Internal Marks: 25 L T P
External Marks: 25 0 0 2
Total Marks: 50

1. To determine the met centric height of a floating body
2. To Verify Bernoullis Theorem
3. To Determine The Discharge Coefficient For Orifice Meter
4. To Determine The Coefficient Of Discharge For A Vee-Notch Or Rectangular Notch
5. To Find Critical Reynolds Number For a Pipe Flow
6. To Determine The Discharge Coefficient For Venturi Meter Meter
7. To Determine The Friction Factor For The Pipes.
8. To Determine The Minor Losses Due To Sudden Enlargement, Sudden Contraction And Bends.
9. To determine the coefficient of discharge, contraction & velocity of an orifice.
10. To determine the coefficient of impact for vanes.

Theory

A body floating in a fluid is subjected to the following system of forces:

1. The downward force of gravity acting on each particle that goes to make up the weight of body, W_e acting through centre of gravity G.

2. The upward buoyant force of the fluid acting on the various elements of the submerged surface of the floating body FB, acting through centre of buoyancy B

For a body to be in equilibrium on the liquid surface, the two forces W_c *and* F_n must lie in the same vertical line i.e. these two forces must be collinear, equal and opposite.

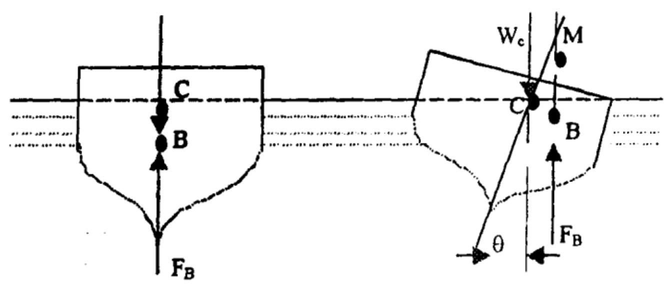

Fig. 1 (a) Fig. 1 (b)

When the vessel has been tilted through an angle θ, the centre of gravity C of the body G, is usually remains unchanged in its position, but B i.e. centre of buoyancy will generally change its position, thus W_c and F_B forms a couple. The line of action of F_B in the new position cuts the axis of the body at M, which is called the metacentre and the distance CM is called the metacentric height. The metacentric height is a measure of the static stability of the floating bodies. The metacentric height can be obtained by equating righting couple and applied moment

$$= \frac{W_m \times X_d}{(W_c + W_m)\tan\theta}$$

where, Wc is the weight of vessel, Wm the weight of unbalanced mass causing moment on the body, Xd is the distance of the unbalanced mass from the centre of the cross bar.

Objective

To determine experimentally the metacentric height of a flat bottomed pontoon.

3.0 EXPERIMENTAL SET UP:

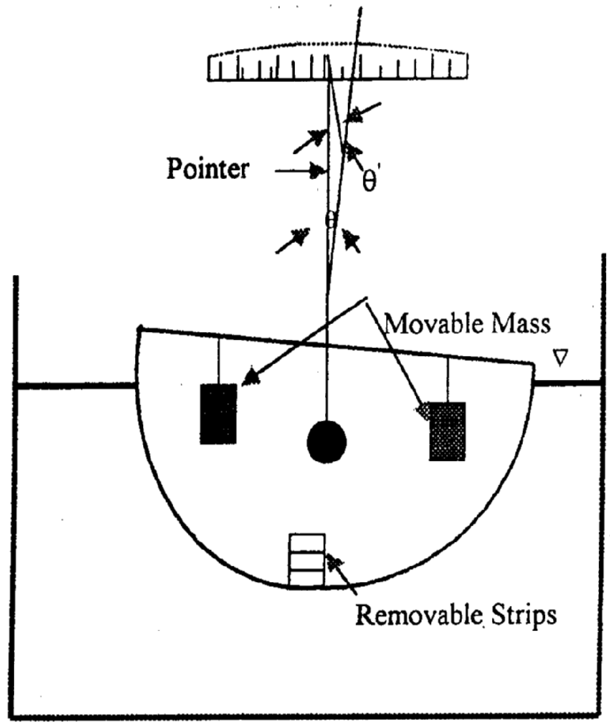

Fig: Flat Bottomed Vessel

The experimental set up consists of a pontoon (flat bottomed vessel), which is allowed to float in a M. S. tank having a transparent side. Removable steel strips are placed in the model for the purpose of changing the weight of the vessel. By means of a pendulum (consisting of a weight suspended to a long pointer), the angle of tilt θ can be measured on a graduated arc, For tilting the ship model a cross bar with two movable hangers is fixed on the model. Pendulum and graduated arc are suitably fixed at the centre of the cross bar.

Suggested Experimental Work:

Step1: Note down the relevant dimensions as area of collecting tank, mass density of water etc.
Step2: Note down the water level in the tank when pontoon is not in the tank.
Step3: Pontoon is allowed to float in the tank. Note down the reading of water level in the tank. Mass of pontoon can be obtained by the help of Archmidie's principle.
Step4: Position of unbalanced mass, weight of unbalanced mass and the angle of heel can be noted down. Calculated the metacentric height of the pontoon.
Step5: The procedure is repeated for other positions and value of unbalanced mass.
Step6: Also the above procedure is repeated while changing the weight of the pontoon by changing the number of strips in the pontoon.

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Sample Data Sheet:

Area of tank, A (cm2) =
Water level (without pontoon), Y1 (cm) =
Unit weight of water w =

Run No.	Reading on tank with pontoon Y_2 (cm)	Mass of pontoon $W_C=(Y_2-Y_1)Aw$ (gm)	Unbalanced mass W_m (gm)	Angle of heel θ (degree)	Distance of unbalanced mass X_d (cm)	Metacentric height (cm) $\frac{W_m X_d}{(W_C+W_m)\tan\theta}$	Average

Precautions:

