NATIONAL INSTITUTE OF TECHNOLOGY, DURGAPUR

DEPARTMENT OF CHEMICAL ENGINEERING

REPORT

TITLE EXPERIMENT ON HYDRAULIC BENCH MODEL

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Section Year 2019

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Date of Experiment 07/01/2019

TITLE: Experiment on Orifice meter (hydraulic bench model).

OBJECTIVE: Flow measurement by an Orifice meter.

THEORY:

The apparatus consist of orifice meter fitted in pipe line. The pipe line is taken out from a common manifold. At the down stream end of the pipe line a control valve is provided to regulate the flow through the orifice meter. Pressure tapping are taken out from inlet and throat of orifice meter and are to be connected to a differential mercury manometer. A collecting tank is provided to measure the actual discharge.

Actual discharge, $Q_a = \frac{(q \times 1000)}{t}$

where, q = discharge in litres

t = time for collection

Theoretical discharge, $Q_t = a\sqrt{2gh}$

where, a = area at orifice

therefore,

Discharge co-efficient, $C_d = \frac{Q_a}{Q_t}$

OBSERVATIONS:

1. D = diameter of the pipe = 2.5 cm
2. d = diameter of the orifice = 1.25 cm
3. a = area of orifice = $\frac{\pi d^2}{4}$ cm^2 = 1.227 cm^2
4. S = Specific gravity of Hg
5. $Q_a = \frac{(q \times 1000)}{t}$ = actual discharge
6. g = acceleration due to gravity = 981 cm/s^2
7. $h = h'(13.6-1) = 12.6 \times h'$

   where h' = cms of Hg

   h = cms of water

   specific gravity of Hg = 13.6
8. Area of tank = 15.5" x 23.25"

   = 39.37 x 59.055 cm^2

   = 2324.99 cm^2
9. Reynolds number, $N_{Re} = \left(\frac{V \times D \times \rho}{\mu}\right) = \left(\frac{V \times D}{\nu}\right)$

   $= \left(\frac{Q \times D}{A \times \nu}\right)$

Here,

$V = Q/A$ = velocity of fluid at pipe inlet

A = area of pipe cross-section

Q = flow rate

D = Diameter of pipe

μ = dynamic viscosity

ν = kinematic viscosity = 0.01004 cm^2/sec of water at 20°C

OBSERVED DATA:

Sl. No.	h_1 (cm)	h_2 (cm)	Δh (cm) $=(h_2-h_1)$	R (cm)	Time, t (sec.)	q = (Area of tank × R) × 10^{-3} (litres)
1	6.9	15.4	8.5	6−4.5 = 1.5	10	3.4874
2	9	13	4	7.2−6 = 1.2	10	2.7899
3	10	12	2	8.5−7.2 = 1.3	10	3.0224
4	10.4	11.6	1.2	8.8−8.5 = 0.3	10	0.6974
5	10.8	11.3	0.5	9.4−8.8 = 0.6	10	1.3949

OBSERVATION TABLE:

Sl. No.	h' (cm)	h (cm)	Q_{actual} or, Q_a (cm^3/sec)	$Q_{theoretical}$ or, Q_t (cm^3/sec)	C_d	N_{Re}
1	8.5	107.1	348.74	562.456	0.62003	17691
2	4	50.4	278.99	385.842	0.72306	14152
3	2	25.2	302.24	272.831	1.10792	15332
4	1.2	15.12	69.74	211.334	0.32999	3538
5	0.5	6.3	139.49	136.415	1.02254	7076

CALCULATIONS:

1. $h = h'(13.6 - 1)$

$= 12.6 \times h'$

$= 12.6 \times 8.5$

$= 107.1$ cm

Similarly, we can get h for other h'

2. Q_{actual} or $Q_a = \frac{(q \times 1000)}{t}$ where q is in litres

$= \frac{(3.4874 \times 1000)}{100}$

$= 348.74\ cm^3/sec$

Similarly, we can get another Q_a.

3. $Q_{theoretical}$ or $Q_t = a\sqrt{2gh}$

$= 1.227 \times \sqrt{2 \times 981 \times 107.1}$

$= 562.456 \text{ cm}^3/\text{sec}.$

Similarly, we can get another Q_t.

4. $C_d = \frac{Q_a}{Q_t} = \frac{348.74}{562.456} = 0.62003$

Similarly, we can get another C_d.

