Robert Slade
Homework #3.2
Problem 12-7

$$h_a = 2(h_w)30\left(\frac{V_a^2}{2g}\right) + f\frac{L_a}{D_a} * \frac{V_a^2}{2g}$$

2" f_{alt} = 0.019
6" f_{alt} = 0.015

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{\varepsilon}{D}\right)} * \frac{5.74}{UR^{0.9}}\right)\right)^2}$$

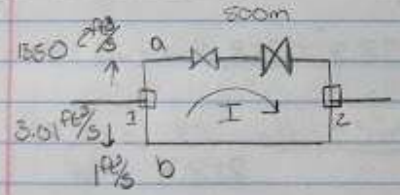
$$h_b = 2*30*f_{alt b} + f\frac{L_b}{D_b} + 100(f_{alt b}) + 340(f_{alt b})$$

$$h_a = 2(f_{alt})(30) + 340 + 100 + f\left(\frac{500}{D_a}\right)$$

$$h_b = 2(f_{alt})(30) +$$

500m

Drawing

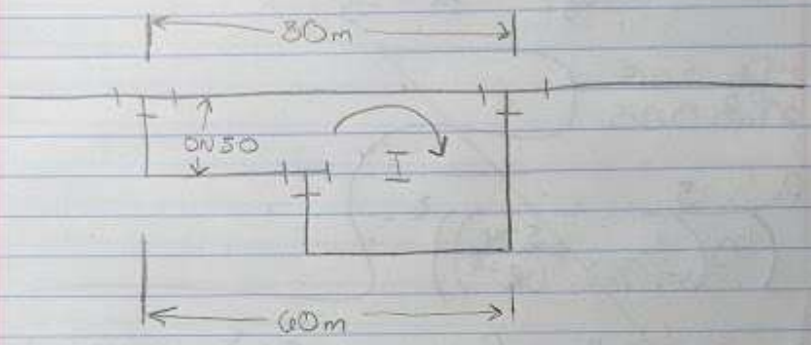


Calculations
see excel

Circuit	Pipe	Q (gal/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	K*Q^2	2*k*Q		Error(%)
1	a	900	2.0052	0.5054	1.50E-04	500	267.5397	3.37E+03	9.995335	5.48825E-10	0.00302	5.5653727	22.377	22.31937		-24%
	b	-450	-1.0026	0.1723	1.50E-04	500	53.86673	1.15E+03	42.99988	2.36104E-09	0.00344	992.67261	-997.8	1990.507	deltaQ (ft^3/s)	48%
													-975.5	2012.826	-0.484623897	
Circuit	Pipe	Q (gal/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	K*Q^3	2*k*Q		Error(%)
1	a	900	2.489824	0.5054	1.50E-04	500	267.5397	3.37E+03	12.41104	6.81467E-10	0.00308	5.67040234	35.152	28.23661		-9%
	b	-450	-0.517976	0.1723	1.50E-04	500	53.86673	1.15E+03	22.21515	1.21979E-09	0.00324	935.168707	-250.9	968.7901	deltaQ (ft^3/s)	42%
													-215.8	997.0267	-0.216396381	
Circuit	Pipe	Q (gal/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	K*Q^4	2*k*Q		Error(%)
1	a	900	2.70622	0.5054	1.50E-04	500	267.5397	3.37E+03	13.48972	7.40695E-10	0.0031	5.71163314	41.83	30.91387		-3%
	b	-450	-0.30158	0.1723	1.50E-04	500	53.86673	1.15E+03	12.93426	7.10196E-10	0.00309	891.714158	-81.1	537.8458	deltaQ (ft^3/s)	23%
													-39.27	568.7597	-0.069048175	
Circuit	Pipe	Q (gal/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	K*Q^5	2*k*Q		Error(%)
1	a	900	2.775268	0.5054	1.50E-04	500	267.5397	3.37E+03	13.8339	7.59593E-10	0.00311	5.72418604	44.088	31.77231		0%
	b	-450	-0.232532	0.1723	1.50E-04	500	53.86673	1.15E+03	9.9729	5.47593E-10	0.00302	871.895821	-47.14	405.4866	deltaQ (ft^3/s)	3%
													-3.056	437.2589	-0.006988699	
Circuit	Pipe	Q (gal/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	K*Q^6	2*k*Q		Error(%)
1	a	900	2.782257	0.5054	1.50E-04	500	267.5397	3.37E+03	13.86874	7.61506E-10	0.00311	5.7254414	44.32	31.8593		0%
	b	-450	-0.225543	0.1723	1.50E-04	500	53.86673	1.15E+03	9.673166	5.31135E-10	0.00301	869.61326	-44.24	392.2701	deltaQ (ft^3/s)	0%
													0.0835	424.1294	0.000196933	