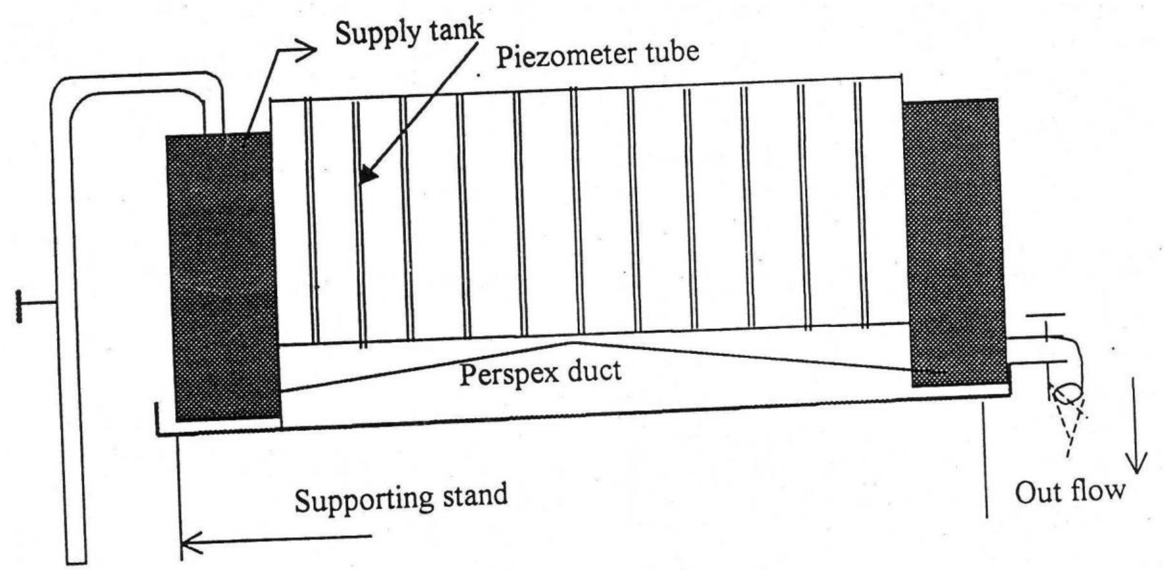
- Apparatus should be in leveled condition.
- Reading must be taken in steady condition of water.
- Unbalanced mass should be measured by taking care that water disturbance should be minimum.

Results & Discussions:

1. Fill up the data sheet.
2. Find the metacentric height of the flat bottomed vessel.

Objective : To verify the Bernoulli's Theorem Experimentally.

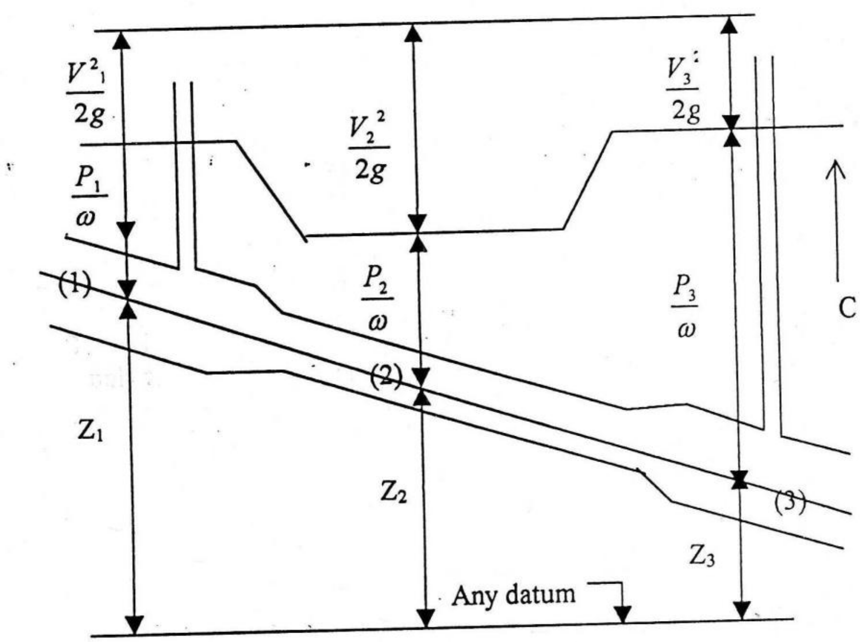
Experimental Set-Up :



The experimental set up consists of a horizontal Perspex duct of smooth variable cross section of convergent and divergent type. The section is 40mm x 40mm at the entrance and exit and 40mm x 20mm at middle. The total length of duct is 90 cm. The piezometric pressure P at the locations of pressure tappings is measured by means of 11 piezometer tubes installed at an equal distance of 7.5 cm long the length of conduit. The duct is connected with supply tanks at its entrance and exit end with means of varying the flow rate. A collecting tank is used to find the actual discharge.

Theory :

Considering friction less flow along a variable area duct the law of conservation of energy states "for an in viscid incompressible, irrotational and steady flow along a stream line the total energy (or head) remains the same". This is called Bernoulli's equation.



The total head of flowing fluid consists of pressure head, velocity head and elevation head. Hence

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2$$

Where P, V and Z refer to the pressure, velocity and position of the liquid relative to some datum at any section.

Suggested Experimental Work :

Step 1: Note down the piezometers distance from inlet section of the Perspex duct.

Step 2: Note down the cross sectional area of Perspex duct at each of the piezometer tapping points.

Step 3: The datum head is treated as constant through out the duct.

Step 4: By maintaining suitable amount of steady head or near by study head conditions in the supply tanks there establish a steady non uniform flow in the conduit.

Step 5: The discharge flowing in the conduit is recorded together with the water levels in each piezometer tubes.

Step 6: This procedure is repeated for other value of discharge.

Results And Discussions :

1. If V is the velocity of flow a particular section of the duct and Q is the discharge, then by continuity equation.

$$V = \frac{Q}{\text{Area of section}}$$

2. Calculate velocity head and total head.
3. Plot piezometric head (P/ω + Z), velocity head ($V^2/2g$), total head (P/ω + Z+$V^2/2g$) v/s distance of piezometer tubes from same reference point.

Sample Data Sheet :

Area of collecting tank, cm A = 40 x 40 cm^2
Increase in depth of water, cm = 14.5 cm
Time, sec = 15 sec
Discharge, cm^3/sec = $\frac{40x40x14.5}{15}$ m^2/s

Tube No.	Distance from inlet section (cm)	Area of c/s of conduit A (cm2)	Velocity of flow (cm/sec) V= (Q/A) cm/sec	$V^2/2g$ (cm)	P/ω + Z (cm)	P/ω +Z+$V^2/2g$ (cm)
1.	7.5	14.67			22.3	
2.	15.0	13.33			20.5	
3.	22.5	12.0			18.2	
4.	30.0	10.67			16.0	
5.	37.5	9.33			12.8	
6.	45.0	8.0			9.5	
7.	52.5	9.33			10.6	
8.	60.0	10.67			12.9	
9.	67.5	12.0			14.2	
10.	75.0	13.33			15.4	
11.	82.5	14.67			16.4	

Comments :

Since the conduit is horizontal, the total energy at any section with reference to the datum line of the conduit is the sum of P/ω and $V^2/2g$ (here ω is the weight density of the fluid and g is the acceleration due to gravity). One can compare the values of the total energy at different sections and comment about the constancy of energy in converging and diverging conduit.

Precautions :

- Apparatus should be in leveled condition.
- Reading must be taken in steady or near by steady conditions and it should be noted that water level in the inlet supply tank should reach the overflow condition.
- There should not be any air bubble in the piezometer and in the Perspex duct.
- By closing the regulating valve, open the control valve slightly such that the water level in the inlet supply tank reaches the overflow conditions. At this stage check the pressure head in each piezometer tube is equal. If not adjust the piezometers to bring it equal.

