ENCE 3318
Fluid Mechanics for Civil Engineering
TEST 4

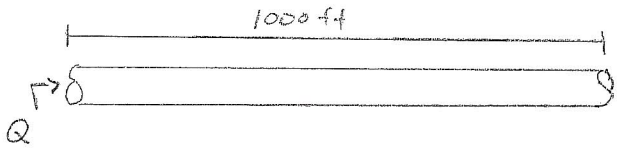
1. A 6 inch cast iron pipe 1000 feet long carries 400 gallons per minute of water. Calculate the head loss when the water is at (a) 40°F, (b) 200°F.

$1_g = 0.13368\ ft^3$

$A = \frac{\pi}{4}(.5ft)^2 = .1963ft^2$

$V = \frac{Q}{A} = \frac{.8912\ ft^3/s}{.1963ft^2}$

$V = 4.54\ ft/s$



$Q = \left(\frac{400\ g}{60\ s}\right)\left(\frac{.13368ft^3}{1g}\right) = .8912\ ft^3/s$

a) h_f @ $T = 40°F$

$R_n = \frac{Vd}{\nu} = \frac{(4.54)(.5)}{1.664 \times 10^{-5}} = 136.48$

$h_f = \frac{f L v^2}{d 2g}$

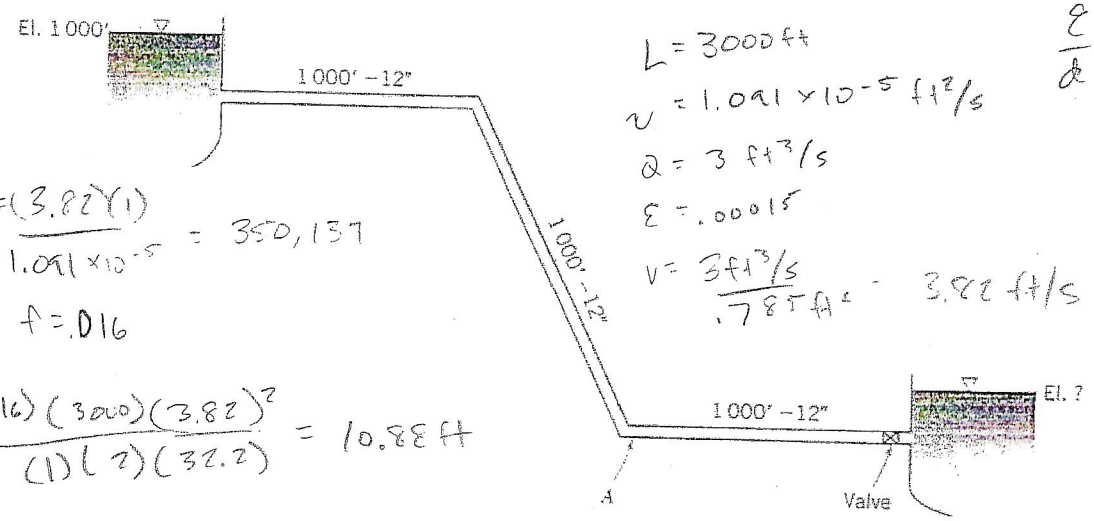
$\frac{\varepsilon}{d} = \frac{.00085}{.5} = .0017 \rightarrow$ (Moody diagram) $= f = .023$

$h_f = \frac{(.023)(1000)(4.54)^2}{(.5)(2)(32.2)} = 14.72\ ft$

b) h_f @ $200°F$ $\quad R_n = \frac{Vd}{\nu} = \frac{(4.54)(.5)}{.341 \times 10^{-5}} = 665.689$

$h_f = \frac{f L v^2}{d 2g} = \frac{(.022)(1000)(4.54)^2}{(.5)(2)(32.2)} = 14.08\ ft$

2. A wrought iron pipe 3000 feet long conveys water (68°F) between two reservoirs. If the discharge is 3.0 ft^3/s, find the elevation of the lower reservoir. A fully open valve is near the lower reservoir. The entrance loss coefficient is 0.04. There are two pipe bends each with a radius of 2 feet. The diameter of the pipe is 12 inches.



$L = 3000\,ft$

$\nu = 1.091 \times 10^{-5}\ ft^2/s$

$Q = 3\ ft^3/s$

$\varepsilon = .00015$

$\frac{\varepsilon}{d} = \frac{.00015\,ft}{1\,ft} = .0015$

$V = \frac{3\,ft^3/s}{.785\,ft^2} = 3.82\ ft/s$

$Re = \frac{(3.82)(1)}{1.091 \times 10^{-5}} = 350{,}137$

$f = .016$

$h_f = \frac{(.016)(3000)(3.82)^2}{(1)(2)(32.2)} = 10.88\ ft$

$\frac{r}{d} = \frac{2}{1} = 2 \quad k_b = .19 \quad h = \frac{k_b v^2}{2g} \Rightarrow \frac{(.19)(3.82)^2}{(2)(32.2)} = .0431\ ft \quad (2)(.0431) = .0862\ ft$

$k_v = .15 \quad h_v = \frac{k_v (v^2)}{2g} = \frac{.15(3.82)^2}{(2)(32.2)} = .034$