Problem 12.8
Solve for flow rate in each branch
Solve for pressure difference

Drawing



calculations
see excel

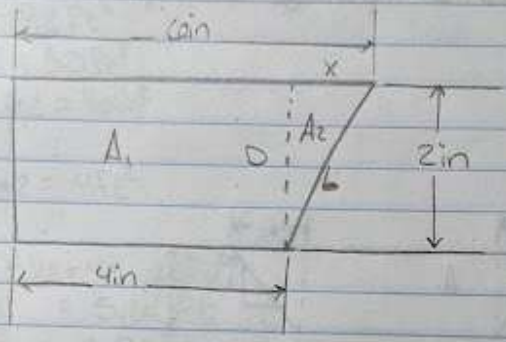
Circuit	Pipe	Q (L/min)	Q (m^3/s)	D (m)	e (m)	L (m)	Le (m)	D/e	V (m/s)	Re	f	k (s^2/m^5)	K*Q^2	2*k*Q		Error(%)
1	a	425	0.00708333	0.0525	4.60E-05	30	10.85714	1.14E+03	3.272118	5.52988E-12	0.002107885	17076.64928	0.856796	241.9191		-20%
	b	-425	-0.0070833	0.0525	4.60E-05	60	34.31429	1.14E+03	3.272118	5.52988E-12	0.002107885	39419.59391	-1.97782	558.444	deltaQ (m^3/s)	20%
													-1.12103	800.3631	-0.001400646	
Circuit	Pipe	Q (L/min)	Q (m^3/s)	D (m)	e (m)	L (m)	Le (m)	D/e	V (m/s)	Re	f	k (s^2/m^5)	K*Q^3	2*k*Q		Error(%)
2	a	509.038547	0.00848398	0.0525	4.60E-05	30	10.85714	1.14E+03	3.919141	6.62335E-12	2.14E-03	17299.99032	1.245216	293.5454		0%
	b	-340.96105	-0.0056827	0.0525	4.60E-05	60	34.31429	1.14E+03	2.625095	4.43641E-12	0.002074941	38803.49616	-1.25308	441.016	deltaQ (m^3/s)	0%
													-0.00786	734.5614	-1.07022E-05	

P1-P2=	-230.11457	kpa

Problem 14-6

find hydraulic radius

Drawing:



Calculations

$$A = A_1 + A_2 = WD + \frac{xD}{2} = 4(2) + \frac{2 \cdot 2}{2} = 10 in^2$$

$$L = \sqrt{2^2 + 2^2} = 2.828 in$$

$$WP = 2 + 4 + 2.828 = 8.828$$

$$R = \frac{A}{WP} = \frac{10}{8.828} = \boxed{1.133 in}$$

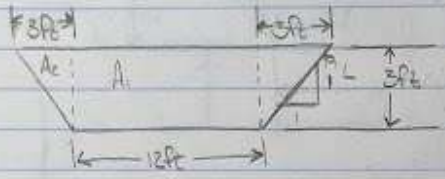
Problem 14.15

Purpose:

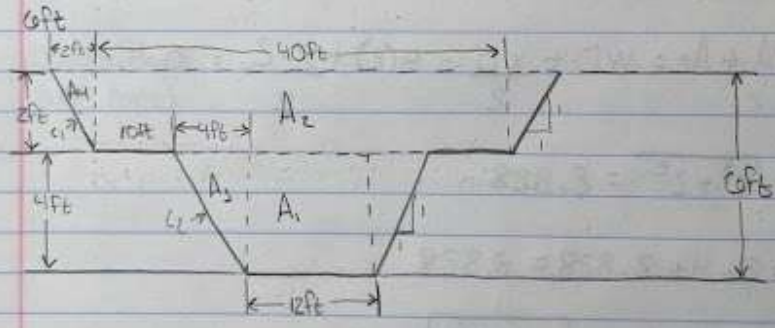
determine normal discharge for depths of 3ft and 6ft

