ $\dfrac{P_1}{\gamma} + \dfrac{V_1^2}{2g} + \cancel{z_1} = \dfrac{P_2}{\gamma} + \dfrac{V_2^2}{2g} + z_2 + \left(K\left(v_1^2/2g\right)\right)$

* Analysis *

→ we know everything right off the bat, except pressures 1 & 2. solving them will have to do with the manometer on the side.

We know $P_1 > P_2$

$\gamma_{H_2O} = 9.69\,kN/m^3$

$\gamma_{Hg} = 132.8\,kN/m^3$

→ $P_1 + (\gamma_{H_2O})(0.25m) - (\gamma_{mercury})(0.35m) - (\gamma_{H_2O})(1.1m) = P_2$

$P_1 + (9.69kN/m^3)(0.25m) - (132.8kN/m^3)(0.35m) - (9.69kN/m^3)(1.1m) = P_2$

$P_1 + 2.42kPa - 46.48kPa - 10.659kPa = P_2$

$\boxed{P_1 - 54.72\,kPa = P_2}$ (solved for P_2 in terms of P_1)

→ $V_1 = \dfrac{Q}{A_1} = \dfrac{6.0\times10^{-3}m^3/s}{0.001662m^2} \Rightarrow V_1 = \boxed{3.61m/s = V_1}$

→ $V_2 = \dfrac{Q}{A_2} = \dfrac{6.0\times10^{-3}m^3/s}{6.793\times10^{-3}m^2} \Rightarrow \boxed{V_2 = 0.88m/s}$

→ Rewrite the stars and Bernoulli's Eqn

$$\rightarrow \frac{P_1}{\gamma_{H_2O}} + \frac{V_1^2}{2g} + \cancel{z_1}^{0} = \frac{P_2}{\gamma_{H_2O}} + \frac{V_2^2}{2g} + z_2 + K(V_1^2/2g)$$

$$\frac{P_1}{9.69\,kN/m^3} + \frac{(3.61\,m/s)^2}{2(9.81\,m/s^2)} = \frac{P_1 - 54.72\,kPa}{9.69\,kN/m^3} + \frac{(0.88\,m/s)^2}{2(9.81\,m/s^2)} + 1.2m + K\left((3.61)^2/2(9.81)\right)$$

$$\cancel{\frac{P_1}{9.69\,kN/m^3}} - \cancel{\frac{P_1}{9.69\,kN/m^3}} + 0.664m + 5.647m - 0.0395m - 1.2m = K(0.661m)$$

$$5.072m = K(0.661m)$$

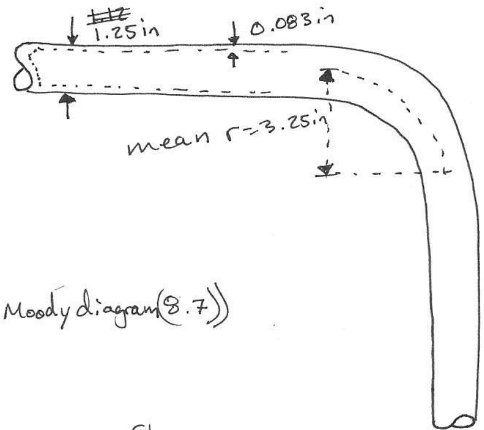
$$\boxed{K = 7.67}$$

$$\rightarrow h_L = K(V_1^2/2g) = (7.67)\left((3.61\,m/s)^2/2(9.81\,m/s^2)\right) = (7.67)(0.661m)$$

$$h_L = 5.07m$$

10 #48 | Compute the energy loss in a 90° bend in a steel tube used for a fluid power system. The tube has a 1¼-in OD and a wall thickness of 0.083 in. The mean bend radius is 3.25 in. The flow rate of hydraulic oil is 27.5 gal/min.

→ $Q = 27.5\,gal/min$



→ compute h_L:

→ $h_L = K\dfrac{V^2}{2g}$

→ $K = f_T\left(\dfrac{L_e}{D}\right)$ (for a pipe bend) (Figure 10.28)

inner ϕ

→ $\dfrac{D}{\varepsilon} = \_\_\_$ (use to help find f_T from Moody diagram (8.7))

→ $V = Q/A$

→ $D = 1.25 - 2(0.083) = \boxed{1.084\,in} = 0.0903\,ft$

→ $V = \dfrac{27.5\,gal}{min} \Big/ \dfrac{\pi(1.084\,in)^2}{4}$

$\dfrac{27.5\,gal}{min} = 0.062\,ft^3/s$

$V = \dfrac{0.062\,ft^3/s}{0.006409\,ft^2} = \boxed{9.67\,ft/s = V} = \boxed{116.04\,in/s}$