$h_e = \frac{(.04)(3.82)^2}{64.4} = .0091$

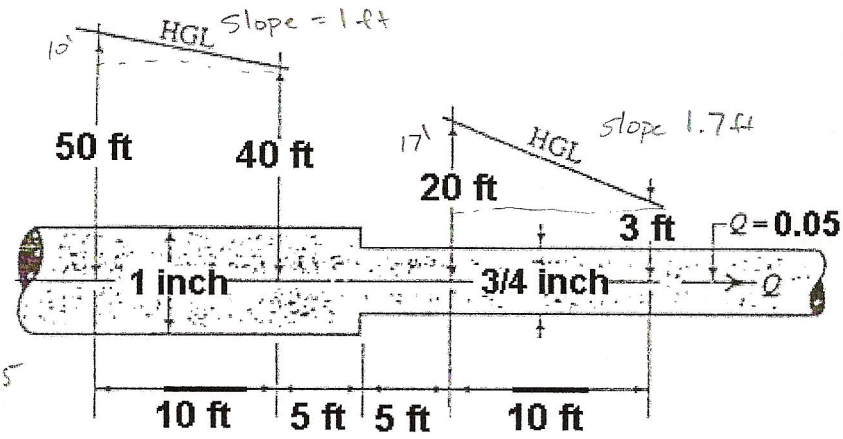
$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$

$1000 = \frac{3.82^2}{64.4} + z_2$

$999.77 - 10.88 - .0431 - .034 - .0091 = z_2$

$z_2 = 988.8\ ft$

3. Calculate the head loss coefficient caused by this restricted contraction.



$A_1 = \frac{\pi}{4}\left(\frac{1}{12}\right)^2$

$A_1 = .00545$

$A_2 = \frac{\pi}{4}\left(\frac{3}{4}\right)\left(\frac{1}{12}\right) = .00306\text{ft}^2$

$V_2 = \frac{Q}{A_2} = 16.31\text{ ft/s}$

$V_1 = \frac{Q}{A} = 9.17\text{ ft/s}$

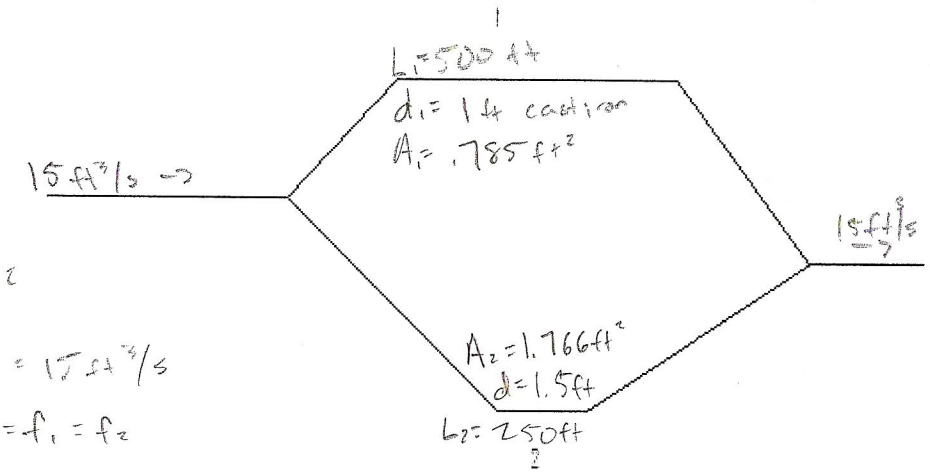
$h_{f1} = 50 - 40 = 10\text{ ft}$

$h_{f2} = 20 - 3 = 17\text{ ft}$

$\frac{d_2}{d_1} = \frac{.75}{1} = .75 \Rightarrow K_L = .215$ → interpolated

$h_c = K_L \frac{V_2^2}{2g} \Rightarrow .215\left(\frac{(16.31)^2}{(2)(32.2)}\right) = .889\text{ ft}$

4. Two pipes are parallel (and horizontal) as shown below. Pipe 1 is cast iron (new), 12 inches in diameter, and 500 feet long. Pipe 2 is riveted steel (few rivets), 18 inches in diameter, and 250 feet long. If the total discharge is 15 ft^3/s and the water temperature is 180°F, what will be the discharge in each line?



assume $h_{f_1} = h_{f_2}$

$Q = Q_1 + Q_2 = 15\ ft^3/s$

assume $f = .02 = f_1 = f_2$

$$\frac{f_1 L_1 V_1^2}{d_1 2g} = \frac{f_2 L_2 V_2^2}{d_2 2g} \Rightarrow \frac{500\ V_1^2}{1} = \frac{250 V_2^2}{1.5} \Rightarrow V_1^2 = .333 V_2^2$$

$V_1 = .577 V_2$ $\quad 15 = .577 V_2 (.785) + 1.766 (V_2)$

$15 = 2.219 V_2 \Rightarrow V_2 = 6.76 \quad V_1 = 3.90$

$$Rn = \frac{V_1 d_1}{\nu} = \frac{3.90(1)}{.385 \times 10^{-5}} = 1.01 \times 10^6 \qquad \frac{\varepsilon}{d} = \frac{.00085}{1} = .00085$$

$f_1 = .019$ $\quad R_2 = \frac{V_2 d_2}{\nu} = \frac{6.76(1.5)}{.385 \times 10^{-5}} = 2.63 \times 10^6 \quad \frac{\varepsilon}{d} = \frac{.003}{1.5} = .002$

$f_2 = .024$

$$.019\left(\frac{500}{1}\right)\frac{V_1^2}{2g} = .024\left(\frac{250}{1.5}\right)\frac{V_2^2}{2g} = V_1 = .649 V_2$$

$15 = .649 V_2 (.785) + 1.766 V_2 \Rightarrow V_2 = 6.59\ ft/s \quad V_1 = 4.28\ ft/s$

$Q_1 = A_1 V_1 \Rightarrow (.785)(4.28) = 3.36\ ft^3/s$

$Q_2 = A_2 V_2 = (1.766)(6.59) = 11.64\ ft^3/s$