

Experiment No. 01

Experiment Name: Flow through a venturi flume



1. INTRODUCTION:

Flume:

- Flumes are **open channel flow sections** that force flow to accelerate. Acceleration is produced by converging the side walls, raising the bottom or a combination of both. Flumes are designed to force a transition from **sub-critical** to **super-critical** flow.
- Such a transition causes flow to pass through **critical depth** at the flume throat. At the critical depth, energy is minimum and there is direct relationship between **the water head and flow head**. However, in super-critical flow the depth is small but velocity is large.

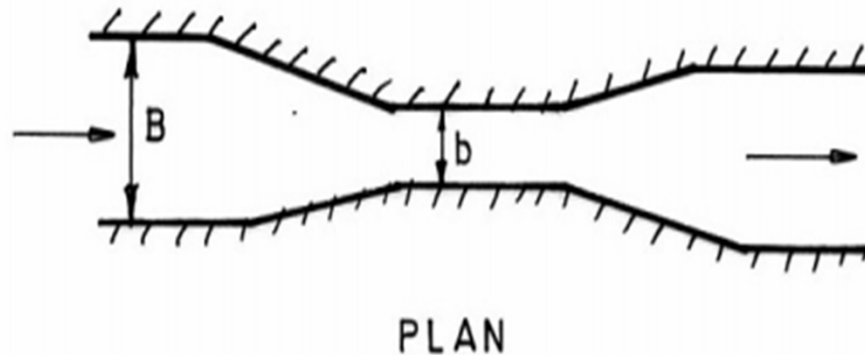


Fig. 1.1 Plan of the flume

Venturi-flume:

- Venturi flume has a converging section, a throat section and a diverging section. A control flume that comprises a short constructed section followed by one expanding to normal width.
- The bed level is kept horizontal.
- The streamlines run parallel to each other at least over a short distance upstream of the flume.

Theory:

Discharge at Free Flow Condition:

- In case of free flow flume, the velocity of flow at the throat of the flume is greater than the **critical velocity**. Free flow is formed at the downstream end of the raised floor. Since the velocity and depth of flow at a section upstream of the entrance of the flume remains unaffected by downstream depth.
- It may be thus mentioned that as long as the downstream depth of flow is kept below the limiting values, the discharge passing through a free flow will be a function of **only the depth of flow at upstream to the entrance section**.

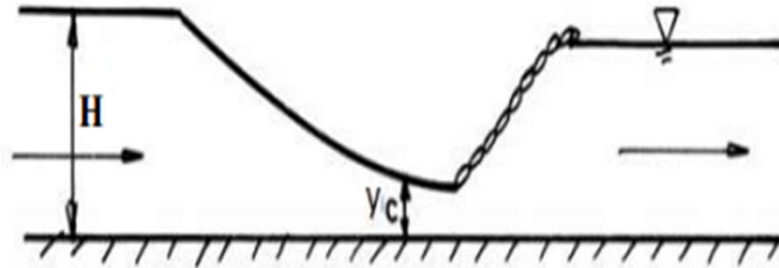


Fig. 1.2 Free flow condition

REQUIRED FORMULA FOR FREE FLOW CONDITION:

Theoretical discharge: $Q_{tf} = (2/3)^{1.5} \sqrt{g} b H^{1.5}$

Where, H is the head measured sufficiently upstream of the flume, b is the width of the Venturi flume at the throat section.

Co-efficient of discharge: $C_{df} = Q_a / Q_{tf}$

Where, Q_a = Actual discharge.

B= Width of the channel entrance

b= Width of throat section

Discharge at submerged flow Condition:

- For the submerged condition, the velocity of flow at the throat is always **less than** critical velocity and hence discharge passing through it will be a function of **the difference between the depth of flow upstream of the entrance section and at the throat**. Further since the velocity of flow at the throat is less than the critical velocity.
- The discharge Q passing through the channel can be calculated by measuring the depth of flow at the entrance and at the throat of the flume and applying the following formula.

$$Q_{ts} = a\sqrt{2g(y_1 - y_2)} \frac{1}{\sqrt{1 - M^2}}$$

Co-efficient of discharge, $C_{ds} = Q_a/Q_{ts}$

Where, Q_a = Actual discharge.