Theory

Orificemeter are devices used for measurement of rate of flow of fluid through a pipe. The basic principle on which orificemeter works is that by reducing the cross- sectional area of flow passage, a pressure difference is created and the measurement of the pressure difference enables the determination of the discharge through the pipe.

An orificemeter is a cheaper arrangement for measurement of discharge through pipes and its installation requires a smaller length as compared with other flow. The opening in the form of orifice is provided at the centre of the plate.

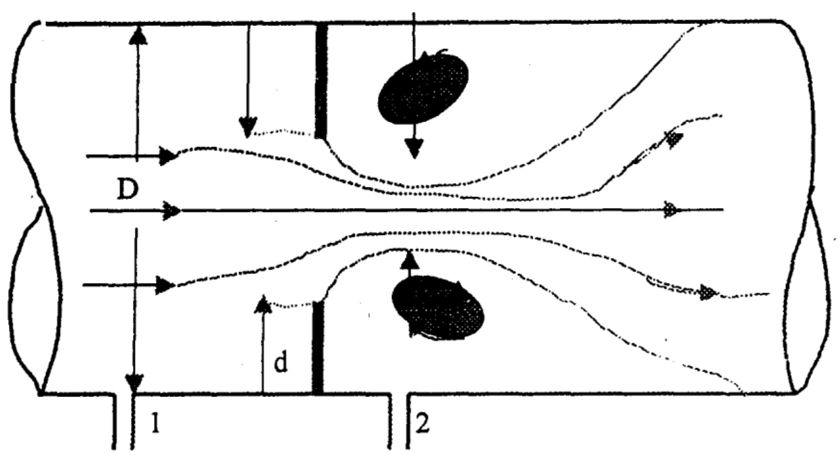


Fig. Orifice Meter

An orifice meter consists of a flat circular plate with a circular hole called orifice with is concentric with the pipe axis. The upstream face of the plate is be leveled at an angle lying between 30^0 and 45^0. The plate is clamped between the two pipe flanges with be leveled surface facing downstream. Two pressure tappings are provided one on the upstream side of plate and other on the downstream side of the orifice plate. The pressure difference exists between two sections which, can be measured by connecting a differential manometer to the two pressure taps.

The discharge coefficient can be calculated using formula.

$$Q = \frac{C_d a_b a_1 \sqrt{2g\Delta h}}{\sqrt{a_1^2 - a_0^2}}$$

Where C_d is coefficient of orifice, a_0 is cross- sectional area of orifice, a_1 is cross-sectional area of pipe, g is the acceleration due to the gravity and z h is the difference of head in terms of water.

The value of C_d, in general, depends on the shape of the orifice, d/D, location of pressure tappings (1) and (2), and the Reynolds number, R_e Since the first three parameters are fixed in an experimental set- up in a laboratory, C_d can be said to depend only on the Reynolds number. The Reynolds number is defined as equal to Vd/v where V is the velocity of flow at tile orifice (=Q/a). It should also be noted that C_d attains a constant value at higher Reynolds number (greater than 10^5).

Experimental Set Up

The experimental set up consists of a circuit through which the water is circulated continuously. The circuit is having two parallel pipelines of 25 mm diameter. A pipeline is connected with a venturimeter while other is connected with a orificemeter. Venturimeter and orificemeter are having a d/D =0.6 and are provided with two pressure tappings one at upstream and other at downstream side (or throat). An U tube differential manometer is provided to measure the pressure difference between two sections of venturimeter and orificemeter. A regulating valve is provided on the downstream side of each pipe to regulate the flow. A collecting tank is used to find the actual discharge through the circuit.

Suggested Experimental Work

Step1: Note down the relevant dimension as diameter of the pipe, diameter of orifice/throat, area of collecting tank, room temperature etc.

Step2: Regulating valve of a pipeline is kept open while for other it is closed.

Measurement Of Flow By Orificemeter

Step8 : Pressure tappings of a orificemeter are kept open while for venturimeter are kept closed.

Step9 : Open the inlet flow control valve and regulate the valve to allow a steady flow through the pipe. Check if there is any air bubble in the manometer tube. If so, remove the same.

Step10: The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non-uniform flow in the circuit. Time is allowed to stabilize the levels in the manometer tube.

Step11: The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.

Stepl2: The flow rate is reduced in stages by means of flow control valve and the discharge & readings of manometer are recorded for every stage.

Sample Data Sheet

Name of Experiment: **Measurement of flow by venturimeter and orificemeter**.

Name of the student: Semester Batch Session

Type of flowmeter =
Diameter of pipe line, D, cm =
Cross sectional area of the pipe line, A, cm^2 =
Diameter of throat/orifice section, d, mm =
Cross sectional area of the throat/orifice section, a, cm^2 =
Area of collecting tank, a', cm^2 =
Temperature of water, °C =
Kinematic viscosity of water,v, m^2/sec =

Run No.	Discharge Measurement				Manometer Reading			C_d	R_e =
	Initial (cm)	Final (cm)	Time (sec)	Discharge Q (cm^3 / sec)	Left limb h_1 (cm)	Right Limb h_2 (cm)	Diff. Of Head $h = 12.6(h_1-h_2)$ (cm)		Q d a v

Appendix-1: Critical data of experiment

Diameter of pipe line, ID, cm = 2.5
Cross sectional area of the pipe line, A, cm^2 = 4.9086
Diameter of throat/orifice section, d, cm = 1.5
Cross sectional area of the throat/orifice section, a, cm^2 = 1.767

Results & Discussions

1. Fill up the data sheet.
2. Calculate the discharge, difference of manometer reading and C_d for different sets of readings for orificemeter.
3. Plot Q v/s Δh on a log graph paper and fit in a straight line for the plotted points. This is the calibration curve.
4. Plot C_d v/s R_e for the observed data.

Precautions

• Remove all entrapped air from two limbs of manometer.
• Maintain constant discharge for one set.
• Take a number of readings to obtain accurate result.

<u>Objectives</u> : Determination of discharge coefficient of :

- 90^0 V-notch
- Rectangular notch

<u>Experimental Set Up</u> :

The experimental set up consists of a tank whose inlet section is provided with 2 nos. of baffles for streamline flow, while at the downstream portion of the tank one can fix a notch of either rectangular or V-notch. A point gauge is used to measure the head of water over the model. A collecting tank is used to find the actual discharge through the notch.

<u>Theory</u> :

Different types of models are available to find discharge in an open channel as notch, venturiflume, weir etc. For calibration of rectangular notch, trapezoidal notch or v notch some flow is allowed in the flume. Once the flow becomes steady, uniform discharge coefficients can be determined for any model.