5. $N_{Re} = \frac{Q \times D}{A \times V}$

$= \frac{348.74 \text{ cm}^3/\text{sec} \times 2.5 \text{ cm}}{4.9087 \text{ cm}^2 \times 0.01004 \text{ cm}^2/\text{sec}}$

$= 17691$

Similarly, we can get another N_{Re}.

TITLE: Experiment on Venturi meter (hydraulic bench model).

OBJECTIVE: Flow measurement by venturi meter.

THEORY:

The apparatus consist of venturimeter fitted in pipe line. The pipe line is taken out from a common inlet. At the down stream end of the pipe line a control valve is provided to regulate the flow through the venturimeter. Pressure tapping are taken out from inlet and throat of venturimeter and are to be connected to a differential mercury manometer. Discharge is taken to the measuring tanks of hydraulic bench.

Actual discharge, $Q_a = \frac{(q \times 1000)}{t}$

where, q = discharge in litres

t = time for collection in sec.

Theoretical discharge, $Q_t = \frac{(a_1 \times a_2 \times \sqrt{2gh})}{\sqrt{(a_1^2 - a_2^2)}}$

where, a_1 = area at inlet

a_2 = area at throat

therefore,

Discharge co-efficient, $C_d = \frac{Q_a}{Q_t}$

OBSERVATIONS:

1. d_1 = diameter at the inlet of the venturimeter = 2.5 cm
2. d_2 = diameter at the throat of the venturimeter = 1.25 cm
3. s = specific gravity of Hg
4. a_1 = area at inlet = $\frac{\pi d_1^2}{4}$ cm^2 = 4.9087 cm^2
5. a_2 = area at throat = $\frac{\pi d_2^2}{4}$ cm^2 = 1.227 cm^2
6. $Q_a = \frac{(9 \times 1000)}{t}$ = actual discharge
7. g = acceleration due to gravity = 981 cm/sec^2

8. $h = h'(13.6 - 1) = 12.6 \times h'$

where h' = cms of Hg

h = cms of water

specific gravity of Hg = 13.6

9. Area of tank = 15.5" × 23.25"

= 39.37 × 59.055 cm^2

= 2324.99 cm^2

10. Reynolds number, $N_{Re} = \frac{V \times D \times \rho}{\mu} = \frac{V \times D}{\nu}$

$= \frac{Q \times D}{A \times \nu}$

Here,

$V = Q/A$ = velocity of fluid at pipe inlet

A = area of pipe cross section

Q = flow rate

D = diameter of pipe

μ = dynamic viscosity

ν = kinematic viscosity

= 0.01004 cm^2/sec of water at 20°c

OBSERVED DATA :

Sl. No.	h_1 (cm)	h_2 (cm)	Δh (cm) $=h_2-h_1$	R (cm)	Time, t (sec.)	q = (Area of tank × R) × 10^{-3} (litres)
1	6.6	15.5	8.9	7.7−5.9 = 1.8	10	4.1849
2	7.5	14.5	7	9−7.7 = 1.3	10	3.0224
3	8.4	13.9	5.5	10.9−9 = 1.9	10	4.4174
4	9	13.2	4.2	12.2−10.9 = 1.3	10	3.0225
5	10	12	2	13.3−12.2 = 1.1	10	2.5575

OBSERVATION TABLE:

Sl. No.	h' (cm)	h (cm)	Q_{actual} or, Q_a (cm^3/sec)	$Q_{theoretical}$ or, Q_t (cm^3/sec)	C_d	N_{Re}
1	8.9	112.14	418.49	594.408	0.704045	21229
2	7	88.2	302.24	527.155	0.573342	15332
3	5.5	69.3	441.74	467.273	0.945357	22408
4	4.2	52.92	302.25	408.333	0.740205	15332
5	2	25.2	255.75	281.776	0.907636	12973

CALCULATIONS:

1. $h = h'(13.6-1)$

$= 12.6 \times h'$

$= 12.6 \times 8.9$

$= 112.14 \text{ cm}$

Similarly, we can get h for other h'.