Q_{ts} = Theoretical discharge

a = Throat area = $y_2 \times b$

b = Width of the throat

h = Depth of flow at the throat

A = Upstream area = $y_1 \times B$

B = Width of entrance

M = Area ratio = a/A

Q_a = Actual discharge

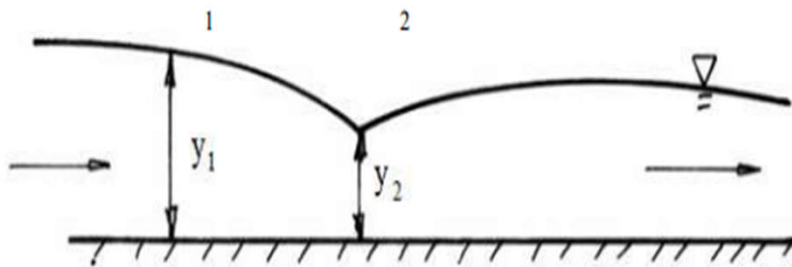


Fig.1.3 Submerged flow condition

2. Objectives of the experiment:

1. Observation of free flow condition and submerged flow condition
2. Determination of the co-efficient of discharge
3. To plot actual discharge with respect to theoretical discharge in the plain graph paper
4. To plot actual discharge with respect to upstream head in the log-log graph paper
5. Determination of exponent of y from the log-log paper

3. Experimental setup:

The experimental setup for this experiment is given below.

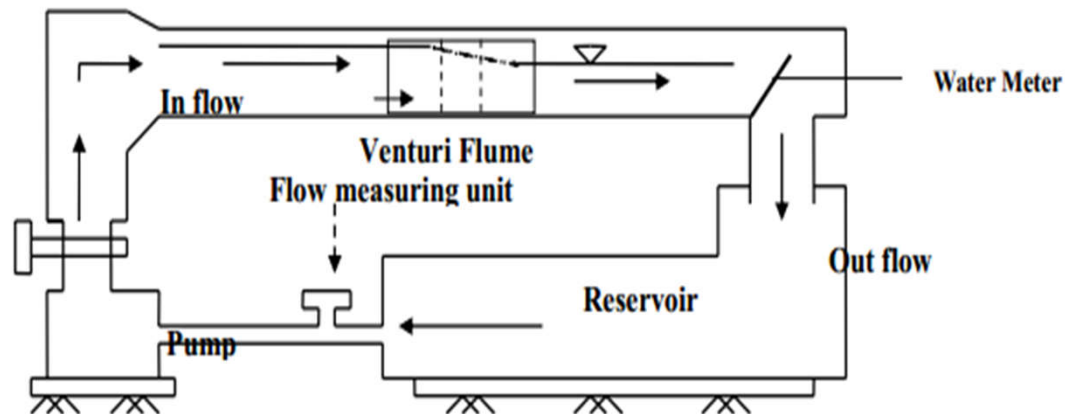


Fig. 1.4 Experimental setup for flow through a Venturi flume

4. Required apparatus:

- a) Venturi flume
- b) Pump
- c) Flow measuring unit
- d) Reservoir
- e) Water meter

5. Experimental Procedure

To determine the theoretical and the actual discharges and the coefficient of discharge at free flow condition:

- 1) Measure the depth of flow sufficiently at upstream of the flume shown in Fig. 1.2 and determine the theoretical discharge.
- 2) Take the reading of actual discharge and hence find the coefficient of discharge using Eq. $C_{df} = Q_a/Q_{tf}$

To determine the theoretical and the actual discharges and the coefficient of discharge in submerged Flow condition:

- 1) Measure the flow depths at sections 1 and 2 shown in Fig. 1.3 and determine the theoretical discharge .
- 2) Take the reading of actual discharge and hence find the coefficient of discharge using $C_{ds} = Q_a/Q_{ts}$

Shape of Q vs y graph

In a plain graph paper the plot $Q = ky^n$ is non-linear. But, in a log-log paper $Q = ky^n$ plots as a straight line since, $\log Q = \log k + n \log y$ is an equation of a straight line (of the form $y = mx + c$).

