Cover Sheet

ME 3414 Experiment #4 – Spring 2026

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CRN, Group, Date/time you performed the experiment: 4/20/26 6:30PM

Pipework energy losses

Compute the average value (averaged over all flow rates) of the loss coefficients for the regular 90 deg elbow, the pipe expansion, and the large radius elbow and enter the values below.

Also enter below the value of *K* listed in your textbook for the same restrictions:

- Regular 90 deg elbow: assume the apparatus elbow is most like the flanged elbow shown below:



Flanged elbow *(mdcprecision.com)*

- Pipe expansion (from appropriate Figure or theoretical expression from the textbook)
- Large radius elbow (from appropriate Figure in your textbook, with R = 50.0 mm, d = 22 mm, ε = 0)

Restriction	*K*		Brief hypothesis explaining why measured and textbook values are different or the same
	Measured	Textbook	
90° regular elbow	1.087	Table 8.2 0.3	Real-world differences such as $\varepsilon \neq 0$ and local turbulence @ the pressure taps could lead to the higher measured K
Expansion	0.336	$K=(1-\frac{A_1}{A_2})^2$ 0.16	The theoretical formula assumes uniform velocity & negligible friction which is not real-world accurate.
Large radius elbow	0.549	90° Bend Pg 8.8 0.19	Same as regular elbow $\varepsilon \neq 0$ & possible low turbulence but also possible for flow to not be fully developed b/c of upstream apparati impeding flow.

CamScanner

Data Sheet for Experiment #4 (Must be included in your formal report, with signatures).

CRN and Group: 22369 B-3 Date and time: 4/20/26 6:30 PM

Honor Pledge: I have neither given nor received unauthorized assistance on this assignment.

Printed names of bench members: Zachary Rathloff Collin Lyons Nicholas Strother

Signatures of bench members: Zachary Rathloff Collin Lyons [illegible]

Table 1: Data sheet for Experiment #4

Start @ 340 per opening

Flow rate	Manometer No. and Water Column Height									
			90 deg regular elbow		Pipe expansion				Large radius elbow	
Q	1	2	3	4	5	6	7	8	9	10
l/s	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
.553	510	330	264	160	154	188	188	82	68	16
.446	486	335	280	200	140	218	218	136	124	82
.455	465	340	292	220	214	236	236	165	160	125
.405	440	340	304	238 ↔ 2[illegible]		256	256	200	192	165
.364	422	344	316	270	266	280	280	235	227	205
.295	400	348	328	296	290	300	300	272	268	252
.237	386	350	332	312	310	[illegible]	322	302	298	288
.161	370	356	350	340	338	340	340	332	330	326
.072	368	365	365	362	362	362	362	360	360	358
0.00	374 →									→ 374
rho =	998 kg/m^3									
mu =	1.002 x 10^{-3} Ns/m^2									

Regular 90 Deg Elbow								
Flow Rate (L/s)	Reynolds Number (Re)	Vup (m/s)	Vdown (m/s)	Dyn Head Up (mm)	Dyn Head Down (mm)	Static ΔP (mm H_2O)	Total Head Loss (mm)	Loss Coef (K)
0.553	31876.8	1.455	1.455	107.865	107.865	104	104	0.964
0.496	28591.2	1.305	1.305	86.775	86.775	80	80	0.922
0.455	26227.8	1.197	1.197	73.022	73.022	72	72	0.986
0.405	23345.6	1.065	1.065	57.855	57.855	66	66	1.141
0.364	20982.2	0.958	0.958	46.734	46.734	46	46	0.984
0.295	17004.8	0.776	0.776	30.695	30.695	32	32	1.042
0.237	13661.5	0.623	0.623	19.812	19.812	20	20	1.009
0.161	9280.6	0.424	0.424	9.143	9.143	10	10	1.094
0.072	4150.3	0.189	0.189	1.829	1.829	3	3	1.641

Pipe Expansion								
Flow Rate (L/s)	Reynolds Number (Re)	Vup (m/s)	Vdown (m/s)	Dyn Head Up (mm)	Dyn Head Down (mm)	Static ΔP (mm H_2O)	Total Head Loss (mm)	Loss Coef (K)
0.553	31876.8	1.455	0.873	107.865	38.842	-34	35.023	0.325
0.496	28591.2	1.305	0.783	86.775	31.247	-28	27.528	0.317
0.455	26227.8	1.197	0.718	73.022	26.295	-22	24.727	0.339
0.405	23345.6	1.065	0.639	57.855	20.833	-20	17.022	0.294
0.364	20982.2	0.958	0.575	46.734	16.829	-14	15.905	0.34
0.295	17004.8	0.776	0.466	30.695	11.053	-10	9.642	0.314
0.237	13661.5	0.623	0.374	19.812	7.134	-12	0.678	0.034
0.161	9280.6	0.424	0.254	9.143	3.292	-2	3.851	0.421
0.072	4150.3	0.189	0.114	1.829	0.658	0	1.17	0.64

