HYDRAULICS

LABORATORY MANUAL

DEPARTMENT OF CIVILENGINEERING

JORHAT ENGINEERING COLLEGE

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DEPARTMENT OF CIVIL ENGINEERING, JORHAT ENGINEERING COLLEGE

HYDRAULICS LABORATORY

FRICTION LOSSES IN PIPES

THEORY:

Various fluids are transported through pipes. When the fluid flows through pipes, energy losses occur due to various reasons, among which friction loss is the predominant one. Darcy-Weisbach equation relates the head loss due to frictional or turbulent through a pipe to the velocity of the fluid and diameter of the pipe as

$$h_f = \frac{flv^2}{gD}$$

Where h_f = Loss of head due to friction

L=length of pipe between the sections used for measuring loss of head

D= Diameter of the pipe 1 ,3/4, 1/2

f= Darcy friction factor

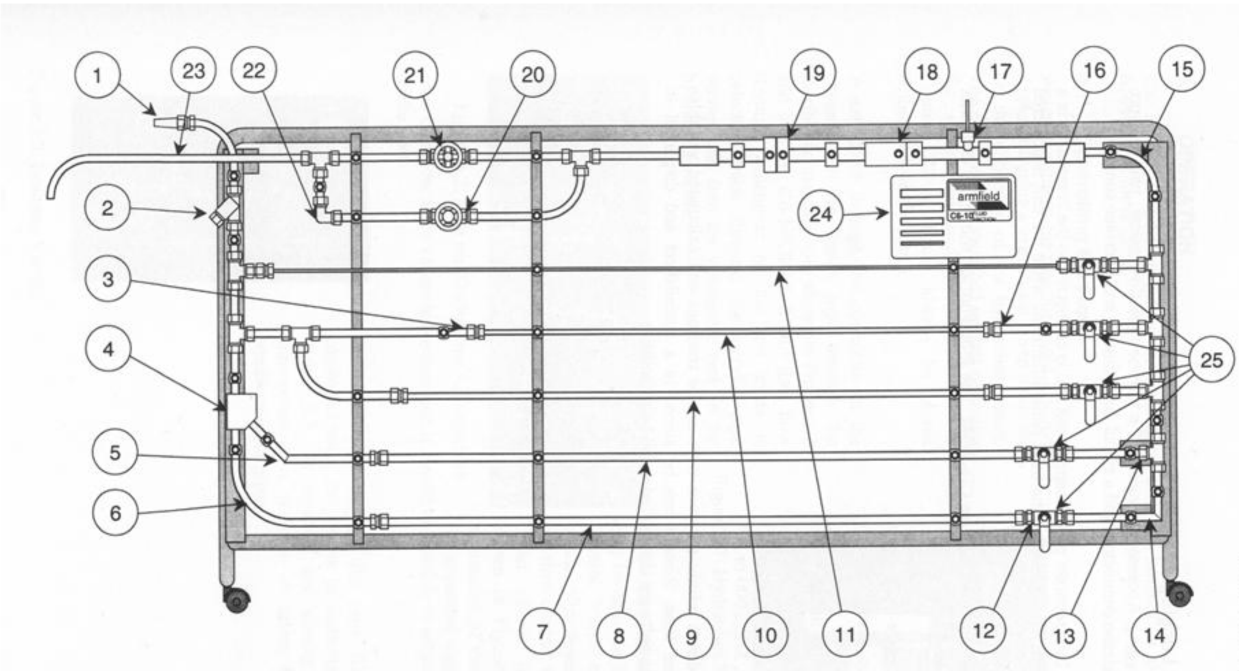

Figure 2.1: General Arrangement of C6-MKII-10 Fluid Friction Apparatus

The experiment is performed by using a number of long horizontal pipes of different diameter connected to water supply using a regulator valve for achieving different constant flow rates. Pressure tapings are provided on each pipe at suitable distances apart and connected to U-tube differential manometer. Manometer is filled with enough mercury to read the differential head 'h_m'. Water is collected in the collecting tank for arriving actual discharge using stopwatch and the piezometric level attached to the collecting tank.

APPARATUS REQUIRED:

1. Flow losses in pipe apparatus with flow control device and manometer
2. Collecting tank = 30 cm (L)*30 cm (W)* h cm
3. Stop watch

FORMULA USED:

Friction factor, $f = \frac{gD\,h_f}{Lv^2}$

where, $h_f = h_m \times (\frac{G_m}{Gw} - 1)h_m$ is differential level of manometer fluid measured in meters

Q_{act} = Actual discharge measured from volumetric technique.

G_m = specific gravity of mercury

G_w = specific gravity of water

1) Reynolds number Re_{D1}= $\frac{\rho vD}{\mu}$ where μ is the coefficient of dynamic viscosity of flowing fluid. The viscosity of water is 8.90×10^{-4} Pa-s at 25°C. Viscosity of water at differenttemp is listed below:

Temperature (°C)	10	20	30	40	50	60	70	80	90	100
Viscosity μ	13.08	10.03	7.978	6.531	5.471	4.668	4.4044	3.550	3.150	2.822

PROCEDURE:

1. Note the pipe diameter 'D', the density of the manometer fluid (mercury) 'G_m' =13.6 kg/$m^3$and the flowing fluid (water) 'G_w' =1kg/m^3

2. Make sure only required water regulator valve and required valves at tapings connected to manometer are opened.

3. Start the pump and adjust the control valve to make pipe full laminar flow. Wait for some time so that flow is stabilized.