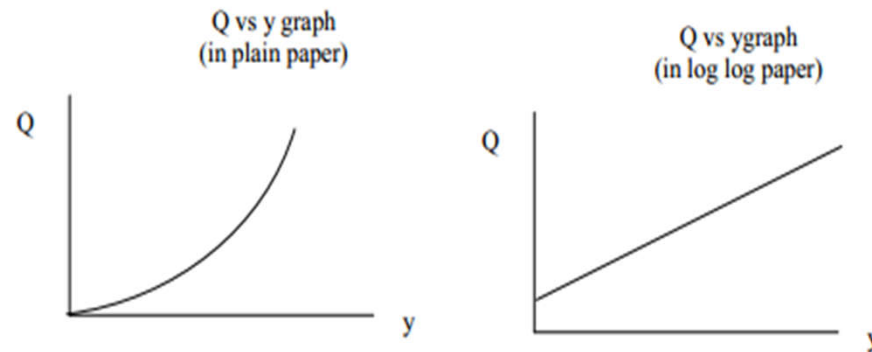


Fig.1.5 Q (actual discharge) vs y(upstream depth of water) graph

Data sheet for example:

Channel width, $B = 7.75$ cm, Throat width, $b = 1.82$ cm

No of Obs.	Actual Discharge Q_a (cm ³ /s)	Free flow condition				Submerged flow condition					Mean C_{ds}
		H (cm)	Q_{thf} (cm ³ /s)	C_{df}	Mean C_{df}	Y1 (cm)	Y2 (cm)	M=a/A	Q_{ths} (cm ³ /s)	C_{ds}	
1.	500	8.0				8.20	5.8				
2.	600	9.0				9.40	6.7				
3.	700	9.7				10.55	7.6				
4.	800	10.4				10.70	8.4				
5.	900	11.10				12.00	9.00				
6.	1000	12.00				13.30	9.50				

7. Sample Calculation:

For free flow condition:

Head of water at upstream, $H = 8$ cm

Width of throat, $b = 1.8$ cm

Actual discharge, $Q_a = 500$ cm³/s

Width of the channel, $B = 7.7$ cm

We know, $Q_{th} = ?$

$C_{df} = ?$

For submerged flow condition:

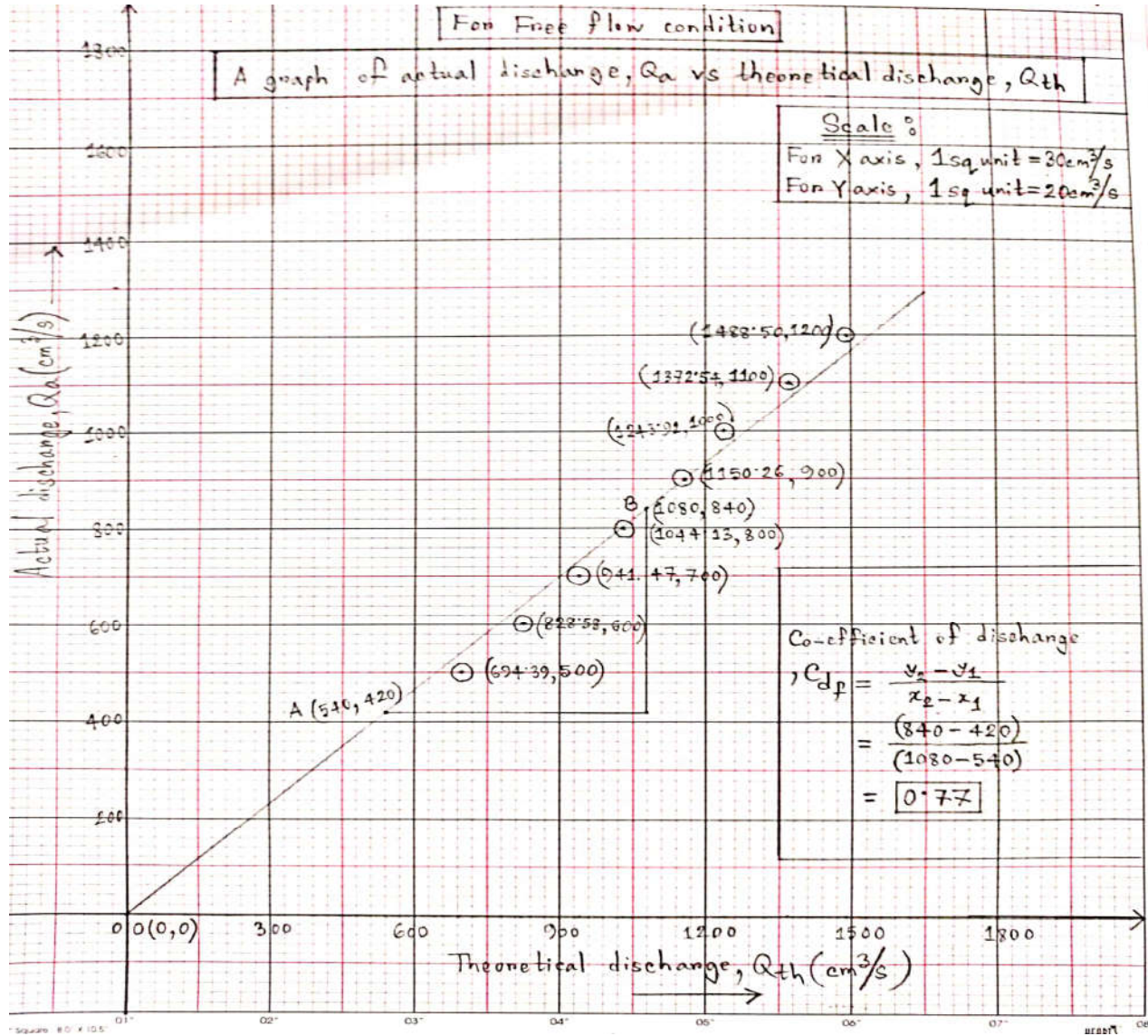
Head of water at upstream, $y_1 = 8.40$ cm = H

