Gr.-II

DETERMINATION OF COEFFICIENT OF BEND LOSS IN FLOW THROUGH PIPES

OBJECTIVE:

1) To determine pressure-drop coefficient for bend, K_b;

2) to plot the variation of K_b with Reynolds No. R_e on a semi-log graph paper.

All notations carry their usual meanings and the quantities are in SI units unless otherwise mentioned.

THEORY:

When liquid flows through a pipe-bend, a pressure drop occurs due to the sudden change in its direction of flow. In the curved path, liquid experiences an inward (centripetal) acceleration and thus an increase in pressure occurs at the outer wall of the bend starting at point A and reaching the maximum value at point B (see figure). On the other hand, a reduction in pressure occurs at point C of the inward wall with a subsequent rise from C to D. This pressure difference causes a back flow resulting in formation of eddies and separation of flow. In general, head loss due to bend is expressed as $h_b = K_b V^2/(2g)$ where h_b is head loss due to bend, V is average velocity of flow through pipe and K_b is pressure drop coefficient for bend. Value of K_b depends on the angle of the bend θ (here $\theta = 90^o$), the relative radius of curvature R/D (where R is radius of curvature at the centre-line of the bend and D is pipe diameter) and Reynolds No. R_e. In the experiment, average velocity V is calculated from discharge Q_a obtained through a venturimeter connected in the pipe line; $Q_a = K(H_m)^N$, where H_m is level difference in the manometer connected to venturimeter, K and N being two constants of the calibrated venturimeter. Again, by Darcy-Weisbach equation, head loss due to friction in the pipe is expressed as $h_f = fLV^2/(2gD)$ where L is length of pipe and f is friction factor. A pipe bend thus causes a loss of head in addition to what would occur if the pipe were of same total length but straight, and the total loss of head across a bend is given by, $h_t = h_b + h_f$.

APPARATUS & INSTRUMENTS:

Pipe line assembly with supply system, venturimeter fitted in the pipe line.

PROCEDURE:

Delivery valve (see figure) was fully opened. For the first set of observations, control valve in the pipeline was then opened to such an extent that maximum level differences occurred in all the three manometers connected across venturimeter, straight portion (L_s) and bend portion (L_b) respectively (denoted by manometer no. I, II & III in figure). Readings in the manometers were noted. For the next set, flow-rate in the pipe-line was decreased by the control valve and corresponding manometer readings were noted.

The procedure was repeated for obtaining, at least, six sets of observations.

OBSERVATION:

Diameter of the pipe, D = 2 inch

Length of straight portion of pipe, L_s =

Length of bend portion of pipe, L_b =

Venturimeter constants: K = 730 x 10^{-5} SI units = ; N = 0.5 .

