BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Mechanical Engineering Department

Fluid mechanics Lab

ENME 312

Section 2

Experiment #3 report

Flow through a venturi meter

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Group 3

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Table of Contents

1- Abstract:

The purpose of the venturi meter experiment is to find the flow rate of the liquid, and this by changing the cross sectional area and the velocity of the liquid which is water, depending on two main principles Bernoulli and continuity equations. We need a hydraulic bench, venturi meter and a manometer.

The results of this experiment are the discharge, pressure distribution and the venturi coefficient which give an indication about the energy losses. The experimental and ideal results are near to each other with some errors which are acceptable.

2- Objectives:

In this experiment we need to find the mass flow rate of water, velocity, venturi meter coefficient, ideal and experimental discharge also the experimental pressure distribution by allowing water to flow through venturi meter with different cross sectional areas at different flow rates and then measuring the time required for raise the weigh arm and the pressure head for the manometer tubes after that make a comparison between the experimental and theoretical values all these depending on Bernoulli and the continuity equations.

3- Sample calculations:

Note: all sample calculations are for run 1 only

- Bernoulli equation principle

$$\frac{u1^2}{2g} + h1 = \frac{u2^2}{2g} + h2 = \frac{un^2}{2g} + hn$$

- The continuity equation principle

Q=a1*u1=a2*u2=an*un

Where:

H1: water head at inlet (m)

H2: water head at throat (m)

Hn: water head at arbitrary section (m)

U1: velocity at inlet (m/s)

U2: velocity at throat (m/s)

Un: velocity at arbitrary section (m/s)

G: gravity acceleration= 9.81 (m/s^2)

A1: inlet cross section (m^2)

A2: throat cross section (m^2)

Q: water discharge (m^3/s)

- $u2 = \sqrt{\frac{2g(h1-h2)}{1-(\frac{a2}{a1})^{\wedge}2}}$

U2= $\sqrt{2 * \frac{9.81(0.225-0.003)}{1-\left(\frac{201.1}{530.9}\right)^2}}$ = 2.255 m/s

The unit of h changed from mm to m

- Mass flow rate= mass (kg)/ time(s)

M= 12/22= 0.545 kg/s

- Q actual= mass flow rate/density of fluid

Q actual=0.545/1000= 0.000545 m^3/s

- Q ideal= a2*u2

Q ideal = 2.255*0.000201= 0.00045 m^3/s

The unit of area changed to m^2

- Q actual= C*a2*u2

- C=q actual / q ideal = 0.000545/0.00045= 1.203
- The experimental pressure distribution=(hn-h1)/(u2^2/2g)
- The ideal pressure distribution= (a2/a1)^2 – (a2/an)^2

Experimental Pressure distribution= (0.225-0.225)/0.26 =0

Ideal Pressure distribution= (201.1/530.9)^2-(201.1/530.9)^2=0

4- Results:

Table 1: data from experiment

Run	Time (sec.)	ha (h1) mm	hb (mm)	hc (mm)	hd (h2) mm	he (mm)	hf (mm)	hg (mm)	hh (mm)	hj (mm)	hk (mm)	hl (mm)
1	22	225	210	125	3	25	93	130	155	172	183	185
2	28	210	196	128	25	43	100	130	154	165	175	180
3	32	185	174	115	30							
4	38	165	150	100	33							
5	41	162	120	84	34							
6	46	100	96	70	38							
7	58	76	75	50	29							
8	64	61	60	45	26							
9	77	48	48	36	24							
10	107	36	36	30	21							

Table 2: calculations

h1 (m)	h2 (m)	u2 (m/s)	mass flow rate (kg/s)	Q actual (m^3/s)	Q ideal (m^3/s)	C (venturi coffecient)	(h1-h2)^0.5
0.225	0.003	2.255	0.545	0.000545	0.0004532	1.203561479	0.471
0.21	0.025	2.058	0.429	0.000429	0.000413713	1.035913641	0.430
0.185	0.03	1.884	0.375	0.000375	0.000378686	0.990265434	0.394
0.165	0.033	1.739	0.316	0.000316	0.000349463	0.903642993	0.363
0.162	0.034	1.712	0.293	0.000293	0.000344127	0.850508397	0.358
0.1	0.038	1.192	0.261	0.000261	0.000239502	1.089215395	0.249
0.076	0.029	1.037	0.207	0.000207	0.000208527	0.992180129	0.217
0.061	0.026	0.895	0.188	0.000188	0.000179948	1.041965768	0.187
0.048	0.024	0.741	0.156	0.000156	0.000149011	1.045854096	0.155
0.036	0.021	0.586	0.112	0.000112	0.000117804	0.952002393	0.122