In general, sharp crested notches are preferred where highly accurate discharge measurements are required. For example in hydraulic laboratories, industry and irrigation pilot schemes, which do not carry debris and sediments.

Notches are those overflow structures whose length of crest in the direction of flow is accurately shaped. They may be rectangular, trapezoidal, v notch etc. The V-notch is one of the most precise discharge measuring device suitable for a wide range of flow. Making the following assumptions as to the flow behaviour can develop the relationship between discharge and head over the weir :

a) Upstream of the weir, the flow is uniform and the pressure varies with depth according to the hydrostatic equation p = pgh
b) The free surface remains horizontal as far as the plane of the weir, and all particles passing over the weir move horizontally.
c) The pressure through out the sheet of liquid or nappe, which passes over the crest of the weir, is atmospheric.
d) The effect of viscosity and surface tension are negligible.
e) The velocity in the approach channel is negligible.

A triangular or V notch is having a triangular or V shaped opening provided in its body so that water is discharged through this opening only. The line which bisects the angle of the notch should be vertical and at the same distance from both sides of the channel. The discharge coefficient C_d of a V notch may be determined by applying formula.

$$Cd = \frac{Q}{\frac{8}{15}\sqrt{2g}H^{5/2}\tan\theta/2}$$

Where Q is the discharge over a triangular notch, θ is the apex angle of notch and H is head over the crest of the notch.

A rectangular notch, symmetrically located in a vertical thin plate, which is placed perpendicular to sides and bottom of a straight channel, is defined as rectangular sharp crested weir. The discharge coefficient Cd of a rectangular notch may be determined by applying formula.

$$Cd = \frac{Q}{\frac{2}{3}\sqrt{2g}\,BH^{3/2}}$$

Where Q is the discharge over a rectangular notch, B is the width of notch, H is the head over the crest of the notch, and g is acceleration due to gravity.

Suggested Experimental Work :

Step 1 : The notch under test was positioned at the end of the tank, in a vertical plane, and with the sharp edge on the upstream side.

Step 2 : The tank was filled with water up to the crest level and subsequently note down the crest level of the notch by the help of a point gauge.

Step 3: The flow regulating valve was adjusted to give the maximum possible discharge without flooding the notch.

Step 4: Conditions were allowed to steady before the rate of discharge and H were taken.

Step 5: The flow rate is reduced in stages and the readings of discharge and H were taken.

Step 6: The above procedure is repeated for other type of notch.

Results And Discussions :

1. Note down the apex angle of V notch and width of the Rectangular notch.
2. Calculate the discharge and head over the notch.
3. Find out the coefficient of discharge Cd of each notch.

S.No.	Discharge Measurement				Final reading of water level above the notch H_2 (cm)	Head over notch $H = H_1 - H_2$ (cm)	$C_d = \dfrac{Q}{\frac{8}{15}\sqrt{2g}\, H^{5/2} \tan \phi/2}$
	Initial h_1 (cm)	Final h_2 (cm)	Time (sec)	Discharge Q (cm^3/sec)			

Sample Data Sheet :

(a) Triangular or V notch

Apex angle of notch, ϕ =

Crest level of V notch , H_1, cm =

Area of collecting tank, a, cm^2 =

Average C_d =

(b) Rectangular notch

Width of notch, B cm =

Crest level of notch, H_1 cm =

Area of collecting tank, a cm^2 =

S. No.	**Discharge Measurement**				**Final reading of water level above the notch H_2 (cm)**	**Head over notch $H = H_1 - H_2$ (cm)**	$C_d = \dfrac{Q}{\frac{2}{3}\sqrt{2g}\,BH^{3/2}}$
	Initial h_1 (cm)	**Final h_2 (cm)**	**Time (sec)**	**Discharge Q (cm^3/sec)**			

Average C_d =

Precautions :

- Reading must be taken in steady or near steady conditions.
- For the measurement of correct discharge there must not be any leakage near the notch and take care that notch is not running in overflow conditions.
- For measurement of correct head over the notch the point gauge must be installed little distance away from the crest of the notch.
- Discharge must be varied very gradually from a higher value to smaller values.

Theory :

Depending upon the relative magnitudes of viscous and internal forces, flow can occur in two different manner viz. Laminar flow and turbulent flow. In laminar flow viscous effect are more predominant than the internal effects. But when shear and normal stresses are added with the increase in velocity of flow the flow is turbulent. To identify the laminar and turbulent ranges of flow a dimensionless parameter is being utilizes which is a measure of the relative importance of inertial forces and viscous force prevailing in the flow of a fluid, which is known as Reynolds number. It is equal to the ratio of the inertial forces to the viscous force per unit volume. This mean that a large value of Reynolds's number signifies less viscous effects and vice versa. For determine the different flow conditions, equipment first used by professor Osborne Reynolds after whose name Reynold's number (Re) exists.

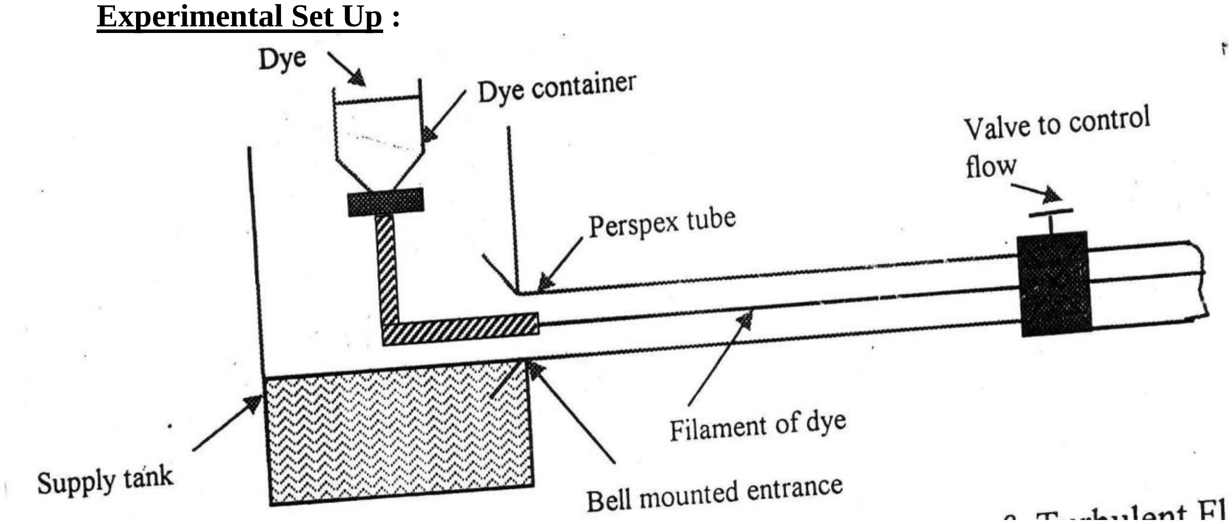
The motion is laminar or turbulent according as the value of Re is less than or greater than a certain value. If a liquid such as water is allowed to flow through a glass tubes, and if one of the liquid filament is made visible by means of dye, then by watching this filament we may get insight into the actual behavior of the liquid as it moves along. After the water in the supply tank has stood for several hours to allow it to come completely to rest. The outlet valve is slightly opened. The central thread of dye carried along by the slow stream of water in the glass tube is seen to be nearly as steady and well defined as the indicating column in an alcohol thermometer. But when, as a result of further opening of the valve, the water velocity passes a specific limit, a change occurs, the rigid thread of dye begins to break up and to group momentarily ill-defined. The moment the dye deviates from its straight line pattern corresponds to the condition when the flow in the conduit is no longer in laminar conditions. The discharge, Q flowing in the conduit at this moment is measured and the Reynolds number = $\frac{4Q}{\pi d v}$