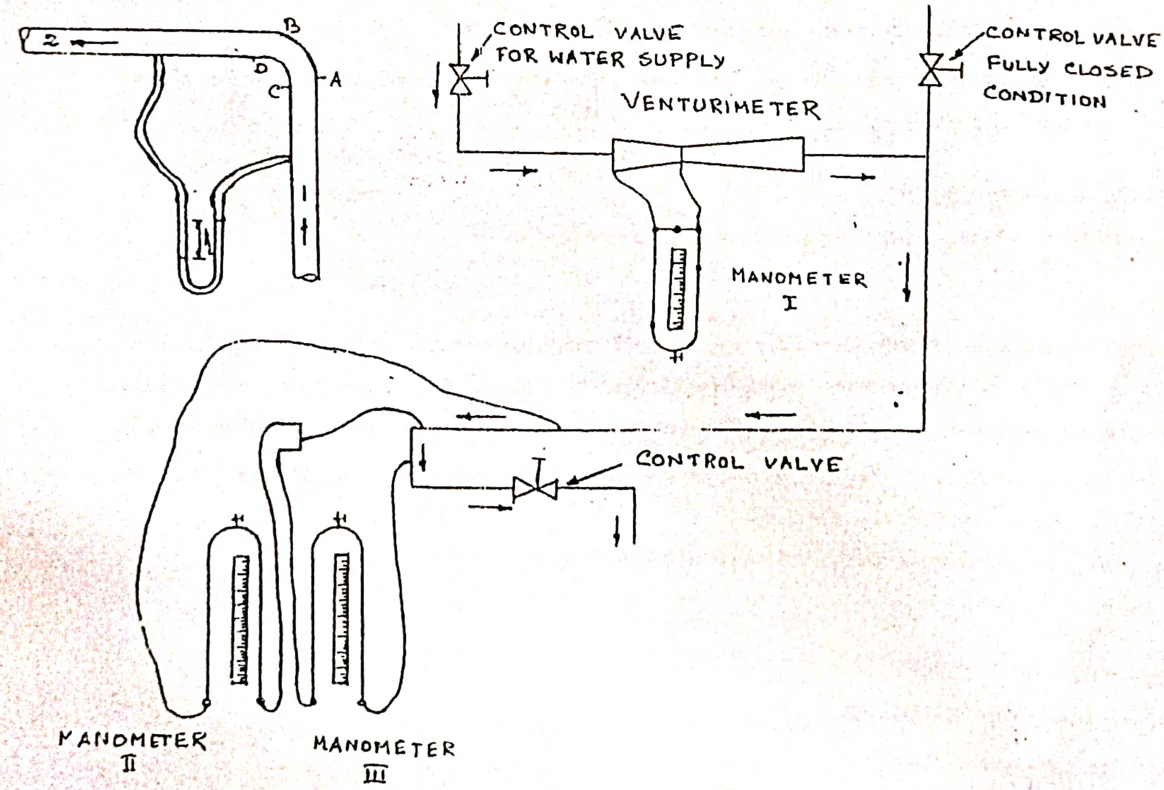
Room temperature, T = °C; kinematic viscosity of water, ν =

Observation No.	Manometer I, connected to venturimeter (in)		Manometer II, connected to straight portion (in)		Manometer III, connected to bend portion (in)	
	LHS (a)	RHS (b)	LHS (c)	RHS (d)	LHS (e)	RHS (f)
At least upto 6						

*RESULT SHEET**:

Set No.	Q_a= (KH_m^N) where H_m =(a)-(b) obtained from I (in)	V=(4Q_a)/(πD^2). (in)	Total loss h_t =(f)-(e) obtained from III (in)	Friction loss in straight portion,H_f =(d)-(c) from II (in)	Friction loss in bend portion,h_f =H_f L_b/L_s (in)	Bend loss, h_b=h_t - h_f (in)	Coefficient of bend loss, K_b	Reynolds No. R_e =(VD)/ν.
1, 2 etc.								

*Show the sample calculation of at least one set. Calculate the average value of K_b.



LINE DIAGRAM OF THE EXPRIMENTAL SET UP
TO FIND THE COEFFICIENT OF BEND LOSS IN A PIPE FLOW

PERFORMANCE TEST OF RECIPROCATING PUMP

Objective: To study the characteristic of a Reciprocating Pump by plotting the curves.

i) H vs. Q.

ii) η_o vs. Q.

iii) η_{vol} vs. Q.

Description of Apparatus:

The apparatus consists of a double-acting single cylinder reciprocating pump operated on a closed circuit. A DC motor is provided to regulate the rpm of the pump. Suction and delivery head can be varied by controlling the valves. Suction and delivery head to be measured by the vaccum and pressure gauges fitted with the apparatus. To find out the input power to the pump an electronic energy meter is fitted. Discharge can be measured with the help of measuring tank and stopwatch.

Given data:

Energy Meter Constant (EMC) 3200 pulses/KWhr.

Efficiency of Motor (η_m) 0·8.

Efficiency of Transmission (η_T) 0·7.

Diameter of cylinder (d) - 0·055 m.

Length of stroke (L) - 0·04 m.

Area of measuring tank (A) - 0·1 m^2.