Depth of flow at throat, $y_2 = 5.80$ cm = h

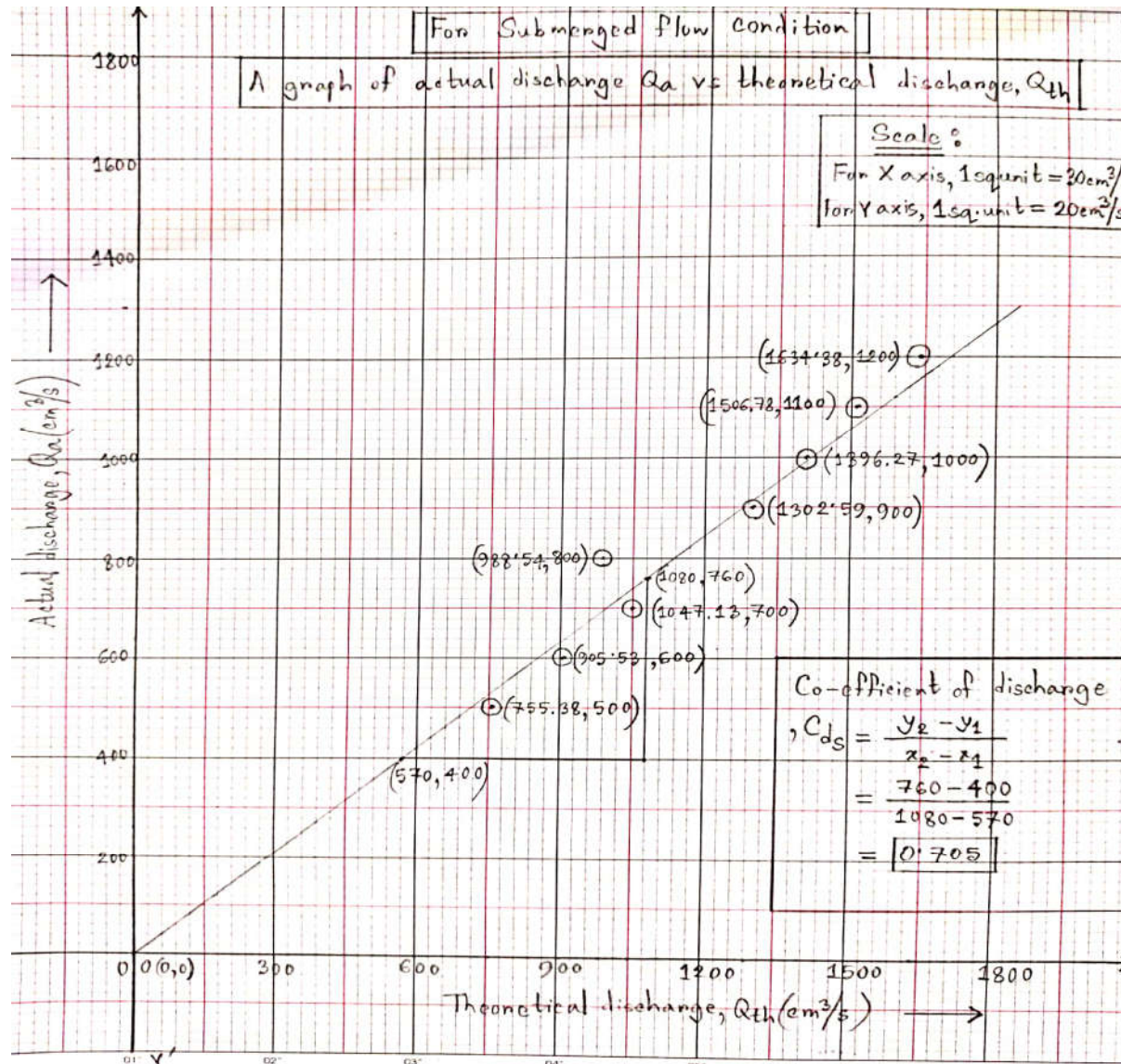