(in which d is the diameter of the conduit and ν is the kinematics viscosity of water) is computed. This is the lower critical Reynolds number. Finally, at high velocities the dye mixes completely with the water and the colored mixture fills the tube.

Objectives :

1. To study different flow conditions.
2. To obtain the Reynolds number in different flow conditions.

Experimental Set Up :



Apparatus consist of storage cum supply tank, which has the provision for supplying coloured dye through jet. A Perspex tube is provided to visualize the different flow condition. The entry of water in Perspex tube is through elliptical bell mouth to have smooth flow at the entry. A regulating valve is provided on the downstream side of the tube to regulate the flow. The discharge must be varied very gradually from a smaller to larger value. A collecting tank is used to find the actual discharge through the Perspex tube.

Suggested Experimental Work :

Step 1 : Note down the relevant dimensions as diameter of Perspex tube, area of collecting tank, room temperature etc.

Step 2 : By maintaining suitable amount of steady flow in the Perspex tube, open inlet of the dye tank so that the dye stream moves as a straight line in the tube.

Step 3 : The discharge flowing in the Perspex tube is recorded.

Step 4 : This procedure is repeated for other values of discharge.

Step 5 : By increasing the velocity of flow in the Perspex, tube, again open the inlet of the dye tank so that the dye stream begins to break up in the tube, which shows the fluid is no more in the laminar conditions. Hence transition stage occurs.

Step 6 : The discharge flowing in the Perspex tube is recorded.

Step 7 : This procedure is repeated for other values of discharge.

Step 8 : On further increase in the velocity of flow in the Perspex tube, again open the inlet of dye tank so that the dye mixes completely in the tube which shows fluid is no more in the transition stage. Hence turbulent flow occurs in the tube.

Step 9 : The discharge flowing in the Perspex tube is recorded.

Step 10 : This procedure is repeated for other values of discharge.

Results And Discussions :

Calculate the discharge in different flow conditions.

Also calculate the Reynolds number for different flow conditions.

Sample Data Sheet :

Inner diameter of conduit, D, mm = 2.5 cm

Room Temperature, θ, ^{0}C =

Kinematics viscosity of water, ν, cm^2/ sec = 1x10^{-2} cm^2/sec

Area of collecting tank, cm^2 = 40x30= 1200 cm^2

S.No.	**Discharge Measurement**				
	Initial (cm)	Final (cm)	Time Taken	Discharge Q (cm^3/sec)	

Theory

Venturimeter are devices used for measurement of rate of flow of fluid through a pipe. The basic principle on which venturimeter works is that by reducing the cross- sectional area of flow passage, a pressure difference is created and the measurement of the pressure difference enables the determination of the discharge through the pipe.

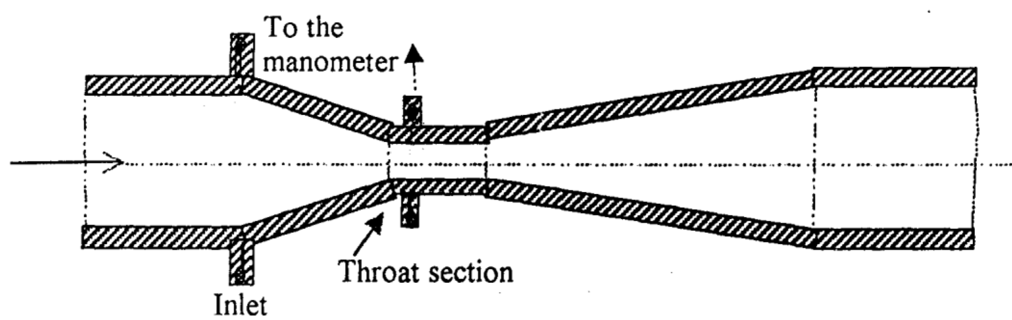


Fig. Venturimeter

A venturi meter consists of (1) an inlet section followed by a convergent cone, (2) a cylindrical throat and (3) a gradually divergent cone. Since the cross-sectional area of the throat is smaller than the cross sectional area of the inlet section, the velocity of flow at the throat will become greater than that at the inlet section, according to continuity equation. The increase in the velocity of flow at the throat results in the decrease in the pressure at this section. A pressure difference is created between the inlet section and throat section which can be determined by connecting a differential U- tube manometer between the pressure taps provided at these sections. The measurement of pressure difference between these sections enables the rate of flow of fluid **(Q)** to be calculated as

$$Q = C_d \frac{a\sqrt{2g\Delta h}}{\sqrt{1-(a/A)^2}}$$

Where a is the area of cross section of throat, A is the area of cross section of inlet section, g is the acceleration due to the gravity, Δh is the difference of head in terms of water and C_d is the coefficient of discharge of venturi meter.

The coefficient C_d accounts for viscous effects of the flow and depends upon the Reynolds number, R_e (which is equal to V. d/v where, *V=Q/a;* d is the diameter of throat) and the ratio *d/D.* For the given experimental set-up, d/D is fixed. Usually C varies between 0.96 and 0.99 for Reynolds number greater than 10^5

Experimental Set Up

The experimental set up consists of a circuit through which the water is circulated continuously. The circuit is having two parallel pipelines of 25 mm diameter. A pipeline is connected with a venturimeter while other is connected with a orificemeter. Venturimeter and orificemeter are having a d/D =0.6 and are provided with two pressure tappings one at upstream and other at downstream side (or throat). An U tube differential manometer is provided to measure the pressure difference between two sections of venturimeter and orificemeter. A regulating valve is provided on the downstream side of each pipe to regulate the flow. A collecting tank is used to find the actual discharge through the circuit.