2. Q_{actual} or $Q_a = \frac{(q \times 1000)}{t}$ where q is in litres

$= \frac{(4.1849 \times 1000)}{10}$

$= 418.49 \text{ cm}^3/\text{sec}.$

Similarly, we can get another Q_a

3. $Q_{theoretical}$ or $Q_t = \frac{(a_1 \times a_2)\sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$

$= \frac{4.9087 \times 1.227 \times \sqrt{2 \times 981 \times 112.14}}{\sqrt{4.9087^2 - 1.227^2}}$

$= 594.408 \text{ cm}^3/\text{sec}.$

Similarly, we can get another Q_t.

4. $C_d = \dfrac{Q_a}{Q_t}$

$= \dfrac{418.49}{594.408}$

$= 0.704045$

Similarly, we can get another C_d.

5. $C_d = \dfrac{(0.704045 + 0.573342 + 0.945357 + 0.740205 + 0.907636)}{5}$

$= 0.774117$

6. $N_{Re} = \dfrac{(Q \times D)}{(A \times V)}$

$= \dfrac{418.49\ cm^3/sec \times 2.5\ cm}{4.9087\ cm^2 \times 0.01004\ cm^2/sec}$

$= 21229$

Similarly, we can get another N_{Re}.

RESULTS:

1. Discharge co-efficient for Venturi meter $= 0.774117$

2. Discharge co-efficient for Orifice meter $= 0.760708$

3. The value of discharge co-efficient for orifice is less than the value for Venturi meter.

4. Based on the graph plotted above, the Calibration of venturi meter is more accurate when measuring the rate of flow of a fluid through a pipe than an orifice meter.

PRECAUTIONS:

1. The parallax error should be avoided.
2. There should be some water in collecting tank.
3. Make sure that velocity of flow does not exceed very much.
4. Make sure there is no bubble present in manometer.

DISCUSSION:

From the experiment, we successfully obtained the flow rate measurement with comparison of pressure drop by utilizing two basic types of flow measuring techniques which are Venturi meter and orifice meter. The flow rates for venturi meter and orifice meter deviate from the theoretical flow rates. This could be happening due to the friction and no-slip condition as water flows through each of the flowmeters. Orifice plates causes high energy losses and high-pressure loss to the flow being measured. Venturi meter, on the other hand, is also based on Bernoulli's principle just like the orifice meter. But instead of sudden constriction caused by an orifice, venturi meter uses a relatively gradual constriction ~~caused by an orifice~~ much like a reducer to cause the pressure drop by increasing fluid velocity. We know that if the value of co-efficient of discharge is higher then flow rate or discharge will be higher and frictional loss will be less. So, power requirements will be decreased and related cost will also be decreased for a venturi meter comparing to an orifice meter. The co-efficient of discharge C_d for venturi meter is greater than that ~~of~~ for the orifice meter, which indicates that the head losses occurred in the head losses occurred in the orifice are larger than that in venturi, this result was predicted theoretically. The probable sources of error in the result are the bubbles that may have appeared in the hose. Another is in reading the measurements and some human errors.

CONCLUSION:

The aim of this experiment is to be able to calibrate the orifice and venturi flow meters by letting a known volume of water pass through and reading the pressure changes from a manometer. From the data obtained, it can be concluded, for the venturi meter, the value obtained were closer to the actual flow rate. This is due to lower pressure drop that results from its streamlined shape and almost eliminates boundary-layer separation and thus ~~from~~ form drag is assumed negligible. This meter is good for high pressure and energy recovery. The arrangement of orifice meter is much economical than the use of the venturi meter, but as seen in this experiment the venturi meter provide more accurate results than the orifice meter, so the choice of which to use depends on the financial ability of the organization occupying the device and, on the accuracy needed. To be concluded, venturi meter was more accurate compared to orifice meter.