We know, $Q_{th} = ?$

$C_{ds} = ?$

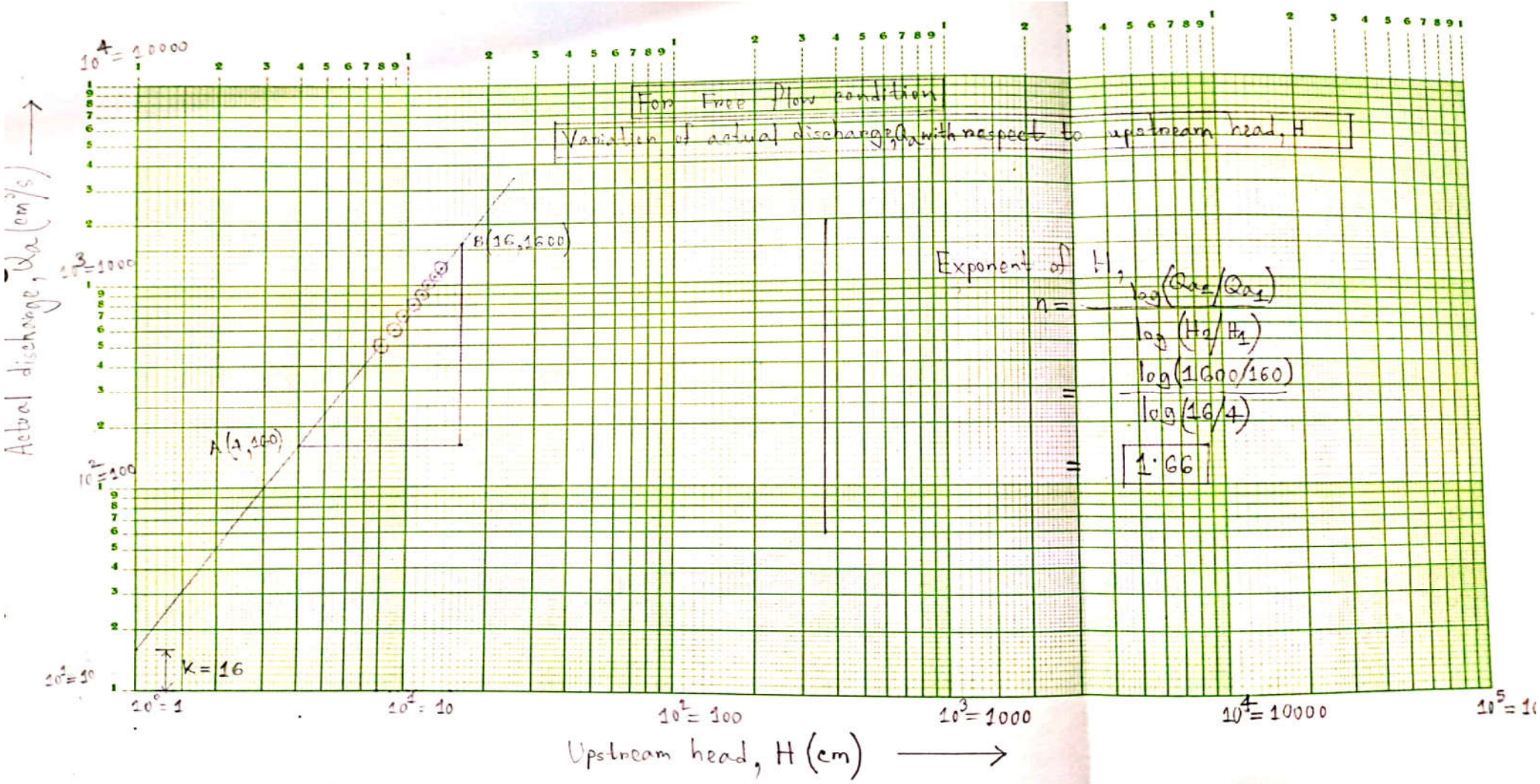
Free Flow Condition:



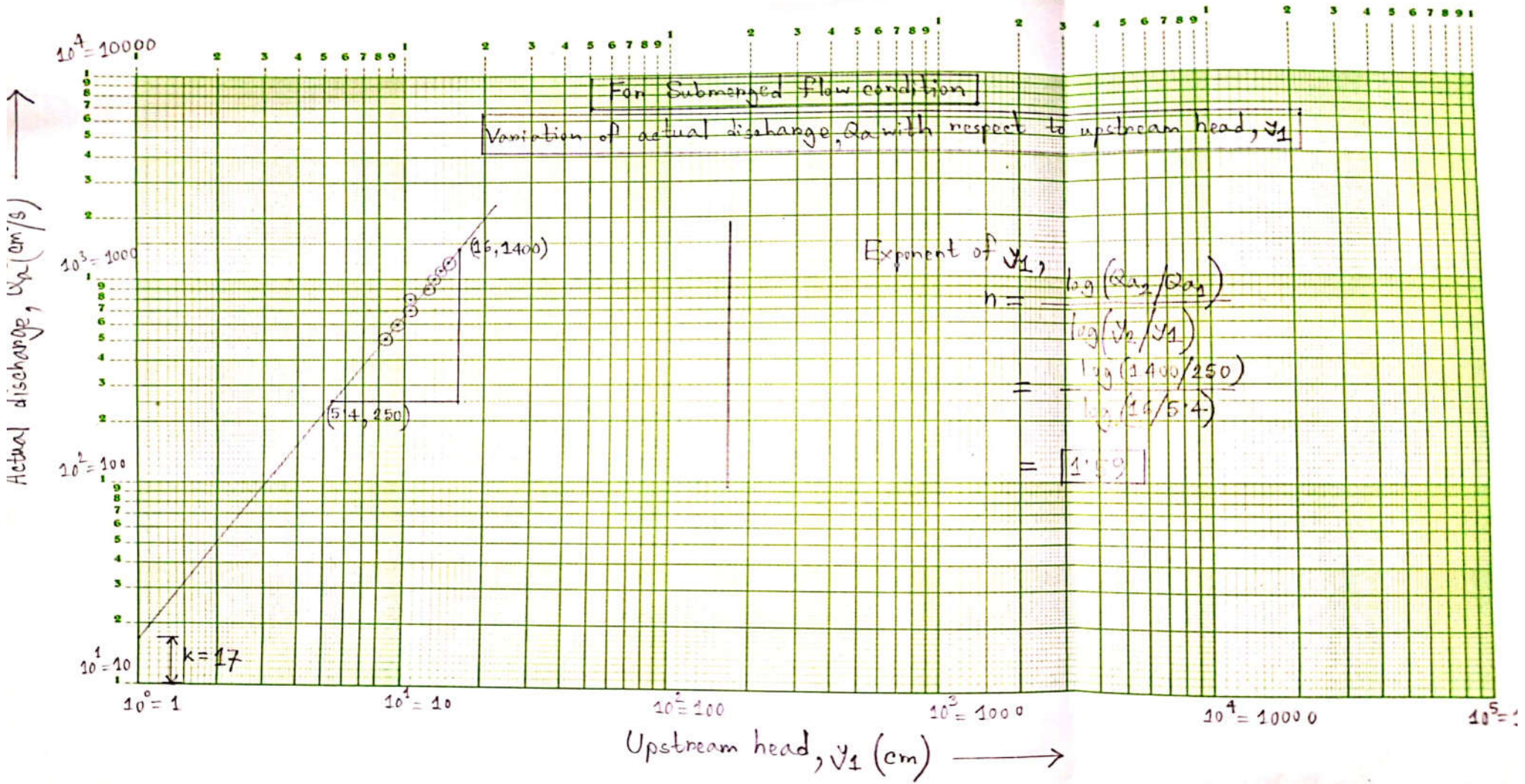
Submerged flow Condition:



Log-log graph for free flow condition:



Log- log graph for submerged flow condition:



8. Results:

9. Discussion on results:

10. Assignments:

1. What are the advantages, disadvantages and uses of a Venturi flume?
2. What is the difference between free and submerged flow? How can you produce submerged flow in a laboratory flume?
3. What is the effect of submergence on the flow?