Suggested Experimental Work

Step1: Note down the relevant dimension as diameter of the pipe, diameter of orifice/throat, area of collecting tank, room temperature etc.

Step2: Regulating valve of a pipeline is kept open while for other it is closed.

Measurement Of Flow By Venturimeter

Step3: Pressure tappings of a venturimeter are kept open while for orificemeter are kept closed.

Step4: Open the inlet flow control valve and regulate the valve to allow a steady flow through the pipe. Check if there is any air bubble in the manometer tube. If so, remove the same.

Step5: The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non-uniform flow in the circuit. Time is allowed to stabilize the levels in the manometer tube.

Step6: The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.

Step7: The flow rate is reduced in stages by means of flow control valve and the discharge & readings of manometer are recorded for every stage.

Suggested Experimental Work

Step1: Note down the relevant dimension as diameter of the pipe, diameter of orifice/throat, area of collecting tank, room temperature etc.

Step2: Regulating valve of a pipeline is kept open while for other it is closed.

Measurement Of Flow By Venturimeter

Step3: Pressure tappings of a venturimeter are kept open while for orificemeter are kept closed.

Step4: Open the inlet flow control valve and regulate the valve to allow a steady flow through the pipe. Check if there is any air bubble in the manometer tube. If so, remove the same.

Step5: The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non-uniform flow in the circuit. Time is allowed to stabilize the levels in the manometer tube.

Step6: The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.

Step7: The flow rate is reduced in stages by means of flow control valve and the discharge & readings of manometer are recorded for every stage.

Sample Data Sheet

Name of Experiment: **Measurement of flow by venturimeter and orificemeter**.

Name of the student: Semester Batch Session

Type of flowmeter =
Diameter of pipe line, D, cm =
Cross sectional area of the pipe line, A, cm^2 =
Diameter of throat/orifice section, d, mm =
Cross sectional area of the throat/orifice section, a, cm^2 =
Area of collecting tank, a’, cm^2 =
Temperature of water, °C =
Kinematic viscosity of water,v, m^2/sec

Run No.	Discharge Measurement				Manometer Reading			C_d	$R_e =$
	Initial (cm)	Final (cm)	Time (sec)	Discharge Q (cm^3 / sec)	Left limb h_1 (cm)	Right Limb h_2 (cm)	Diff. Of Head $h = 12.6(h_1 - h_2)$ (cm)		$\underline{Q\ d}$ a v

Results & Discussions

1. Fill up the data sheet.
2. Calculate the discharge, difference of manometer reading and C_d for different sets of readings for venturimeter.
3. Plot Q v/s Δh on a log graph paper and fit in a straight line for the plotted points. This is the calibration curve.
4. Plot C_d v/s R_e for the observed data.

Precautions

- Remove all entrapped air from two limbs of manometer.
- Maintain constant discharge for one set.
- Take a number of readings to obtain accurate result.

Theory :
When liquid flows through a pipe under pressure, some head is lost in overcoming the friction between the pipe wall and flowing fluid. The frictional resistance offered to flow depends on type of flow. Mostly the flow of fluids in pipes lies in turbulent zone. On the basis of the experimental observations the laws of fluid friction for turbulent flow are as under:-

The frictional resistance in the case of turbulent flow is

(i) proportional to $(velocity)^n$ where n varies from 1.72 to 2.0.
(ii) independent of pressure
(iii) proportional to density of the flowing fluid.
(iv) slightly affected by variation of temperature of the fluid.
(v) proportional to area of surface in contact.
(vi) dependent on the nature of the surface in contact.

The generally accepted formula governing turbulent flow in pipes may be summarized as follows by Darcy-Weisbach formula for head loss due to friction

$$h_f = \frac{fLV^2}{2gd}$$

$$h_f = \frac{8fLQ^2}{\pi^2 g D^5}$$

Where f is known as friction factor which is dimensions quantity, L is length of pipe, V is mean velocity of flow in pipe, Q is discharge through pipe, g is acceleration due to gravity and D is diameter of the pipe.

Objective :
To Study the variation of friction factor, f for turbulent flow in rough commercial pipes.

Apparatus :
Apparatus consists of a pipe circuit through which five pipes of G.I. of different diameter viz. 15mm, 20mm, 25 mm, 32mm and 40 mm diameter are provided with means of varying flow rate. Each pipe is provided with two pressure tappings at certain distance apart. A u-tube

differential manometer is provided to find the difference of head between two pressure tappings. The tappings may be connected to a manometer turn by turn. A collecting tank is used to find the discharge of water through the pipes.

Suggested Experimental Work :

Step 1 : Note down the relevant dimensions as diameter of the pipe, length of pipe between the pressure tappings, area of collecting tank etc.

Step 2 : Pressure tappings of a pipe are kept open while for other pipes it is kept closed.

Step 3 : Open the inlet flow control valve and regulate the value to allow a steady flow through the pipe. Check if there is any air bubble in the manometer tube. If so, remove the same.

Step 4 : The flow rate was adjusted to its maximum value. By maintaining suitable amount of steady flow or near by steady flow in the pipe circuit, there establishes a steady non uniform flow in the circuit. Time is allowed to stabilize the levels in the manometer tube.

Step 5 : The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.

Step 6 : The flow rate is reduced in stages by means of flow control valve and the discharge & readings of manometer are recorded.

Step 7: This procedure is repeated by closing the pressure tappings of this pipe and for opening of another pipe.

Results & Discussions :

1. Fill up the data sheet.
2. Calculate the discharge, difference of manometer reading and f friction factor for different pipes for different sets of readings.
3. Find the average friction factor ‘f’.
4. The observation shows that the coefficient f is not a constant but its value depends on the roughness condition of the pipe surface and the Reynold’s number of the flow.

Sample Data Sheet:

Name of Experiment : To study the variation of friction factor, f for turbulent flow in the rough commercial pipes.

Name of the student : **Semester** **Batch** **Session**

Diameter of pipe, D, cm =
Length of pipe between two pressure tappings, L, cm
Area of collecting tank, a, cm^2 =
Temperature of water, ^0C =
Kinematic viscosity of water, ν, m^2/sec =
Material of pipe =

Run No.	Manometer readings			Discharge Measurement				
	Left limb h_1 (cm)	Left limb h_2 (cm)	Difference of head in terms of water $h_f = 12.6\ (h_1 - h_2)$	Initial (cm)	Final (cm)	Time (Sec)	Discharge Q (cm^3/sec)	$f = \frac{\pi^2 g D^5}{8\ L Q^2} h_f$
1.								
2.								
3.								

Precautions :

- Apparatus should be in leveled condition.
- Reading must be taken in steady or near by steady conditions.
- There should not be any air bubble in the manometer.
- Discharge must be varied very gradually from a higher to smaller values.