Large Radius Elbow								
Flow Rate (L/s)	Reynolds Number (Re)	Vup (m/s)	Vdown (m/s)	Dyn Head Up (mm)	Dyn Head Down (mm)	Static ΔP (mm H_2O)	Total Head Loss (mm)	Loss Coef (K)
0.553	31876.8	1.455	1.455	107.865	107.865	52	52	0.482
0.496	28591.2	1.305	1.305	86.775	86.775	42	42	0.484
0.455	26227.8	1.197	1.197	73.022	73.022	35	35	0.479
0.405	23345.6	1.065	1.065	57.855	57.855	27	27	0.467
0.364	20982.2	0.958	0.958	46.734	46.734	22	22	0.471
0.295	17004.8	0.776	0.776	30.695	30.695	16	16	0.521
0.237	13661.5	0.623	0.623	19.812	19.812	10	10	0.505
0.161	9280.6	0.424	0.424	9.143	9.143	4	4	0.437
0.072	4150.3	0.189	0.189	1.829	1.829	2	2	1.094

4a)

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

assume flat

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

$$h_L = \frac{P_1 - P_2}{\gamma} + \frac{V_1^2 - V_2^2}{2g}$$

$$h_L = K\frac{V_1^2}{2g}$$

$$K = \frac{\frac{P_1 - P_2}{\gamma} + \frac{V_1^2 - V_2^2}{2g}}{\frac{V_1^2}{2g}}$$

4b)

$d_5 = 22$

$d_L = 28.4$

$Q = .456$

$\frac{P_5 - P_6}{\gamma} = -24.0\ mmH_2O$

$$K_{expan} = \frac{-24 + \frac{V_5^2 - V_6^2}{2g}}{\frac{V_5^2}{2g}}$$

$$A_5 = \pi\frac{d_5^2}{4} = 1.2\ m/s$$

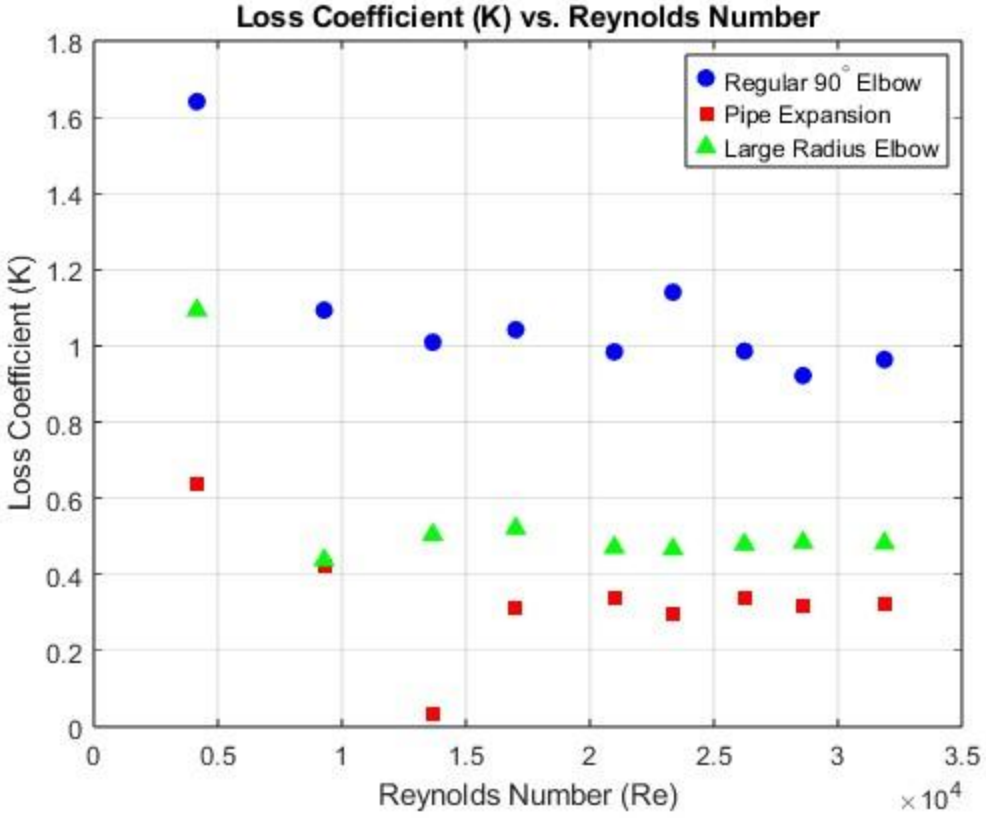
$$A_L = \pi\frac{d_L^2}{4} = .72\ m/s$$

$$V_5 = \frac{Q}{A_5} \qquad V_6 = \frac{Q}{A_L}$$

$g = 9.81$

$$\frac{-24 \cdot \frac{1}{1000} + \frac{1.2^2 - .72^2}{9.81 \cdot 2}}{\frac{1.2^2}{9.81 \cdot 2}}$$

$= 0.312$


Loss Coefficient (K) vs. Reynolds Number
Regular 90° Elbow
Pipe Expansion
Large Radius Elbow
Loss Coefficient (K)
Reynolds Number (Re)
×10^4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
0.5
1
1.5
2
2.5
3
3.5