Calculation:

$$\text{Power input } (E_i) = \frac{\text{No. of Pulses } (P) \times 3600}{\text{Time required for } P \text{ pulses in Sec} \times \text{EMC}} \text{ kW}$$

$$\text{Shaft output } (E_s) = \text{Power input } (E_i) \times \text{Motor eff}^n (\eta_m) \times \text{Transmission eff}^n (\eta_t) \text{ - in kW}$$

$$\text{Rise of Water Level in measuring tank } (R) = \frac{\text{Final Level } (R_2) - \text{Ini. Level } (R_1)}{100}$$

$$\text{Actual discharge } (Q_a) = \frac{A \times R}{\text{time } (t)} \ m^3/s.$$

$$\text{Theoretical discharge } (Q_t) = \frac{2 \times \text{Area of cylinder } (a) \times \text{length of stroke } (L) \times \text{RPM}}{60} \ m^3/s$$

$$\text{where} \quad a = \frac{\pi}{4} d^2 \ m^2.$$

$$\text{Total head } (H) = 10 \times \left[\text{Delivery pressure gauge reading in kg/cm}^2 + \left[\frac{\text{Suction pressure gauge reading in mm Hg}}{\cancel{760} \ 1000} \right] \times 13.6 \right]$$

$$+ \text{ height of pressure gauge above the suction gauge.}$$

$$\text{Pump Output } (E_o) = \frac{\gamma \cdot Q_a \cdot H}{1000} \text{ kW}$$

$$\text{Overall efficiency } (\eta_o) = \frac{E_o}{E_i} \times 100\ \%$$

$$\text{Pump efficiency } (\eta_p) = \frac{E_o}{E_s} \times 100\ \%$$

$$\text{Volumetric efficiency } (\eta_{vol.}) = \frac{Q_a}{Q_t} \times 100\%.$$

Observation Table

SR No	N RPM.	Delivery Pr. Gauge reading Pd (Kg/cm²)	Suction Pr. Gauge reading Ps (mm Hg)	Initial reading of Measuring Tank. (cm)	Final reading of Measuring Tank (cm)	Time taken for taking pulse (t_p)	Time taken for collecting water in Meas. Tank (t_i)

1. Write your comments about the experiment.
2. What is meant by 'error analysis.?'
   What should be the acceptable error for this type of Laboratory Experiments?

CALIBRATION OF ORIFICEMETER

OBJECTIVE:

1) To determine the orificemeter-constants (K & N) from plotting of Q_a vs. H_m on log-log graph paper;

2) to determine coefficient of discharge C_d of orificemeter and to plot C_d vs. R_e on semi-log graph paper.

All notations carry their usual meanings and the quantities are in SI units unless otherwise mentioned.

THEORY:

An orificemeter is used to measure flow in a pipeline. Theoretical discharge through an orificemeter is expressed as $Q_t = A_1 A_2 \sqrt{(2gh)} / \sqrt{(A_1^2 - A_2^2)}$ where A_1 & A_2 are cross-sectional areas of flow in pipe and orifice respectively and h is differential head across the orificemeter in terms of flowing liquid. If head h is measured by a differential manometer with heavier liquid of sp. gr. S_m (than flowing liquid of sp. gr. S) then $h = H_m(S_m/S - 1)$. However, depending on the shape of orifice, reduction of flow-section at vena contracta and orifice friction, actual discharge Q_a is much smaller than Q_t and is given by $Q_a = C_d \times Q_t$ where discharge-coefficient $C_d < 1$. Therefore, practically the expression $Q_a = C_d A_1 A_2 \sqrt{[2g\{H_m (S_m/S - 1)\}]} / \sqrt{(A_1^2 - A_2^2)}$ is reduced to $Q_a = K(H_m)^N$ where, $K = C_d A_1 A_2 \sqrt{[2g\{(S_m/S - 1)\}]} / \sqrt{(A_1^2 - A_2^2)}$ and $n = 1/2$. Thus, the orificemeter is to be calibrated means its constants, i.e. K and N, are to be determined experimentally. Now, the discharge equation $Q_a = K(H_m)^N$ in its logarithmic form is given as: $\log Q_a = N \log H_m + \log K$. When plotted, Q_a vs. H_m represents a straight-line on a log-log graph from which the values of K and N may be determined. Reynolds No. is given by $R_e = V_2 D_2 / \nu$, subscript 2 representing for orifice.

APPARATUS & INSTRUMENTS:

Pipe line assembly with orificemeter fitted with mercury-manometer, volumetric tank, stop watch etc.

