Florida International University Department of Civil and Environmental Engineering
CWR 3201 Fluid Mechanics,
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Homework Assignment 6 Solutions
Mechanics of Fluids (Fifth edition), by M.C. Potter, D.C. Wiggert and B.H. Ramadan.

1. 7.20 (same number in Fourth Edition)

$$Dishcarge\ Q = A * V \rightarrow 0.025 = \frac{\pi}{4}(0.06)^2 V$$
$$V = 8.84\ m/s$$
$$Re = \frac{VD}{\nu} = \frac{8.84 * 0.06}{1.005 * 10^{-6}} = 527877$$

Since Reynolds number is greater than 2000, flow is turbulent.

$$Re > 10^5$$
$$\frac{L}{D} = 120$$
$$L = 7.2\ m$$

Since Length of pipe is 50 m, which is greater than 7.2 m, assumption of developed flow is acceptable.

2. 7.94 (same number in Fourth Edition)

a) $Re = \frac{VD}{\nu} = \frac{0.025*0.04}{10^{-6}} = 1000$ less than 2000 so flow is laminar

Relative Roughness: $\frac{e}{D} = \frac{0.25}{40} = 0.00625$

Friction factor: $f = \frac{64\nu}{VD} = \frac{64*10^{-6}}{0.025*0.04} = 0.064$

b) $Re = \frac{VD}{\nu} = \frac{0.25*0.04}{10^{-6}} = 10000$ Turbulent flow so use Moody Diagram

Relative Roughness: $\frac{e}{D} = \frac{0.25}{40} = 0.00625$

Moody diagram: $f = 0.04$

3. 7.108 (same number in Fourth Edition)

a) $D = 0.66[e^{1.25}\left(\frac{LQ^2}{gh_L}\right)^{4.75} + \nu Q^{9.4}(\frac{L}{gh_L})^{5.2}]^{0.04}$

$$h_L = \frac{\Delta p}{\gamma} = \frac{200000}{9810} = 20.38\ m$$

$$D = 0.66[0^{1.25}\left(\frac{LQ^2}{gh_L}\right)^{4.75} + 10^{-6} * 0.002^{9.4}\left(\frac{100}{9.81 * 20.38}\right)^{5.2}]^{0.04} = 0.032m$$

Note that the other parts have same method but differing specific weights for each type of medium.

4. 7.113 (same number in Fourth Edition)

$$h_L = \frac{\Delta p}{\gamma} = \frac{100}{9810} = 0.01\ m$$

Hydraulic Diameter: $D = 4\frac{Area}{perimeter} = 4\frac{(0.04*0.1)}{2(0.04+0.1} = 0.057m$

Flow Rate:

$Q = -0.965[g\frac{D^5 h_L}{L}]^{0.5}\ln\left[\frac{e}{3.7D} + \left(\frac{3.17\nu^2 L}{gD^3 h_L}\right)^{0.5}\right] = -0.965[9.81\frac{0.057^5*0.01}{5}]^{0.5}\ln\left[\frac{0}{3.7D} + \left(\frac{3.17(10^{-6})^2*5}{9.81*0.057^3 0.01}\right)^{0.5}\right] = 7.31*10^{-4}\frac{m^3}{s}$

5. 7.117 (same number in Fourth Edition)

$$V_1 = \frac{Q}{A_1} = 63.66\frac{m}{s}$$

From continuity: $V_2 = V_1\frac{r_1^2}{r_2^2} = 15.92\ m/s$

Ideal gas law to calculate density of air: $\rho = \frac{p_{atm}+p_{gage}}{RT} = \frac{101.3+50}{0.287*293} = 1.799\ \frac{kg}{m^3}$

Head loss due to sudden enlargement: $h_L = \frac{K_L V_1^2}{2g}$

$$K_L = (1 - \frac{r_1^2}{r_2^2})^2 = 0.5625$$

$$h_L = 116.18$$

Bernoulli energy equation: $\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_L$

$$p_2 = 51.366\ kPa$$

6. 7.121 (same number in Fourth Edition)

Manometer: $p_1 + \gamma_1 H = \gamma_{mmHg}H + p_2$

$$\Delta p = 123606H$$

$$V = \frac{Q}{A} = 4.77\ m/s$$

Using energy equation and rearranging to solve for K: $K\frac{V^2}{2g} = \frac{\Delta p}{\gamma}$

If H=4 cm: $K\frac{4.77^2}{2*9.81} = \frac{123606H}{9810}$

$$K = 0.435$$
$$K = 0.869$$

7. 7.124 (same number in Fourth Edition)

Energy Equation: $H = (K_{en} + 2K_{elbow} + K_{ex})\frac{V^2}{2g} + f\frac{L}{D}\frac{V^2}{2g}$