APPROVED BY :-

HOD (M.E. DEPTT.)

Theory :

In long pipes, the major loss of energy in pipe flow is due to friction while the minor losses are those, which are caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). Losses due to change in cross- section, bends, valves & fittings of all types are categorized as minor losses. In short pipes, above losses may sometimes outweigh the friction losses.

The minor energy head lose h_L in terms of the velocity head can be expressed as

$$h_L = k \frac{V^2}{2g}$$

Where, k is loss coefficient, which is practically constant at high Renold's number for a particular flow geometry, V is velocity of flow in the pipe and g is acceleration due to gravity.

However , for sudden enlargement of the section, the simultaneous application of continuity , Bernoulli's and momentum equation shows that

$$h_L = k \frac{(V-V_1)^2}{2g}$$

Where V and V_1 are velocities of flow in the smaller and larger diameter pipes respectively.

Objective :

To determine the minor head loss coefficient for different pipe fittings.

Experimental Set Up :

The experimental set up consists of a pipe circuit of 25 mm diameter fitted with following fittings with means of varying flow rate.

- Large bend
- Sudden enlargement to 50 mm dia
- Small bend
- Sudden contraction from 50 mm dia to 25 mm dia.

Pressure tappings are provided on up stream and down stream ends of each of these fittings to enable the measurement of pressure head difference across the fittings to compute the head loss through the fittings. The pressure tappings are connected to a differential manometer. A collecting tank is used to find the actual discharge of water through the pipe fittings.

Suggested Experimental Work :

Step 1: Note down the relevant dimension of each individual fittings, are of collecting tank etc.

Step 2: Pressure tappings of a fitting are kept open while for other fittings it is kept closed.

Step 3: The flowrate is adjusted to its maximum valve,

Step 4: By maintaining suitable amount of steady flow in the pipe circuit, there establishes a steady non uniform flow in the circuit. Time is allowed to stabilize the levels in the two limbs of manometer.

Step 5: The discharge flowing in the circuit is recorded together with the water levels in the two limbs of a manometer.

Step 6: The flowrate is reduced in stages by means of flow control valve and the discharge & readings of manometer are recorded.

Step 7: This procedure is repeated by closing the pressure tappings of this fitting, together with other two fittings and for opening of another left fitting.

Results And Discussions :

1. Fill up the data sheet.
2. Calculate the discharge, difference of manometer reading and ‘k’ loss coefficient for different pipe fittings for different sets of readings.
3. Find the average loss coefficient ‘k’.

Sample Data Sheet :

Name of Experiment : Apparatus for Determination of Losses in Pipe Fittings

Name of the Student : Semester Batch Session

Diameter of pipe, D cm =

Area of Pipe, a cm^2 =

Area of collecting tank, A cm^2 =

Table -1

<u>Type of fitting</u>

Manometer Reading			**Discharge Measurement**				**V = Q/a (cm/sec)**	**Loss coefficient $K = \frac{2g h_L}{V^2}$**
Left limb h1 (cm)	**Right limb h_2 (cm)**	**Difference of head in terms, of water h_L = 12.6 (h_1-h_2) (cm)**	**Initial (cm)**	**Final (cm)**	**Time (sec)**	**Discharge Q (cm^3/sec)**		

Average loss coefficient , k =

Table-2

<u>Type of fitting</u> : Sudden Enlargement

Diameter of smaller pipe =
Area of smaller pipe, a cm^2 =
Diameter of bigger pipe =
Area of bigger pipe, a_1 cm^2 =
Area of collecting tank, A cm^2 =

Manometer Reading			Discharge Measurement				V = Q/a (cm/sec)	V_1=Q/a_1	Loss coefficient k = 2 g / (V-V_1)
Left limb h_1 (cm)	Right limb h_2 (cm)	Difference of head in terms of water h_L= 12.6 (h_1-h_2) (cm)	Initial (cm)	Final (cm)	Time (sec)	Discharge Q (cm^3/sec)			

Average loss coefficient , k =

Precautions :

- Apparatus should be in leveled condition.
- Readings must be taken in steady or near by steady conditions.
- There should be no air bubble in the manometer.

Theory:

An orifice is an opening in the wall of a tank, while a mouthpiece is a short pipe fitted in the same opening. A mouthpiece will be running full if its length does not exceed two to three times the diameter Both orifice and mouthpiece are used for discharge measurement. The jet approaching the orifice continues to converge beyond the orifice till the streamlines becomes parallel. This section of the jet is then a section of minimum area and is known as vena contracta.

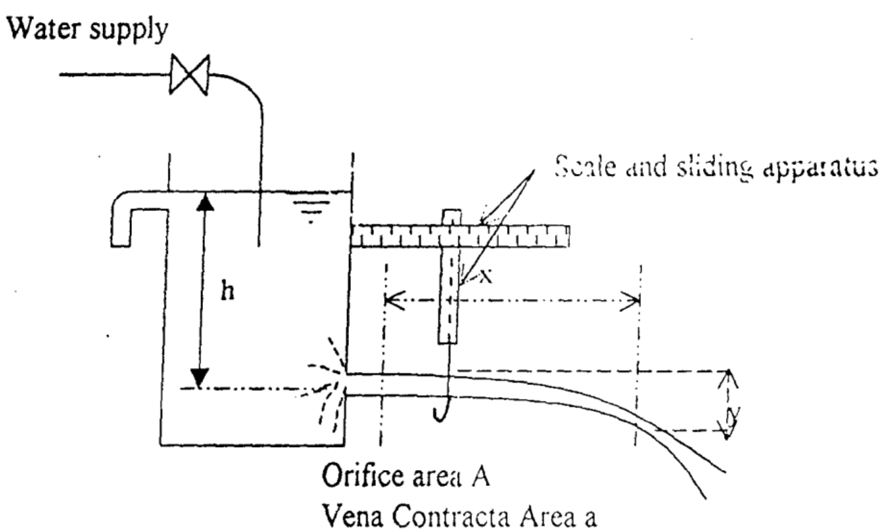


Fig: Experimental set up for Orifice Experiments

If V_c is the true horizontal velocity at the vena contracta, then the properties of jet trajectory give the following relationship:

$$y = \frac{g}{2v_e^2}.x^2$$

$$V_c = \left\{\frac{gx^2}{2y}\right\}^{1/2}$$

The theoretical velocity in the plane of the vena contracta V_o is given by

$$\frac{V_0^2}{2g} = h$$

i.e. $V_o = (2gh)^{1/2}$

Now coefficient velocity C = actual velocity / the critical velocity

$$C_v = \frac{x}{2\sqrt{yh}}$$

In which h is the constant head in the supply tank and x & y are coordinates of jet with respect to centre of opening.