Table 3: pressure distribution calculations for run 1 and 2

	area (mm^2)	distance	run 1	pressure distribution	run 2	pressure distribution
ha (m)	530.9	-54	0.225	0.000	0.21	0
hb (m)	422.7	-34	0.21	-0.058	0.196	-0.064814815
hc (m)	265.9	-22	0.125	-0.385	0.128	-0.37962963
hd (m)	201.1	-8	0.003	-0.854	0.025	-0.856481481
he (m)	221.7	7	0.025	-0.769	0.043	-0.773148148
hf (m)	268	22	0.093	-0.508	0.1	-0.509259259
hg (m)	318.8	37	0.13	-0.365	0.13	-0.37037037
hh (m)	375	52	0.155	-0.269	0.154	-0.259259259
hj (m)	435	67	0.172	-0.204	0.165	-0.208333333
hk (m)	500.8	82	0.183	-0.162	0.175	-0.162037037
hl (m)	530.9	102	0.185	-0.154	0.18	-0.138888889

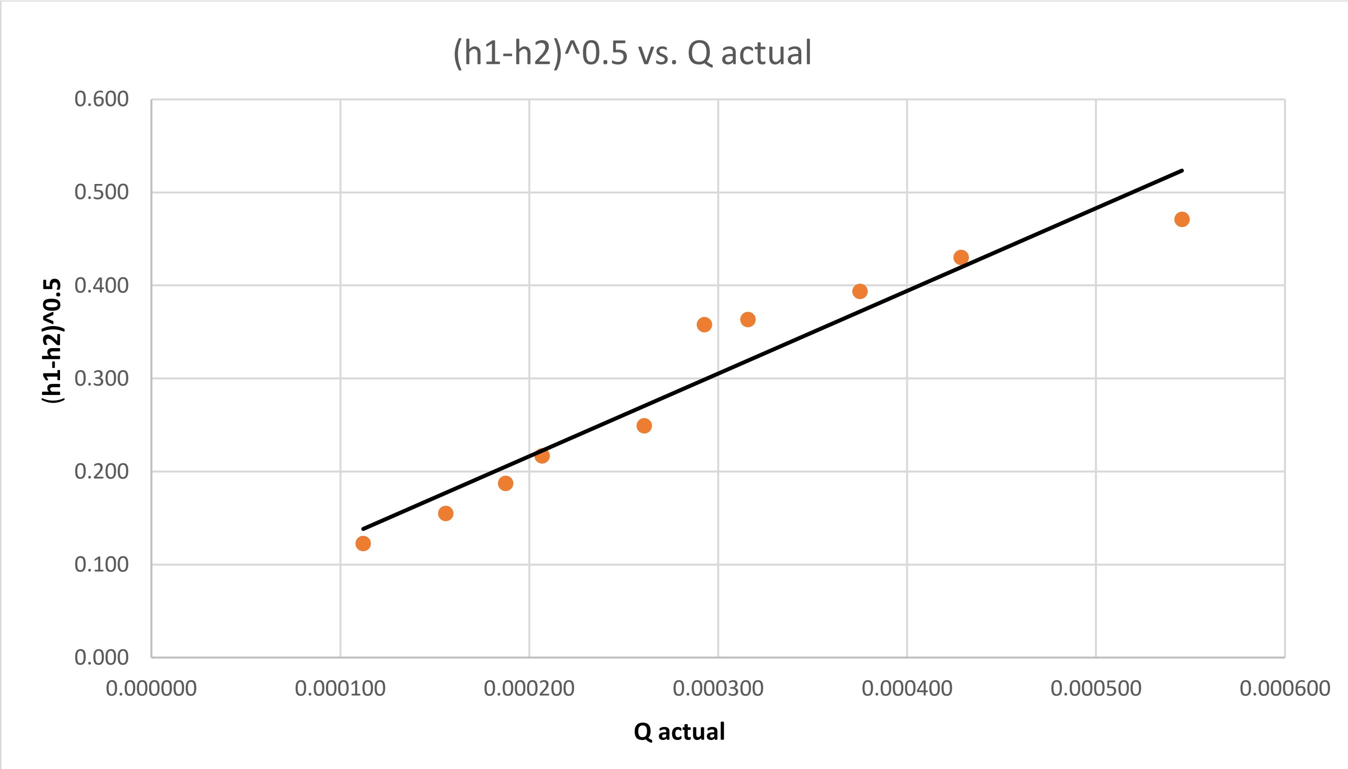


Figure 1: (h1-h2)^0.5 vs. Q actual

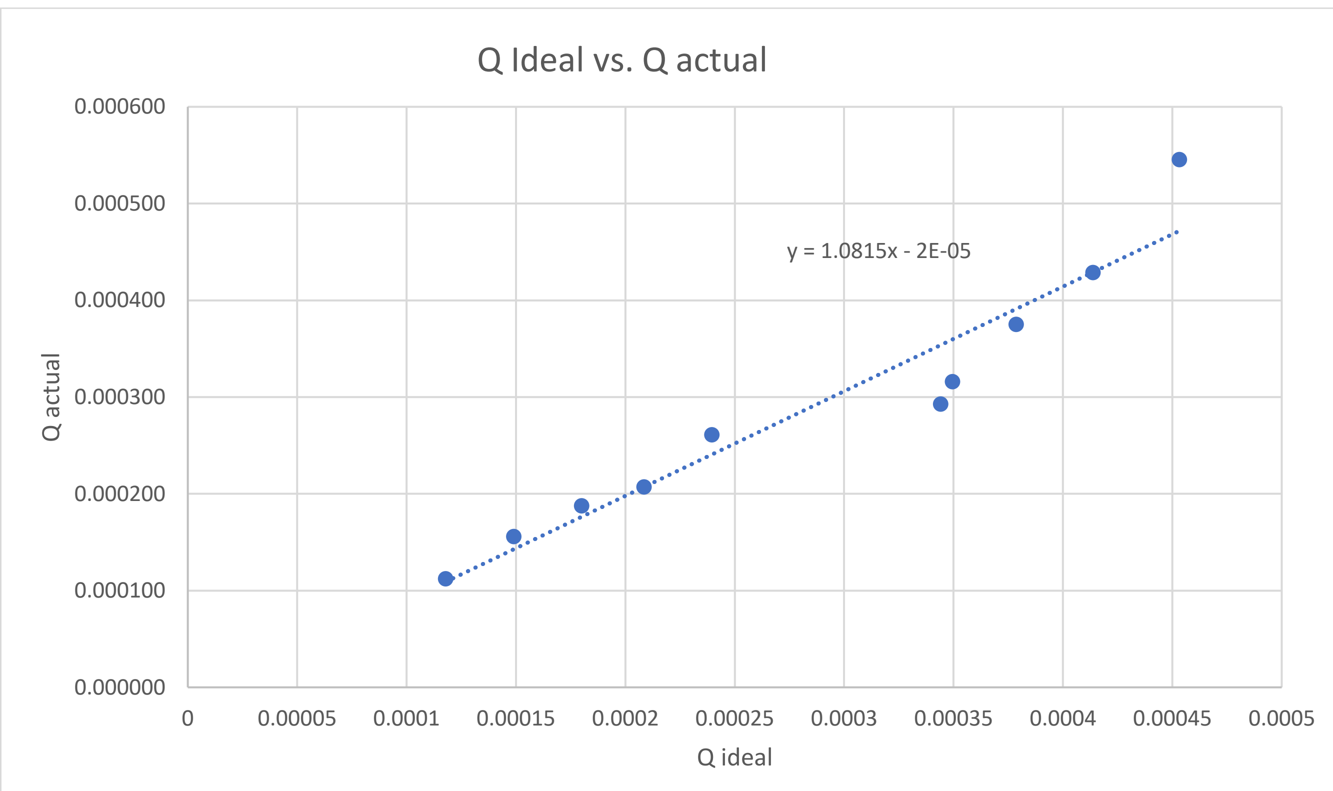


Figure 2: Q Ideal vs. Q actual