Assume friction factor f= 0.020

Nominal loss coefficients K: $K_{elbow} = 1.0$

$$K_{en} = 0.8$$
$$K_{ex} = 1.0$$

$$2 = (0.8 + 2(1.0) + 1)\frac{V^2}{2*9.81} + 0.02\frac{20}{0.04}\frac{V^2}{2*9.81}$$

$$V = 1.69\ m/s$$

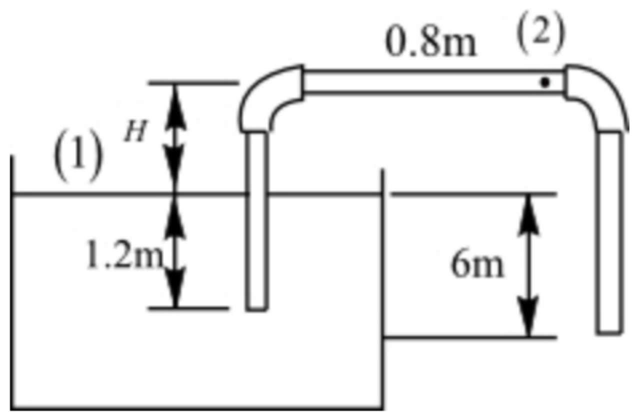
Check Assumption: Calculate Reynolds $Re = \frac{VD}{\nu} = \frac{1.69*0.04}{1.14*10^{-6}} = 59298$

Relative Roughness: Assume smooth pipe

Moody diagram: $f = 0.019$ since it is close to the assumption OK

$$Q = AV = \frac{\pi}{4} * 0.04^2 * 1.69 = 0.0021\ m^3/s$$

8. 7.127 (same number in Fourth Edition)



Energy Equation: Since point 1 and 3 are open to atmosphere and velocity at point 1 is zero, the energy equation reduces to:

$$H = (K_{en} + 2K_{elbow} + K_{ex})\frac{V^2}{2g} + f\frac{L}{D}\frac{V^2}{2g}$$

Nominal loss coefficients K: $K_{elbow} = 1.39$

$$K_{en} = 0.8$$
$$K_{ex} = 1.0$$

Assume f=0.20

$$6 = (0.8 + 2(1.39) + 1.0)\frac{V^2}{2 * 9.81} + 0.02\frac{6.8 + 2H}{0.03}\frac{V^2}{2 * 9.81}$$

Apply Bernoulli at point 2 and exit: $\frac{p_{exit}}{\rho g} + \frac{V_{exit}^2}{2g} + z_{exit} = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + (K_{elbow})\frac{V^2}{2g} + f\frac{L}{D}\frac{V^2}{2g}$

$$0 + 0 + 0 = \frac{1.13\ kPa}{(1000)(9.81)} + \frac{V_2^2}{2 * 9.81} + (6 + H) + (1.39)\frac{V^2}{2g} + 0.02\frac{6 + H}{0.03}\frac{V^2}{2 * 9.81}$$

Solving system of equations: $H = 0.64\ m$

$$V = 3.348\ m/s$$

$$Re = \frac{VD}{\nu} = \frac{3.348 * 0.03}{1.31 * 10^{-6}} = 7.7 * 10^4$$

$$Moody\ Diagram: f = 0.018$$

Recalculate using new friction factor: $H = 0.78\ m$

$$V = 3.477\ m/s$$

$$Re = \frac{VD}{\nu} = \frac{3.477 * 0.03}{1.31 * 10^{-6}} = 7.9 * 10^4$$

$Moody\ Diagram\ f = 0.018$

Friction factor has converged so $H = 0.78\ m$

9. Problem

Due to length of solution, please follow link below for complete solution:

http://web.eng.fiu.edu/arleon/courses/Hydraulic_engineering/Quizzes/Quiz_3_4_sol.pdf

10. 11.41 (same number in Fourth edition)

Using EPANET:

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm	
1	6	8	610	350	
2	8	9	914	350	
3	9	10	760	350	
4	10	13	610	350	
6	11	12	457	300	
7	11	10	610	350	
8	7	11	914	350	
9	6	7	760	350	
10	8	11	610	350	
11	10	2	30	200	
12	4	12	61	150	
13	5	6	1500	400	
14	7	3	975	300	
16	12	13	610	350	
18	1	5	#N/A	#N/A	Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
18	100.00	75.00	0.52	971.98	971.98	0.00
					Demand Charge:	0.00
					Total Cost:	0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality	
5	0.00	146.93	143.93	0.00	
6	0.00	61.82	49.82	0.00	
7	60.00	41.24	26.24	0.00	
8	0.00	40.32	28.32	0.00	
9	110.00	31.32	13.32	0.00	
10	110.00	30.78	15.78	0.00	
11	0.00	36.07	24.07	0.00	
12	60.00	31.94	25.94	0.00	
13	60.00	30.77	18.77	0.00	
1	-516.40	3.00	0.00	0.00	Reservoir
2	56.12	30.00	0.00	0.00	Reservoir
3	83.11	34.00	0.00	0.00	Reservoir
4	-22.83	34.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Headloss m/km	Status	
1	265.67	2.76	35.25	Open	
2	145.21	1.51	9.85	Open	
3	35.21	0.37	0.71	Open	
4	4.72	0.05	0.02	Open	
6	92.45	1.31	9.04	Open	
7	135.63	1.41	8.68	Open	
8	107.62	1.12	5.65	Open	
9	250.73	2.61	27.08	Open	
10	120.46	1.25	6.97	Open	
11	56.12	1.79	25.86	Open	
12	22.83	1.29	33.81	Open	
13	516.40	4.11	56.74	Open	
14	83.11	1.18	7.42	Open	
16	55.28	0.57	1.92	Open	
18	516.40	0.00	-143.93	Open	Pump