→ $\varepsilon = (\text{table } 8.2) = 1.5\times10^{-4}\,ft$

→ $\dfrac{D}{\varepsilon} = \dfrac{0.0903\,\cancel{ft}}{1.5\times10^{-4}\,\cancel{ft}} = 602 \therefore f_T = 0.022$

→ $\dfrac{L_e}{D}$ = (according to figure 10.28) =

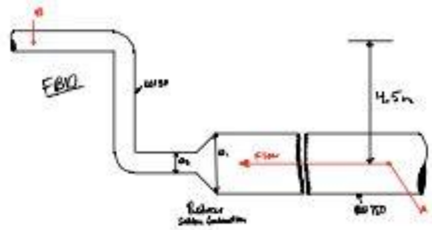
→ $\boxed{\dfrac{r}{D} = \dfrac{3.25\,in}{1.084\,in} = 3.00} \therefore \boxed{\dfrac{L_e}{D} = 12}$

→ $K = f_T\left(\dfrac{L_e}{D}\right) = (0.022)(12) = 0.264$

→ $h_L = 0.264\left(\dfrac{(9.67\,ft/s)^2}{2(32.2\,ft/s^2)}\right)$ → $h_L = 0.38$

Homework 2.1

11-5) Given:
- $Q_{oA} = 0.015\ \frac{m^3}{s}$
- $\gamma_o = 8.80\ \frac{kN}{m^3}$
- $\nu_o = 2.12 \times 10^{-5}\ \frac{m^2}{s}$
- Length of DN 150 pipe = 130 m
- Length of DN 50 pipe = 8 m
- Both pipes are Schedule 80 steel
- $D_{DN150} = 146.3\ mm = 0.146\ m$
- $D_{DN50} = 49.3\ mm = 0.049\ m$



- Considering all pipe friction and minor losses, calculate the pressure at A.

Step 1) Determine velocities with Q=VA;

- $Q = V_A A_A$
  $V_A = \frac{Q}{A_A} = \frac{0.015}{(1.685 \times 10^{-2})} \frac{m^3/s}{m^2}$
  $V_A = 0.89\ m/s$
- $Q = V_B A_B$
  $V_B = \frac{Q}{A_B} = \frac{0.015}{(1.905 \times 10^{-3})} \frac{m^3/s}{m^2}$
  $V_B = 7.87\ \frac{m}{s}$

Step 2) Determine Friction factors

- $N_{R,A} = \frac{V_A D_A}{\nu} = \frac{(0.898)(0.146\ m)}{(2.12 \times 10^{-5}\ \frac{m^2}{s})} = 6129$
  $\to N_{R,A} = 6.13 \times 10^3$
- D/ε with schedule 80 STEEL pipe, $\varepsilon = 4.6 \times 10^{-5}\ m$
  using $D_A = 0.146\ m$, $\frac{D}{\varepsilon_A} = \frac{0.146\ m}{4.6 \times 10^{-5}\ m} \to \frac{D}{\varepsilon_A} = 3174$
- Now with $N_{R,A} = 6.13 \times 10^3$ and $\frac{D}{\varepsilon_A} = 3174$, using Moody's diagram

  $f_T = 0.015$ $f_A = 0.035$

- $N_{R,B} = \frac{V_B D_B}{\nu} = \frac{(7.878)(0.049\ m)}{(2.12 \times 10^{-5}\ \frac{m^2}{s})} = 18190$
  $\to N_{R,B} = 1.82 \times 10^4$
- $\frac{D}{\varepsilon_B}$, $\varepsilon = 4.6 \times 10^{-5}\ m$ and using $D_B = 0.049\ m$
  $\to \frac{D}{\varepsilon_B} = \frac{0.049\ m}{(4.6 \times 10^{-5}\ m)} \to \frac{D}{\varepsilon_B} = 1065$
- Now with $N_{R,B} = 1.82 \times 10^4$ and $\frac{D}{\varepsilon_B} = 1065$, using Moody's diagram