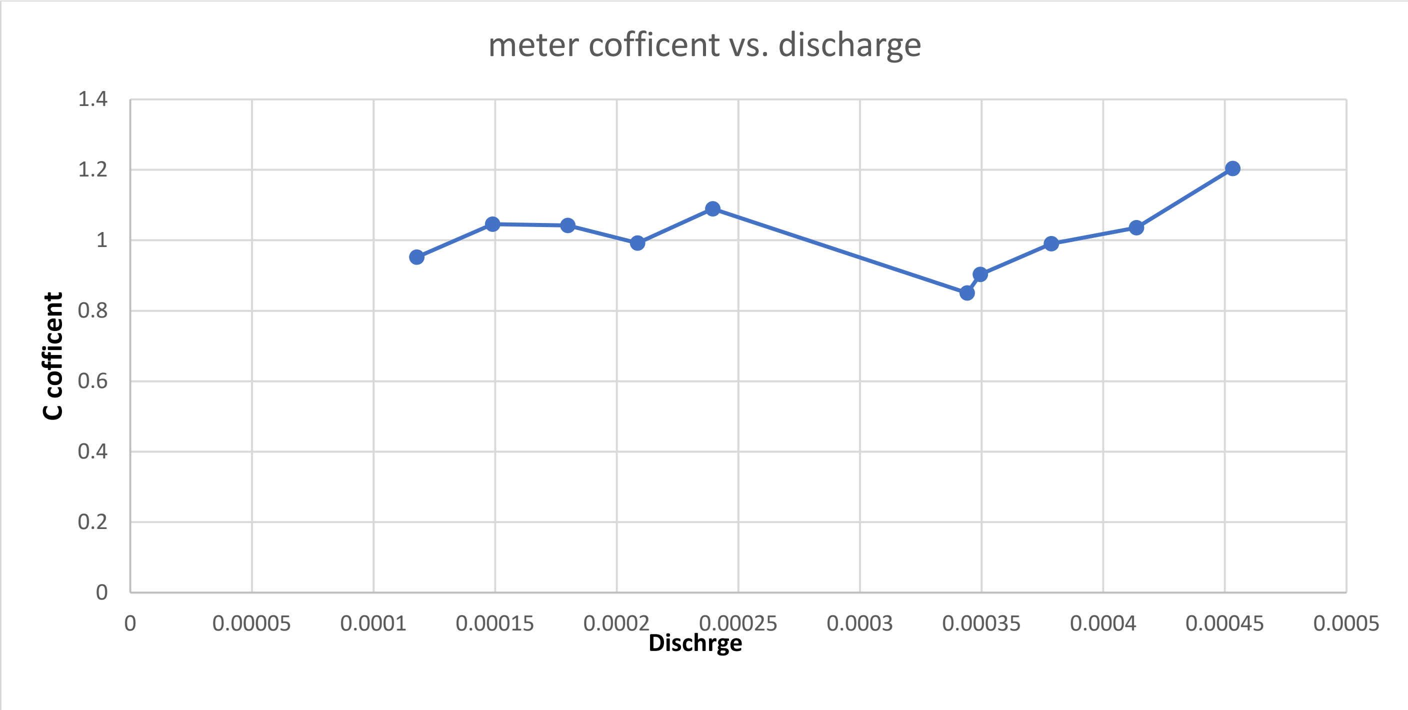


Figure 3: meter coefficient vs. discharge

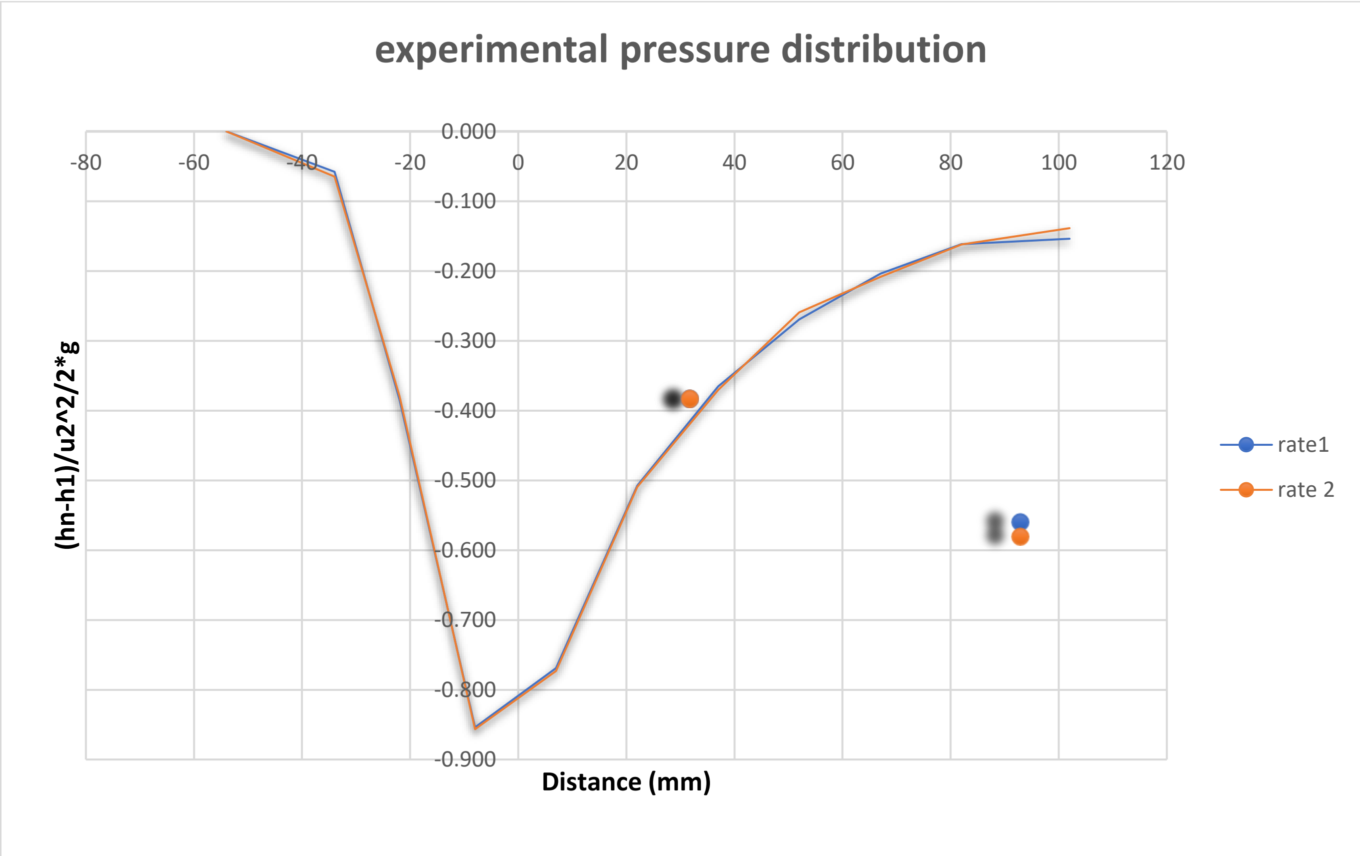


Figure 4: pressure distribution vs. Distance

5- Discussion of results:

After doing all measurements and calculations for the experiment as shown above there is a relationship between them and the results as shown in figures, we have an independent variables like water flow rate, cross sectional area and wight while the dependent variables are like velocity, time and pressure for example there is an inverse relation between the water flow rate with time so when the flow rate decreases the time increases, and a direct relation with velocity. When the cross sectional area decreases the velocity increases and the pressure decreases. When the weight increases the mass flow rate increases.

It is obvious that Q actual and Q ideal values are very near to each other so the venturi meter coefficient is approximately 1.

From graph 1 above the minimum head difference is when the discharge has the minimum value and the relation is approximately linear with some errors, from graph 2 we can find the mean value for C coefficient because it equals Q exp./Q ideal and the relation is nearly linear because there are some energy losses which represent C values. The relation between Q and C from graph 3 is nearly constant, the last graph represents the relation between distance from datum between D and E tubes and the experimental pressure distribution at two different flow rates.

If the venturi meter placed vertically instead of horizontal the effect of gravity will be larger and the losses will be larger so the C coefficient will be smaller and more pressure from water will be at the bottom of the tube.

The experimental results agree with the theory with a little difference due to some errors and uncertainties, in all experiments there is always a little difference between the experimental and theoretical values due to equipment errors, losses, environmental variables like temperature and approximations. To reduce the experimental uncertainties, we can for example use the phone timer instead of the stopwatch because it is more accurate and easier to use. There is also a random errors like estimation while manometer head pressure reading and not exact time reading from the stopwatch, a systematic errors like temperature which can effect on the experiment.