PROCEDURE:

Delivery valve was fully opened. For the first set of observations, control valve was so regulated that maximum flow was allowed in the pipeline and the level difference H_m in the orificemeter-manometer reached maximum. Manometer reading was noted. Water coming out of the pipe was stored in a collecting tank during some time interval t which was noted through a stop-watch. Height of the collected water H was noted through a piezometer tube fitted to the tank. The volume of collected water v was then obtained from the product of H multiplied by the area of the tank A. Actual discharge through the orifice Q_a could then be calculated from $Q_a = v/t$. For the next set, flow in pipeline was decreased by control-valve and corresponding readings at tank, stop watch and manometer were noted. The procedure was repeated for obtaining, at least, six sets of observations.

OBSERVATION:

Cross-sectional area of flow in pipe, $A_1 = (\pi D_1^2)/4$

Cross-sectional area of the orifice, $A_2 = (\pi D_2^2)/4$

Specific gravity of manometric liquid, S_m=

Area of the collecting tank, A = (length × breadth) =

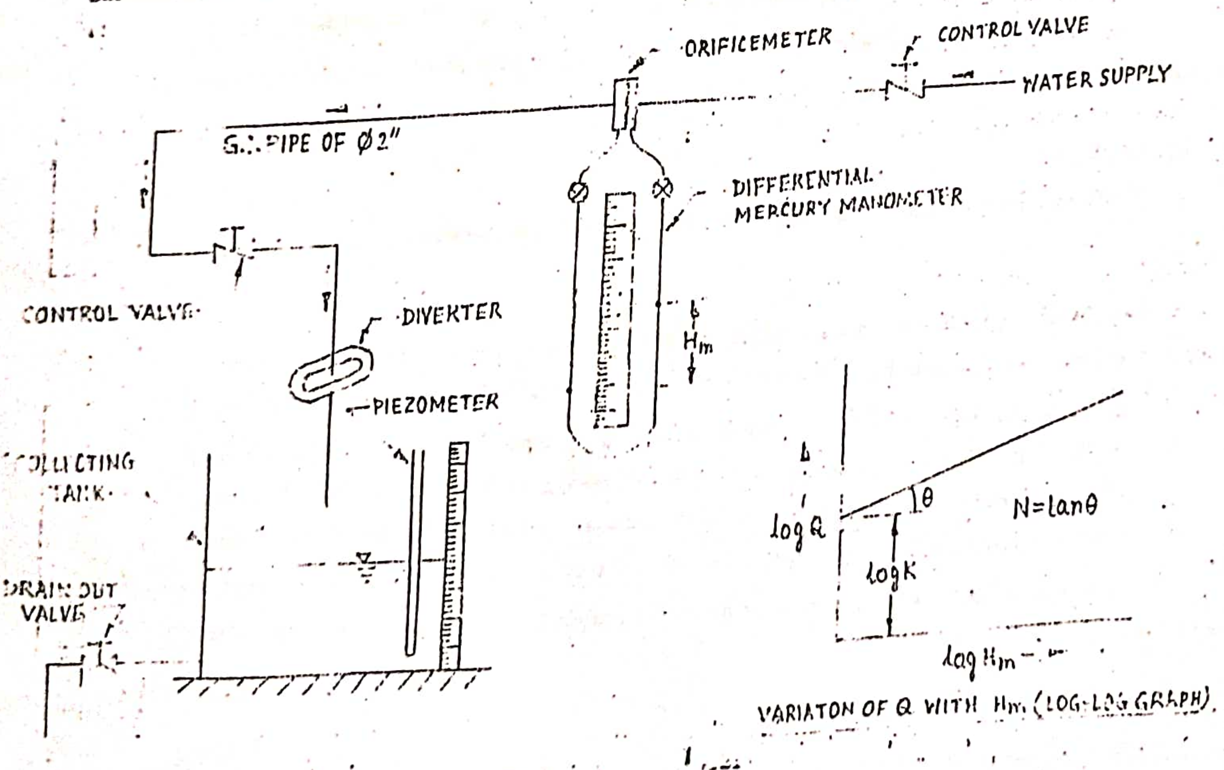
Room temperature, T = °C; kinematic viscosity of water, ν =