  $f_T = 0.019$ $f_B = 0.028$

Step 3) Determine minor losses in pipes

- $h_{L1} = f_{1A} \cdot \left(\frac{L}{D}\right)_A \cdot \left(\frac{V_A^2}{2g}\right) = 0.035 \cdot \left(\frac{130\,ft}{3.1\,in}\right) \cdot \left(\frac{(0.44\,\frac{m}{s})^2}{2 \cdot 9.81\,\frac{m}{s^2}}\right)$ [m]
  $\hookrightarrow h_{L1} = 1.74\,m$

- $h_{L2} = f_{2B} \cdot \left(\frac{L}{D}\right)_B \cdot \left(\frac{V_B^2}{2g}\right) = 0.028 \cdot \left(\frac{8\,m}{0.044\,m}\right) \cdot \left(\frac{(2.45\,\frac{m}{s})^2}{2 \cdot 9.81\,\frac{m}{s^2}}\right)$ [m]
  $\hookrightarrow h_{L2} = 14.43\,m$

- energy loss in elbows
  $h_{L3} = N_{elbows} \cdot 20 \cdot f_{1A} \cdot \left(\frac{V_B^2}{2g}\right) = (2) \cdot 20 \cdot 0.019 \cdot \left(\frac{(2.45\,\frac{m}{s})^2}{2 \cdot 9.81\,\frac{m}{s^2}}\right)$ [m]
  $\hookrightarrow h_{L3} = 2.4\,m$

- $h_{L4} = K\left(\frac{V_2^2}{2g}\right)$, with $D_1/D_2 \approx 3.0$ and $V_2 \approx 8\,\frac{m}{s} \rightarrow K = 0.57$
  $= (0.57)\left(\frac{(2.87\,\frac{m}{s})^2}{2(9.81\,\frac{m}{s^2})}\right)$ [m]
  $h_{L4} = 1.17\,m$

- Sum all energy losses: $\Sigma h_L = h_{L\,total}$
  $\Sigma h_L = h_{L1} + h_{L2} + h_{L3} + h_{L4} = 1.74 + 14.43 + 2.4 + 1.17$ [m]
  $\hookrightarrow \Sigma h_L = h_L = 19.74\,m$

Step 4) Use Bernoulli's Equation and plug in values to find P_A

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

$\frac{P_A}{\gamma} + \emptyset + \frac{(0.44\,\frac{m}{s})^2}{2(9.81\,\frac{m}{s^2})} = \frac{P_B}{\gamma} + (4.5\,m) + \frac{(2.87\,\frac{m}{s})^2}{2(9.81\,\frac{m}{s^2})} + h_L$

$\frac{P_A}{8.80\,\frac{kN}{m^3}} = \frac{12.5 \times 10^6\,\frac{N}{m^2}}{8.80\,\frac{kN}{m^3}} + (4.5\,m) + \left(\left(\frac{V_B^2}{2g}\right) - \left(\frac{V_A^2}{2g}\right)\right) + 19.74\,m$

$\frac{P_A - (12.5\,MPa)}{8.80\,\frac{kN}{m^3}} = 27.35\,m \cdot 8.8\,\frac{kN}{m^3}$

$P_A - 12.5\,MPa = 240.7\,kPa$

$P_A = 240.7\,kPa + 12.5\,MPa$ " $[12.5 + 0.24\,MPa]$

$\underline{P_A = 12.74\,MPa}$

$\boxed{\therefore P_A = 12.74\,MPa}$

11-11) Water at 15 °C is flowing downward in a vertical tube 7.5 m long. The pressure is 550 kPa at the top and 585 kPa at the bottom. A ball-type check valve is installed near the bottom. The hydraulic tube is drawn steel, with a 32 mm OD and a 2.0 mm wall thickness. Compute the volume flow rate of water.

- Given [Top-bottom = A-B respectively]:
  - $T = 15\,°C$: $\gamma = 9.81\ \frac{kN}{m^3}$
  - $P_A = 550$ kPa, $\rho = 1000\ \frac{kg}{m^3}$
  - $P_B = 585$ kPa, $\eta = 1.15\times10^{-3}$ Pa·s
  - $z = 7.5$ m, $\nu = 1.15\times10^{-6}\ \frac{m^2}{s}$
  - 32 mm OD
  - $t = 2$ mm

- Step 1) Determine cross-sectional Area of pipe
  - $D = OD - 2t = 32 - 2(2)$ mm
    - $\rightarrow D = 28$ mm $= 0.028$ m
  - $A = \frac{\pi D^2}{4} = \frac{\pi (0.028)^2}{4}$
    - $\rightarrow A = 6.16\times10^{-4}\ m^2$