Drawing

3ft



6ft



Calculations:

for 3ft:

$A = A_1 + 2A_2 = 12 \times 3 + 2 * \frac{3 \times 3}{2} = 45ft$

$L = \sqrt{3^2 + 3^2} = 4.24$

$WP = 2 \cdot 4.24 + 12 = 20.48ft$

$R = \frac{45}{20.48} = 2.197ft$

$\therefore Q = \left(\frac{1.49}{0.04}\right)(45)(2.197)^{2/3} * 0.00015^{1/2} = \boxed{34.70 ft^3/s}$

for 6ft

$A = A_1 + A_2 + 2 \cdot A_3 + 2 \cdot A_4$

$A_1 = 12 \times 4 = 48\,ft^2$

$A_2 = 40 \times 2 = 80\,ft^2$

$A_3 = \frac{4 * 4}{2} * 2 = 16\,ft^2$

$A_4 = \frac{2 * 2}{2} * 2 = 4\,ft^2$

$A = 48 + 80 + 16 + 4 = 148\,ft^2$

$z_1 = \sqrt{4^2 + 4^2} = 5.66\,ft$

$z_2 = \sqrt{2^2 + 2^2} = 2.83\,ft$

$WP = 2 * 5.66 + 2 * 10 + 2 * 2.83 + 12 = 48.98\,ft$

$R = \frac{148}{48.98} = 3.022\,ft$

$Q = \left(\frac{1.49}{0.04}\right)(148)(3.022)^{2/3}(0.00015)^{1/2} = \boxed{141.13\,ft^3/s}$

∴ discharge at 3ft = 34.70 ft^3/s

discharge at 6ft = 141.13 ft^3/s

Problem 15-4

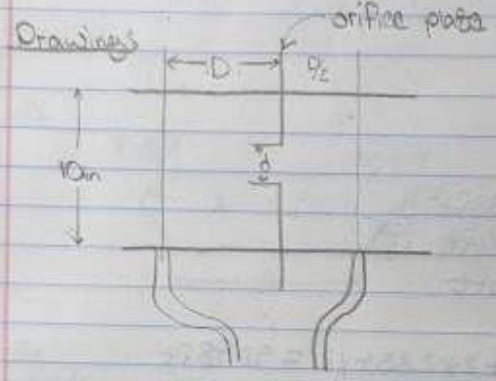
Purpose:

Calculate the deflection of a manometer

a. Orifice diameter 1.0 in

b. Orifice diameter 7.0 in

Drawing:



Data and Variables:

$Q = 25\ gal/min \rightarrow 0.056\ ft^3/s$

$D = 10in \rightarrow 0.83ft$

$d = 1.0in$ and $7.0in$

$Sg = 0.83 \quad \gamma_A = 0.83 * 62.4 = 51.79\ lb/ft^3$

$\mu = 2.6 \times 10^{-6}\ lb \cdot s/ft^2$

Calculations:

$A_1 = 0.5454\ ft^2$ (from table) Per 10in

$A_2 = 5.454 \times 10^{-3}\ ft^2$ (from table) for 1in

$A_2 = 0.2673\ ft^2$ (From table) Per 7in

$$h = \frac{\left(\frac{Q}{A_1 \times C}\right)^2 \times \left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]}{2g\left(\frac{\gamma_m}{\gamma_A} - 1\right)}$$

$\nu = \frac{\mu}{\rho}$ (Page 22 in book.)
I had to look this up.