Observation No.	Manometer reading(in)		tank reading(in)		Time of collection, t (in)
	LHS (a)	RHS (b)	initial(h_i)	final(h_f)	
At least upto 6					

*RESULT SHEET**:*

Set No.	Manometer deflection, H_m=(a)-(b) (in)	$H=(h_f - h_i)$ (in)	$Q_a=v/t$ $=(A\times H)/t$ (in)	$Q_t=A_1A_2 \times\sqrt{(2gh)}/\sqrt{(A_1^2-A_2^2)}$ (in)	$C_d=Q_a/Q_t$	$R_e=V_2D_2/\nu$ $=(Q_a/A_2)\times(D_2/\nu)$
1, 2 etc.						

*Show the sample calculation of at least one set. Calculate average value of C_d.



LINE DIAGRAM OF THE EXPERIMENTAL SET UP
FOR THE CALIBRATION OF ORIFICEMETER

CALIBARATION OF V-NOTCH

OBJECTIVE:-

1) To determine the v-notch constant (K&N) from plotting of Q_a Vs H on a Log-log graph paper.
2) To determine coefficient of discharge C_d of the V- notch.

(ALL the notations carry the usual meaning and the quantities are in S.I units unless otherwise mentioned)

THEORY:-

For measuring flow through open channels notches or weirs are used .In laboratory experiments, where amount of flow is relatively small, discharge is generally measured by V-notch .Without considering the approach velocity, theoretical discharge through V-Notch is given by

$$Q_t = {}^8/_{15}\sqrt{2g}\tan{}^{\theta}/_2\ H^{5/2}$$

Where θ is the angle of notch & H is the height of water surface from crest –level .But depending on shape of the notch and its friction actual discharge Q_a is smaller than Qt and is given by $Q_a=C_d X Q_t$ where discharge coefficient C_d is always lesser than unity .For practical use ,

$Q_a=C_d \times {}^8/_{15}\sqrt{2g}\tan{}^{\theta}/_2\ H^{5/2}$ is reduced to $Q_a=KH^N$ where $K={}^8/_{15}C_d\sqrt{2g}\tan{}^{\theta}/_2$ & $N=5/2$.

In the experiment ,Q_a is calculated from collecting tank method .So the V-Notch is to be calibrated means that constant K & N of the notch are to be determined experimentally. In its logarithm, the V-Notch discharge equation $Q_a=K\ H^N$ takes the form of log Q_a = N log H+ log K. When plotted Q_a Vs H represents a straight line on a log-log graph paper and the values of K & N may be determined from the graph.

APPARATUS & INSTRUMENTS

Pipe line assembly with water supply by electrical pump and motor. Collecting tank, V-notch, pointer gauge.

PROCEDURE

Delivery value was fully opened. For the first set of observations, the control valve was so regulated that maximum flow was allowed in the channel and level difference 'H' reached maximum.The final pointer gauge reading h_f at free water surface in the channel were noted. Initial & Final reading of pizometer also noted. For the next set,

flow in channel was decreased by the control valve and the corresponding reading were noted .The procedure was repeated for obtaining at least six set of observations.
At last, initial pointer gauge reading h_i (common for all sets) was noted when the water surface touched the crest of the V-notch.

OBSERVATION

Collecting tank area (A) =

Observation No:- (at least six sets)	Pointer gauge reading in( )		Pizometer reading in( )		Water collection time in second (T)
	Initial(h_i)	Final(h_f)	Initial(a)	Final(b)	

RESULT SHEET

Set No:- (1,2,3....etc.)	Pizometer Level Diff. h=b-a	$Q_a=\frac{Ah}{T}$	$H=h_i-h_f$	$Q_t={}^{8}/_{15}\sqrt{2g}\tan{}^{\theta}/_{2}\ H^{5/2}$	$C_d=Q_a/Q_t$	Average C_d

***SHOW THE SAMPLE CALIBRATION OF AT LEAST ONE SET**

Impact of Jet.

Length of the Collecting tank (L) = cm.

Width of the collecting tank (B) = cm.