- Step 2) Determine $\frac{D}{\varepsilon}$ ratio with $D = 0.028$
  - Drawn Steel: $\varepsilon = 1.5\times10^{-6}$ m
  - $\frac{D}{\varepsilon} = \frac{0.028}{1.5\times10^{-6}}\frac{m}{m}$
    - $\rightarrow \frac{D}{\varepsilon} = 18666$

- Step 3) Apply and rearrange Bernoulli's
  - $\frac{P_A}{\gamma} + z_A + \frac{V_A^2}{2g} - h_L = \frac{P_B}{\gamma} + z_B + \frac{V_B^2}{2g}$ put everything to the left side
  - $\left(\frac{P_A - P_B}{\gamma}\right) + (z_A - z_B) + \left(\frac{V_A^2 - V_B^2}{2g}\right) = h_L$ [V is constant]
  - $h_L = \left(\frac{550 - 585}{9.81}\right) + (7.5 - 0)$
    - $h_L = 3.93$ m

- Step 4) Determine velocity using Darcy's
  - $h_L = f\cdot\left(\frac{L}{D}\right)\cdot\left(\frac{V^2}{2g}\right)$
  - $3.93\text{ m} = f\cdot\left(\frac{7.5\text{ m}}{0.028\text{ m}}\right)\cdot\frac{V^2}{2g}$
  - $\frac{3.93\text{ m}}{267.86} = f\cdot\frac{V^2}{2g}$
  - $2(9.81)(0.0147) = f\cdot V^2$
  - $\frac{0.288}{f} = V^2$
  - $V = \sqrt{\frac{0.288}{f}}$ Eq 1
    - with $f = 0.018$
  - $V = \sqrt{\frac{0.288}{0.018}}$
    - $\rightarrow V = 4\ \frac{m}{s}$

- Step 5) Determine friction factor for velocity
  - $N_R = \frac{\rho V D}{\eta} = \frac{(1000\ \frac{kg}{m^3})(0.028\text{ m})V}{(1.15\times10^{-3}\text{ Pa·s})}$
    - $\rightarrow N_R = 24347.82\cdot V$
  - Make assumption for f to see if it graphically compares and agrees [was set up using Excel for trials]
  - for $f = 0.018$, $V = \sqrt{\frac{0.288}{0.018}} = 4\ \frac{m}{s} \rightarrow N_R = 24347.82\cdot(4)$
    - $N_R = 97391.3 \approx$ with $\frac{D}{\varepsilon} = 18666$
  - best accepted assumption $f = 0.018$ (solve for V)

- Step 6) Determine flow rate, Q
  - $Q = V\cdot A = (4\ \frac{m}{s})\cdot(6.15\times10^{-4}\ m^2)$
    - $\rightarrow Q = 0.00246\ \frac{m^3}{s}$

$\boxed{\therefore Q = 0.00246\ \frac{m^3}{s}}$

11.20)

Bernoulli's equation

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

$$\frac{\rho g\,(H-y)}{\rho g} + y = \frac{0}{\rho g} + 0 + h_L$$

$$H - \cancel{y} + \cancel{y} = L_L$$

$$H = h_L$$

Known : Temperature = 80°F

length = 75 ft

flowrate = 400 gal/m

steel pipes roughness ε = 1.5×10^{-5} ft

Kinetic viscosity of water at 80°F = 9.15×10^{-6} ft²/s

Size of pipe dia

$$D = .66 \left[\left(1.5 \times 10^{-4}\right)^{1.25} \left(\frac{75 \times \left(400 \times \frac{1}{9h1}\right)^2}{32.2 \times H} \right) \right]^{4.75} + 9.15 \times 10^{-6} \times \left(\frac{400 \times 1}{3h1} \right)^{2.4}$$

$$\times \left(\frac{75}{32.2 \times H} \right)^{5.2} \Bigg)^{.04}$$

$$D = .66 \times \left(1.66 \times 10^{-5} \times \frac{16.48}{(H)^{4.85}} + \frac{1.57 \times 10^{-9}}{(H)^{5.2}} \right)^{.04}$$

$$D = .66 \left[\frac{24.037}{(H)^{4.85}} + \frac{1.57 \times 10^{-9}}{(H)^{5.2}} \right]^{.04}$$

Assume or guess youre value of H

$H = (12\text{ft})$

$$= .66 \left[\frac{24.037}{(12)^{4.75}} + \frac{1.57 \times 10^{-9}}{(12)^{5.2}} \right]^{.04}$$

$$\boxed{D = .485 \text{ ft}}$$