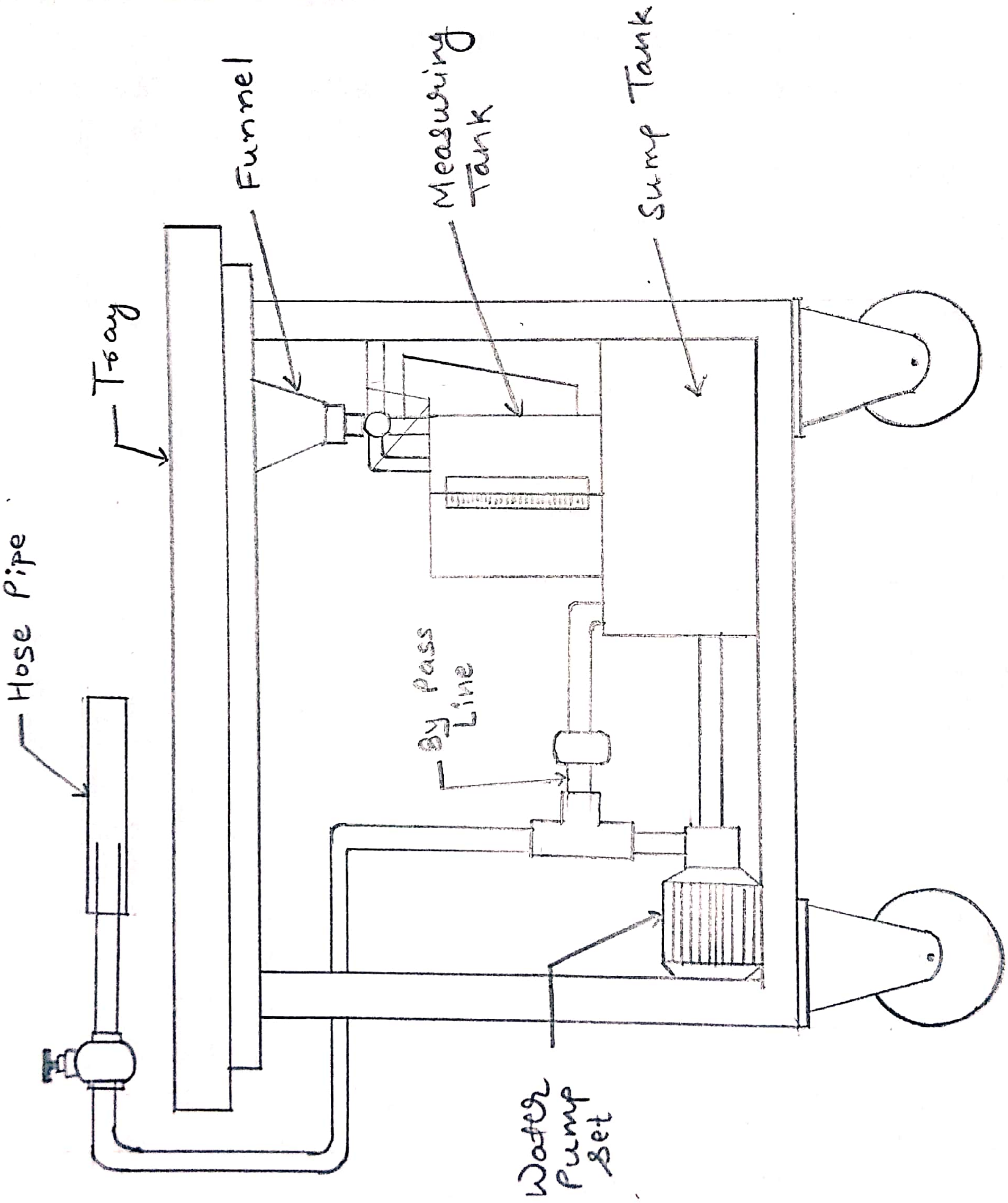

Fig. HYDRAULIC BENCH

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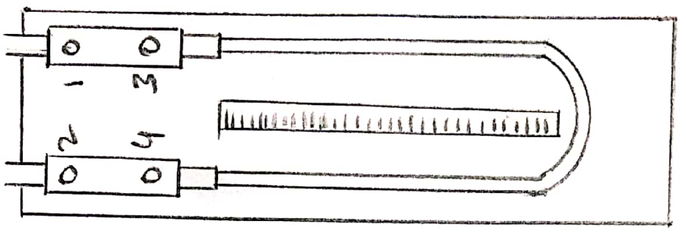