$N_R = \frac{vD}{\nu} = \frac{0.103(0.83)}{1.42\times10^{-6}} = 60204.23$

$\nu = 2.5\times10^{-6} = \quad = 1.42\times10^{-6}\ ft^2/s$
1.77 (from table 8.2)

$V = \frac{Q}{A} = \frac{0.056}{0.5454} = 0.103\ ft/s$

$\frac{d}{D} = \frac{1.0}{10} = 0.1 \qquad \frac{d}{D} = \frac{7.0}{10} = 0.7$

$\therefore C = 0.595$ (from chart) $\qquad \therefore C = 0.619$ (from chart)

$$h = \frac{\left(\frac{0.056}{0.5454\times0.595}\right)^2 * \left[\left(\frac{0.5454}{5.454\times10^{-3}}\right)^2 - 1\right]}{2*32.2\left(\frac{62.4}{51.79} - 1\right)}$$

$= \frac{0.0298 * 9999}{13.1934} = \boxed{22.60\ ft}$ for 1in

$$h = \frac{\left(\frac{0.056}{0.5454*0.619}\right)^2 * \left[\left(\frac{0.5454}{0.2673}\right)^2 - 1\right]}{2*32.2\left(\frac{62.4}{51.79} - 1\right)}$$

$= \frac{0.0298 * 3.1632}{13.1934} = \boxed{0.00714\ ft}$

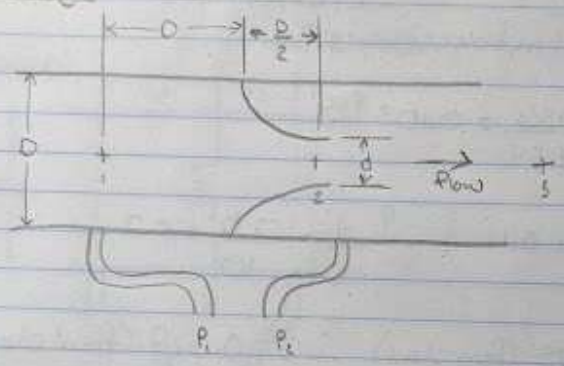
Summary:
The deflection of water for 1in diameter orifice is 22.60 ft and for 7in is 0.00714 ft.

Problem 15.9

Purpose:

Determine the diameter of the nozzle

Drawings:



Data and Variables

D = 5 in → 0.4004 ft $A_1 = 0.1259\ ft^2$

linseed oil @ 77° $\nu = 3.84 \times 10^{-4}\ ft^2/s$

mercury manometer - 0 to 8.0 in → 0.67 ft

Q = 700 gal/min - 1000 gal/min

1.56 ft^3/s - 2.23 ft^3/s

Calculations

$$A_2 = \frac{A_1}{\sqrt{\frac{2gh\left(\frac{\gamma_m}{\gamma_{H_2O}} - 1\right)}{\left(\frac{Q}{A_1 C}\right)^2} + 1}}$$

$$= \frac{0.1259}{\sqrt{2 \times 32.2 \times 0.67\left(\frac{844.9}{58} - 1\right)}{\left(\frac{2.23}{0.1259 C}\right)^2} + 1}}$$

$$A_2 = \frac{0.1259}{2\sqrt{\frac{585.40}{17.71}\left(\frac{1}{C}\right)+1}} = \frac{0.1259}{2\sqrt{33.10 * C^2+1}}$$

Assume $C = 0.92$

$A_2 = 0.0254 ft^2$ $\quad d = 2\left(\frac{0.0254}{\pi}\right) = 0.0149 ft$

$\frac{d}{D} = \frac{0.0149}{0.4004} = 0.037$

$N_R = \frac{VD}{\nu} =$ $\quad V = \frac{2.23}{0.1259} = 17.71 \ ft/s$

$= \frac{17.71(0.4004)}{3.84 \times 10^{-4}}$

$= 1.85 \times 10^4$

$\therefore C = 0.9975 - 6.53\sqrt{\frac{0.037}{1.85 \times 10^4}}$

$= 0.9975 - 6.53 * 0.001595$

$= 0.988$

$A_2 = \frac{0.1259}{2\sqrt{33.10 * 0.988^2+1}} = 0.022 ft^2$ $\quad d = 2\left(\frac{0.022}{\pi}\right) = \boxed{0.014 ft}$

$\therefore d = 0.014 ft \rightarrow 0.168 in$

Summary:
The diameter of the orifice is 0.014ft or 0.168in