The actual discharge Q when divided by a $\sqrt{2gh}$ yield the coefficient of discharge Cd Here is the area of cross section of the orifice (or the mouthpiece) and g is the acceleration due to gravity.

Once Cd and Cv are known, the coefficient or contraction Cc can be obtained by dividing Cd with Cv

$$Cc = \frac{C_d}{C_F}$$

The coefficient of discharge can be also be computed by falling head method in which the supply is kept closed after filling he tank to a suitable level and fall in the head from h_1 to h_2 in time T is noted. The coefficient or discharge is then obtained from

$$C_d = \frac{2A}{T.a\sqrt{2g}}\left[h_1^{1/2} - h_2^{1/2}\right]$$

Objective:

To determine the coefficients of discharge C_d velocity C_v and contraction C_c of various types of orifices and mouth pieces.

Apparatus:

The experimental set up consists of an supply tank with overflow arrangement and gauge glass tube for water level measurement in the tank, There is also provision for fixing the various orifices and mouthpieces (interchangeable) installed in the vertical plane of the tank side. A set of orifice consisting of 10 mm dia and 15 mm dia orifice is provided with the apparatus. Further a set of mouth piece is also provided which consists of(i) 10 mm dia x 25 mm length, (ii) 10 mm dia x 40mm length, (iii) 10 mm x 25 mm x 25 mm long divergent and (iv) 25x 10 x25 mm long convergent mouthpiece. Arrangement is made such that the water passes only through this attached opening. Water comes out of the opening in the form of jet.

A horizontal scale on which is mounted a vertical scale with a hook gauge is attached to the supply tank. Thus hook gauge can be moved horizontally as well as vertically in x and y direction and its corresponding movement can be read on horizontal and vertical scales respectively. A collecting tank is used to find the actual discharge of water through the jet.

Suggested Experimental Work:

Step1: Note down the relevant dimensions as area of collecting tank and supply tank.

Step2: Attach a orifice mouthpiece and note down its diameter.

Step3: The water supply was admitted to the supply tank and conditions were allowed to steady to give a constant head. The lowest point of the orifice mouthpiece is used as the datum for the measurement of h and y.

Step4: The discharge flowing through the jet is recorded together with the water level in the supply tank.

Step5: A series of readings of dimensions x and was taken along the trajectory of the jet.

Step6: The above procedure is repeated by means of flow control valve.

Step7: The above procedure is repeated for other types of orifice mouthpiece.

Results & Discussions:

1. Fill up the data sheet.
2. Calculate the C_d C_v and C_v

Sample Data Sheet:

Name of Experiment: **Determination of coefficients of discharge C_d, velocity C_v and contraction C_c of various types of orifices and mouth piece.**

Name of the student: Semester Batch Session

Size & shape of the mouth piece/ orifice =
Area of cross- section of mouth piece Orifice, a, cm^2 =
Area of cross section of collecting tank, cm^2 =
Area of cross section of supply tank, A, cm^2 =
Reading on the piezometer at the level on the centre of mouth piece / orifice h_0 =

A. Constant Head Method:

(i) Determination of C_d

Run. No.	Reading on the piezometer a_1 (cm).	Value of h $h = a_1 - h_0$ (cm)	Discharge measurement				$C_d = \frac{Q}{a\sqrt{2gh}}$
			Initial (cm)	Final (cm)	Time (sec)	Discharge Q (cm^3/sec)	

Average C_d =

(ii) Determination of Cv

Reading horizontal scale at exit of orifice/ mouthpiece x_0 =

Reading vertical scale at exit orifice / mouthpiece y_0 =

Run No.	h (cm)	x' (cm)	y' (cm)	$x=x'-x_0$ (cm)	$y=y'-y_0$ (cm)	$C_v = \frac{X}{2\sqrt{yh}}$

Average C_v =

Therefore, C_c = Cd= Cv

B. Falling Head Method:

Reading on the piezometer at the level on the centre of mouth piece/ orifice h_0 =

$$k = \frac{2A}{a\sqrt{2g}}$$

Run No.	Piezometer reading		$h_1=a_1-h_o$ (cm)	$h_2=a_2-h_o$ (cm)	Time in lowering the water T (sec)	$C_d = \frac{k}{T}(\sqrt{h_1} - \sqrt{h_2})$
	Initial a_1 (cm)	Final a_2 (cm)				

Average value of C_d =

Precautions:

1.Apparatus should be in leveled condition

2. Reading must be taken in steady or near by steady conditions. And it should be noted that water level in the inlet supply tank must be constant.
3. There should not be any air bubble in the piezometer.
4. Orifice must be free from dirt and kept clean.

Theory

Momentum equation is based on Newton's second law of motion which states that thealgebraic sum of external forces applied to control volume of fluid in any direction is equal to the rate ofch ange of
momentum in that direction. The external forces include the component of the weight of the fluid & of the
forces exerted externally upon the boundary surface of the control volume. If a vertical water jet moving
with velocity is made to strike a target, which is free to move in the vertical direction then aforce will be exerted on the target by the impact of jet, according to momentum
equation this force (whichis also equal to
the force required to bring back the target in its original position) must be equal to therate of cha nge of momentum of the jet flow in that direction.

Formula Used:

$F=\rho\ Q\ v(1-\cos\beta)$
$F=\rho\ Q2\ \ (1-\cos\beta)/A$ as $v=Q/A$

Where
F =force (calculated)

ρ = density of water
β=angle of vane
V =velocity of jet
Q =discharge
A =area of nozzle($\pi/4d2$)

(i) for flat vane β=90o

$$F' = \rho Q2/A$$

(ii) for hemispherical vane β=180o

for % error =F- F'/ F'x100

F' = 2 ρQ2/A

F = Force (due to putting of weight)

(iii) for inclined vane

F'=ρ Q v(1-cosβ)

F'=ρ Q2 (1-cosβ)/A

Procedure:

1. Note down the relevant dimension or area of collecting tank, dia of nozzle, and density of water.
2. Install any type of vane i.e. flat, inclined or curved.
3. Note down the position of upper disk, when jet is not running.
4. Note down the reading of height of water in the collecting tank.
5. As the jet strike the vane, position of upper disk is changed, note the reading in the scale to which vane is raised.
6. Put the weight of various values one by one to bring the vane to its initial position.
7. At this position finds out the discharge also.
8. The procedure is repeated for each value of flow rate by reducing the water supply.
9. This procedure can be repeated for different type of vanes and nozzle.

Observations & Calculations:

Dia of nozzle =

Mass density of water ρ =

Area of collecting tank =

Area of nozzle =

Horizontal flat vane

When jet is not running, position of upper disk is at =

SNO	Discharge measurement				Balancing		Theoretical Force F'= ρQ2/A	Error in % = F-F'/F'
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm3/sec) Q	Mass W (gm)	Force F		