Fig. Manometer

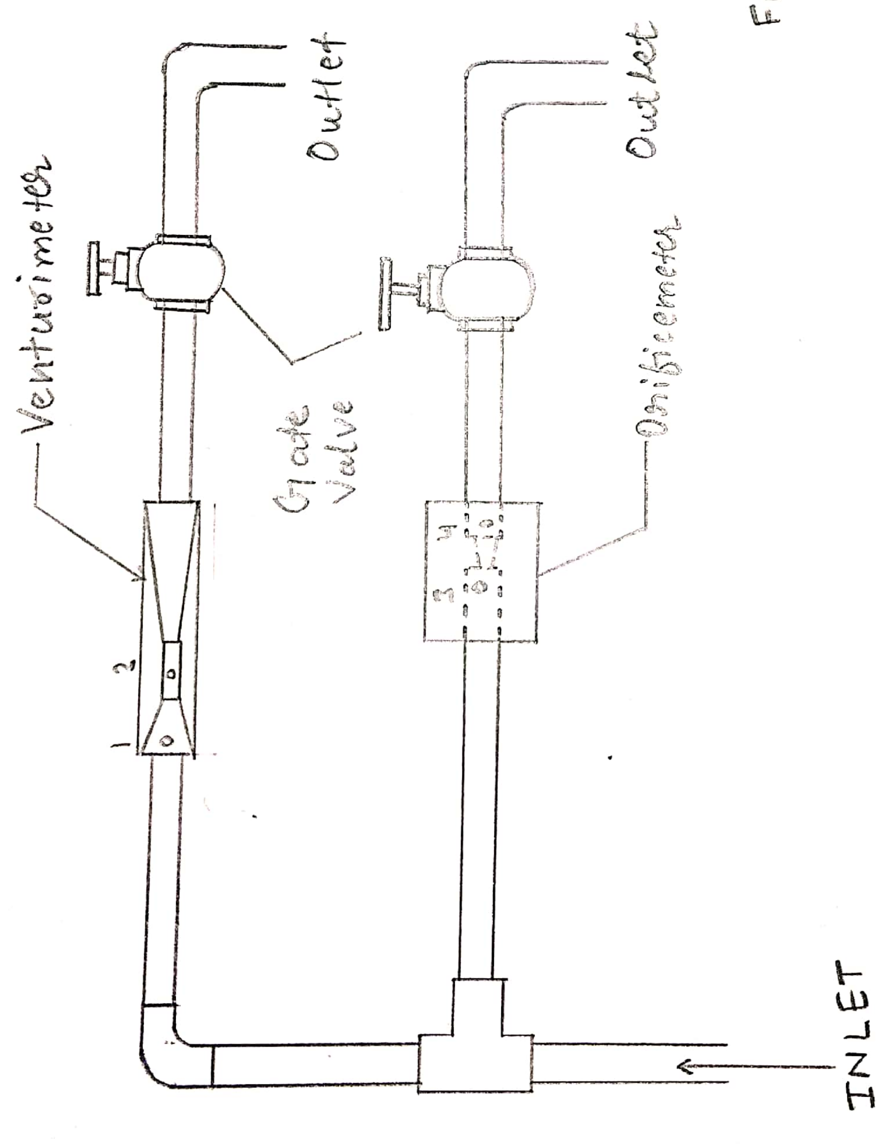

Fig. Venturimeter and Orificemeter

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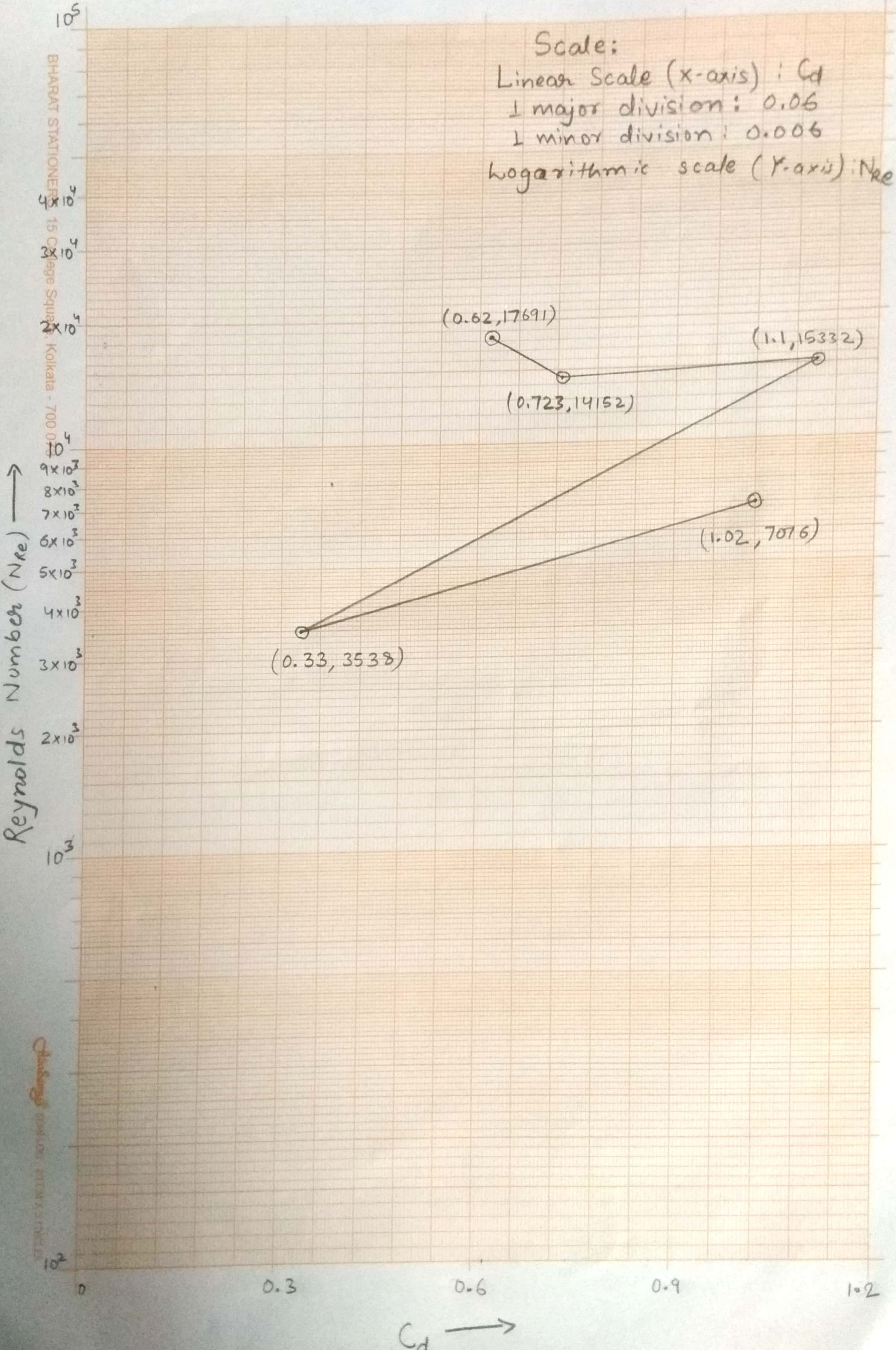
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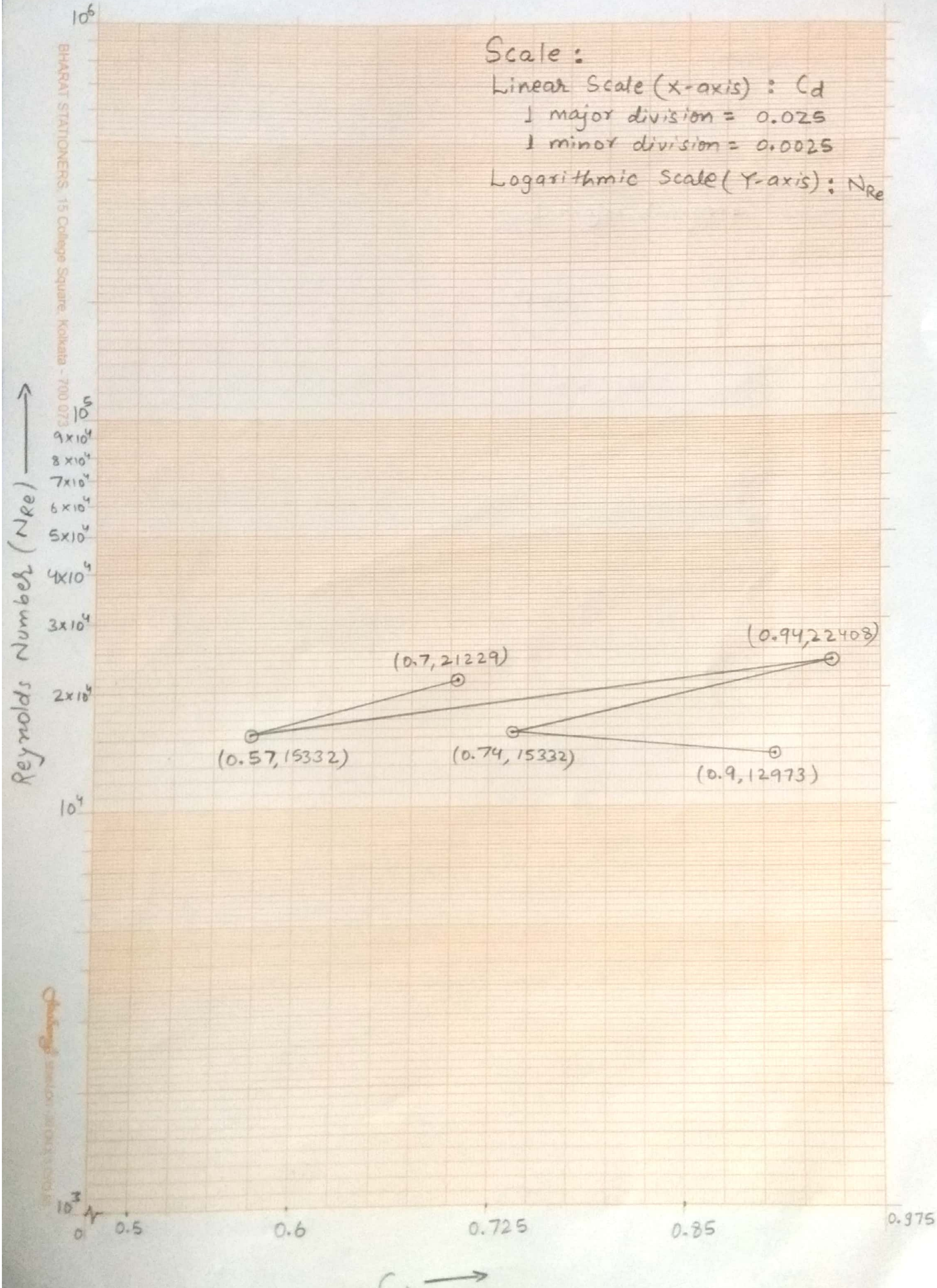
Linear Scale (x-axis) : Cd
1 major division : 0.06
1 minor division : 0.006
Logarithmic scale (Y-axis) : NRe
(0.62, 17691)
(1.1, 15332)
(0.723, 14152)
(1.02, 7016)
(0.33, 3538)
Reynolds Number (NRe) →
Cd →
10^5
4×10^4
3×10^4
2×10^4
10^4
9×10^3
8×10^3
7×10^3
6×10^3
5×10^3
4×10^3
3×10^3
2×10^3
10^3
10^2
0
0.3
0.6
0.9
1.2