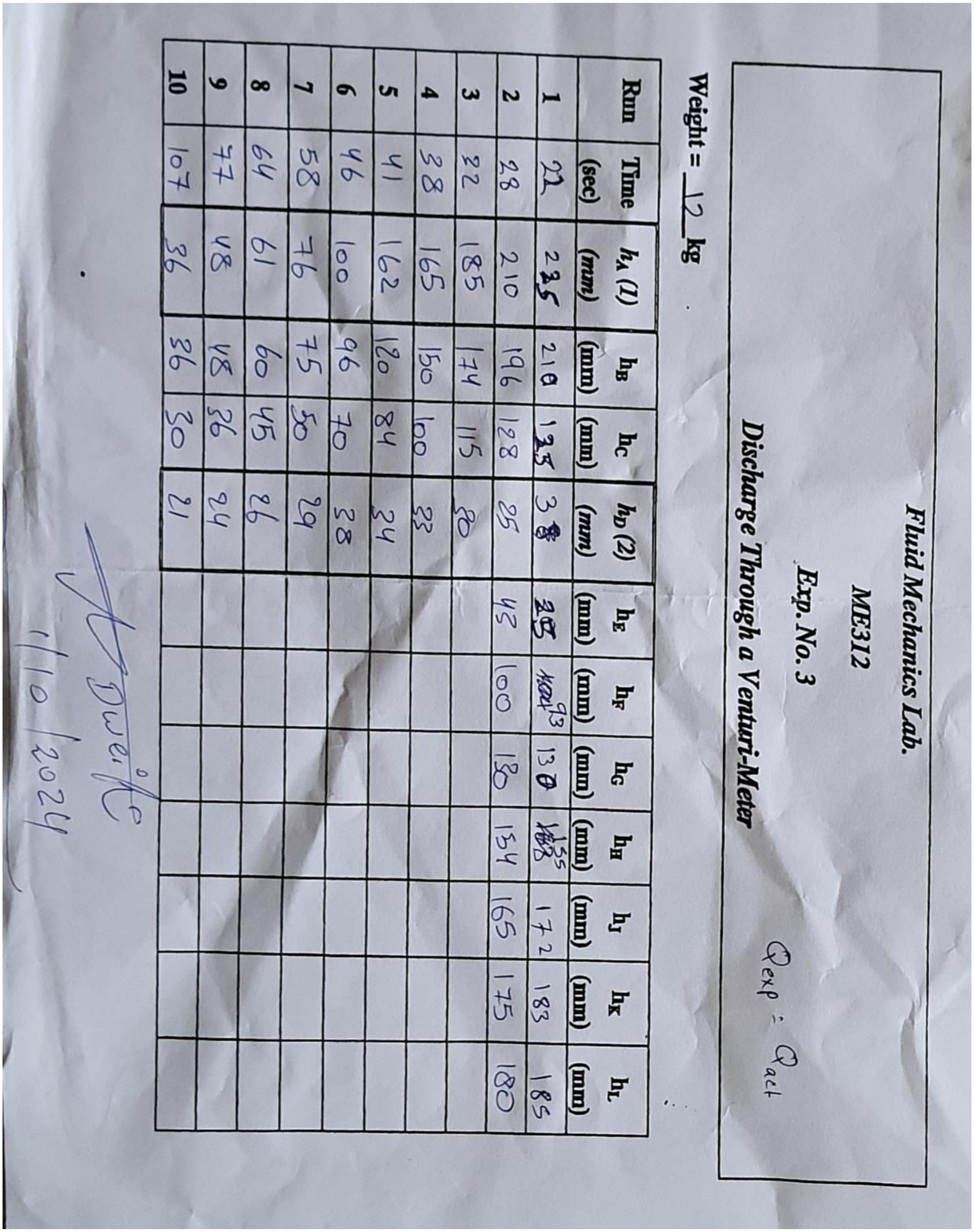
6- Conclusion:

The main results of this experiment are to find the experimental and ideal flow rate (discharge) and to compare them also is to find the pressure distribution and the venturi meter coefficient, all these are related to each other by direct or indirect relations.

After measuring the ideal and experimental discharge I found that they are very near to each other so it is acceptable also any value of the coefficient is larger than 1 is not acceptable because there are losses so it must be less or equal to 1. To improve the experiment result we need to be more accurate while doing all steps and measurements of it.

7-Appendices:

-fluid mechanics laboratory manual-2022



Fluid Mechanics Lab.

ME312

Exp. No. 3

Discharge Through a Venturi-Meter

$Q_{exp} = Q_{act}$

Weight = 12 kg

Run	Time (sec)	h_A (1) (mm)	h_B (mm)	h_C (mm)	h_D (2) (mm)	h_E (mm)	h_F (mm)	h_G (mm)	h_H (mm)	h_J (mm)	h_K (mm)	h_L (mm)
1	22	235	210	135	38	25	93	130	135	172	183	185
2	28	210	196	128	25	45	100	130	134	165	175	180
3	32	185	174	115	80							
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Dweik

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