Diameter of the nozzle exit (d) = cm. (10 mm)

Angle of difflection of jet (θ) = 180°

Density of the working fluid (Water) (ρ) = kg/m³ 1000

Weight of the ~~vane set up~~ Hemispherical/Flat vane. (W_v) = gm. 44 gm.

weight of the weight pan + Rod. (W_p) = gm. 261 gm.

OBSERVATION CHART:-

Obsv. No.	Piezometer Reading.		Time of Water collection (t) (sec.)	Weight on the weight pan. W (gm)
	Initial reading (h_i), cm	Final reading (h_f) cm		
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				

RESULT SHEET:-

$\Delta h = h_f - h_i$ cm.

* Height of the water collected

Obs. No	* Δh ($h_f - h_i$)	Discharge Q (m³/sec)	jet velocity V. (m/sec).	Theoritical Force of Impact F_{th} (N)..	Actual Force. F_a (N)	Coefficient of Impact of Jet (C_j).

Sample Calculation:

Area of the collecting tank $A = L \times B = 756.36$ cm^2.

Volume of water collected $V = A\,\Delta h$ $= 10967.22$ cm^3.

Discharge $Q = \dfrac{\text{Volume of water Collected } (V)}{\text{Time of collection of water} (t)} = 548.36$ cm^3/sec.

~~jet velocity~~

Area of nozzle opening $(a) = \dfrac{\pi d^2}{4} = 0.785$ cm^2

∴ Jet velocity $(V) = \dfrac{Q}{a} =$ m/sec.

Theoritical Force $F_{th} = \underline{\rho Q V(1-\cos\theta)}$ N

$=$ N.

Actual Force $F_a = (W_v + W_p + W)g =$ N ~~kg~~

$\therefore C_j = \dfrac{F_a}{F_{th}}$.

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1) Title.
2). ~~Obj~~ Objectives.
3). Theory.
4). Set up.
5). Obs. Sheet.
~~7~~ Sample Col.
~~6~~ Result sheet.
8 Conclusion.

CALIBRATION OF VENTURIMETER

OBJECTIVE:

1) To determine the venturimeter-constants (K & N) from plotting of Q_a vs. H_m on log-log graph paper;

2) to determine coefficient of discharge C_d of venturimeter and to plot C_d vs. R_e on semi-log graph paper.

All notations carry their usual meanings and the quantities are in SI units unless otherwise mentioned.

THEORY:

A venturimeter is used to measure the flow-rate in a pipeline quite accurately. Theoretical discharge through a venturimeter is expressed as $Q_t=A_1A_2\sqrt{(2gh)}/\sqrt{(A_1^2-A_2^2)}$ where A_1 and A_2 are cross-sectional areas of pipeline and venturimeter-throat respectively, and h is differential head across sections 1 & 2 (in figure) in terms of flowing liquid. If head h is measured by a differential manometer with a heavier liquid of sp. gr. S_m (than flowing liquid of sp. gr. S) then $h=H_m(S_m/S-1)$. But, actual discharge Q_a is smaller than theoretical discharge Q_t and is given by $Q_a=C_d\times Q_t$ where discharge-coefficient C_d depends on roughness etc. and is always lesser than unity. For all practical purposes expression $Q_a=C_dA_1A_2\sqrt{[2g\{H_m(S_m/S-1)\}]}/\sqrt{(A_1^2-A_2^2)}$ is reduced to $Q_a=K(H_m)^N$ where, $K=C_dA_1A_2\sqrt{[2g\{(S_m/S-1)\}]}/\sqrt{(A_1^2-A_2^2)}$ and $n=1/2$. So, the venturimeter is to be calibrated means its constants, K & N, are to be determined experimentally. Now, the discharge equation $Q_a=K(H_m)^N$, in its logarithm, takes the form of : $\log Q_a=N\log H_m+\log K$. When plotted, Q_a vs. H_m represents a straight-line on a log-log graph paper and K & N may be determined from it. Reynolds No. is given by $R_e=V_2D_2/\nu$, subscript 2 representing throat-section.

APPARATUS & INSTRUMENTS:

Pipe line assembly with venturimeter fitted with mercury-manometer, volumetric tank, stop watch etc.