Scale :
Linear Scale (x-axis) : C_d
1 major division = 0.025
1 minor division = 0.0025
Logarithmic Scale (Y-axis) : N_{Re}
Reynolds Number (N_{Re}) ⟶
10^6
10^5
9×10^4
8×10^4
7×10^4
6×10^4
5×10^4
4×10^4
3×10^4
2×10^4
10^4
10^3
0
0.5
0.6
0.725
0.85
0.975
C_d ⟶
(0.7, 21229)
(0.94, 22408)
(0.57, 15332)
(0.74, 15332)
(0.9, 12973)
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1. Orifice Meter

Observation Table:

Sl.	h_1	h_2	Δh (cm)	R (cm)	t (sec)
1	6.9	15.4	= 8.5	6 - 4.5 = 1.5	10
2	9	13	6	7.2-6	10
3	10	12	2	8.5-7.2	10
4	10.4	11.6	1.2	8.8-8.5	10
5	10.8	11.3	0.5	9.4-8.8	10

area = 15.5" × 23.25" = 2324.99 cm^2

2. Venturi Meter

Observation Table:

Sl.	h_1	h_2	Δh (cm)	R (cm)	t (sec)
1	6.6	15.5	8.9	7.7-5.9	10
2	7.5	14.5	7	9-7.7	10
3	8.4	13.9	5.5	10.9-9	10
4	9	13.2	4.2	12.2-10.9	10
5	10	12	2	13.3-12.	10

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