PROCEDURE:

Delivery valve was fully opened. For the first set of observations, control valve was so regulated that maximum flow was allowed in the pipeline and level difference H_m in the venturimeter-manometer reached maximum. Manometer reading was noted. Water coming out of the pipe was stored in a collecting tank during some time interval t which was noted through a stop-watch. Height of the collected water H was noted through a piezometer tube fitted to the tank. The volume of collected water v was then obtained from the product of H multiplied by the area of the tank A. Actual discharge through the orifice Q_a could then be calculated from $Q_a=v/t$. For the next set, flow in pipeline was decreased by control-valve and corresponding readings at tank, stop watch and manometer were noted. The procedure was repeated for obtaining, at least, six sets of observations.

OBSERVATION:

Cross-sectional area of flow in pipe, $A_1 = (\pi D_1^2)/4$

Cross-sectional area of venturimeter throat, $A_2 = (\pi D_2^2)/4$

Specific gravity of manometric liquid, S_m=

Area of the collecting tank, A = (length × breadth) =

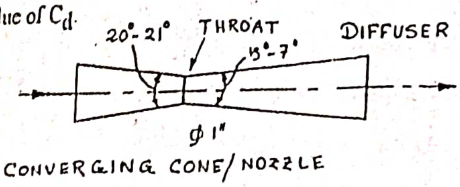
Room temperature, T = ^oC; Kinematic viscosity of water, ν =

Observation No.	Manometer reading(in)		tank reading(in)		Time of collection, t (in)
	LHS (a)	RHS (b)	initial(h_i)	final(h_f)	
At least upto 6					

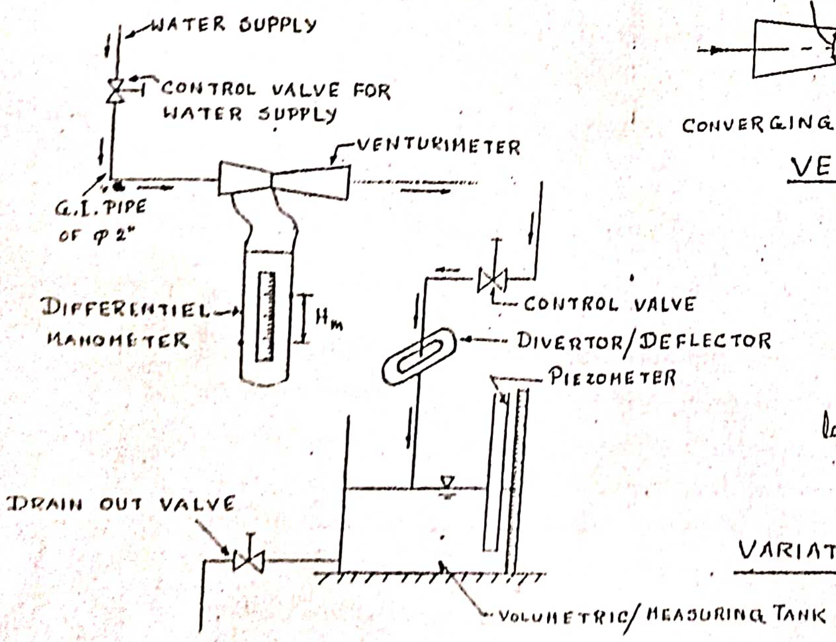
RESULT SHEET:*

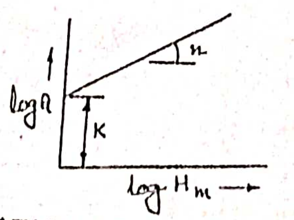
Set No.	Manometer deflection, H_m=(a)-(b) (in)	$H=(h_f - h_i)$ (in)	Q_a=v/t =(A×H)/t (in)	$Q_t=A_1A_2 \times\sqrt{(2gh)}/\sqrt{(A_1^2-A_2^2)}$ (in)	$C_d=Q_a/Q_t$	$R_e=V_2D_2/\nu$ $=(Q_a/A_2)\times(D_2/\nu)$
1, 2 etc.						

*Show the sample calculation of at least one set. Calculate average value of C_d.



VENTURIMETER





VARIATION OF Q WITH H_m

LINE DIAGRAM OF THE EXPRIMENTAL SET UP FOR THE CALIBRATION OF VENTURIMETER