4. Measure the pressure difference 'h_m' across the orifice meter.

5. Note the piezometric reading 'Z_0' in the collecting tank while switch on the stopwatch.

6. Record the time taken 'T' and the piezometric reading 'Z_1' in the collecting tank after allowing sufficient quantity of water in the collecting tank.

7. Increase the flow rate by regulating the control valve and wait till flow is steady.

8. Repeat the steps 4 to 6 for different flows.

RESULTS AND DISCUSSIONS

A) FOR PIPE NO. 1:

Diameter of pipe ‘D’ = ………..m

Area of pipe ‘A’= …………m

Length of Pipe ‘L’= 1 m

Area of collecting tank A_{ct} = ……. m^2

Coefficient of dynamic viscosity at ℃ =

Density of the manometer liquid G_m = 13.6 x 1000 kg/m^3

Density of the flowing liquid Gw= 1 kg/m^3

TABULATION-

No.	Actual measurement				Calculated values					*f*	Re no	log (Re)
	Time **T** (sec)	Z_1 (m)	Z_0 (m)	h_m (m)	Collecting tank h_{ct} (m) (3)-(4)	Volume (m^3) $A_{ct} \times h_{ct}$	Discharge Q_{act} (7)/(2)	Velocity (8)/A	h_f (m) (5) × $(\frac{G_m}{Gw} - 1)$	$f=\frac{gD\,h_f}{Lv^2}$	$\frac{\rho vD}{\mu}$	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1												
2												
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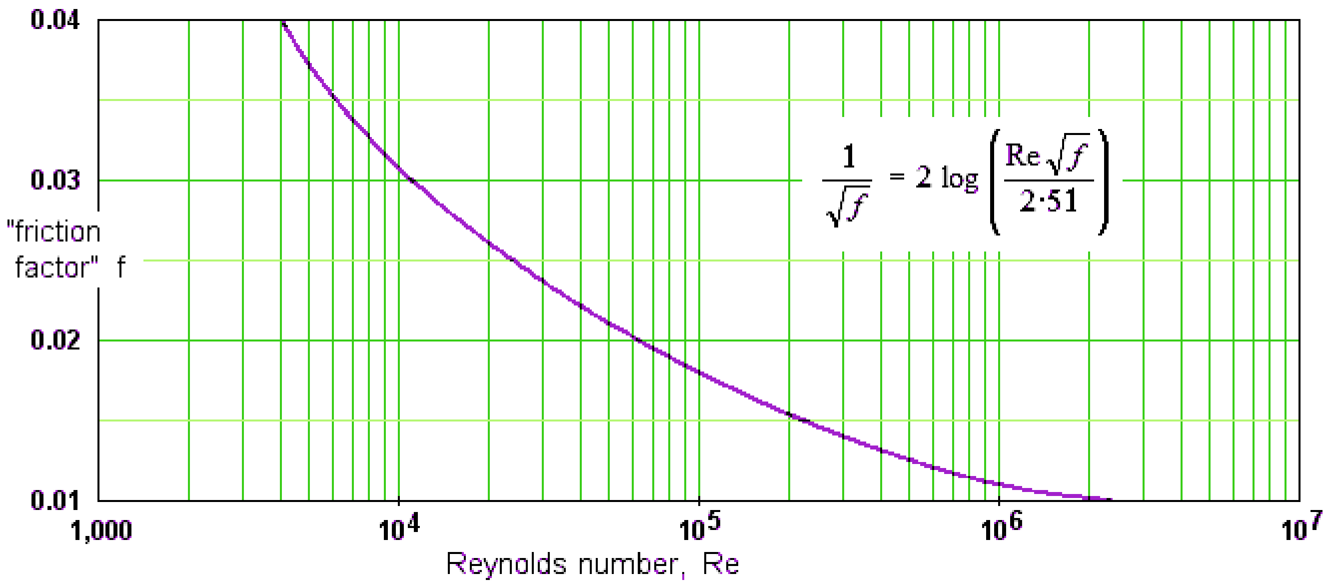
7												
8												

9												
10												

GRAPHS REQUIRED:



PRECAUTIONS:

1. When fluid is flowing, the lower meniscus reading should be taken into considerations.
2. There should be some water in the collecting tank.
3. The valve in the downstream end should be closed only when the upstream valve is closed.

QUESTIONS:

1. Define major and minor loss in pipe.
2. Define Reynolds number.
3. Define friction factor in the pipe.
4. State the relation between head loss and diameter of pipe.

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CALIBRATION OF DIFFERENT TYPES OF NOTHCES

(A)FLOW THROUGH RECTANGULAR NOTCH

OBJECTIVES:

To determine the coefficients of discharge of the rectangular notch.

THEORY:

In open channel hydraulics, weirs are commonly used to either regulate or to measure the volumetric flow rate. They are of particular use in large scale situations such as irrigation schemes, canals and rivers. For small scale applications, weirs are often referred to as notches and invariably are sharp edged and manufactured from thin plate material. Water enters the stilling baffles which calms the flow. Then, the flow passes into the channel and flows over a sharp-edged notch set at the other end of the channel. Water comes of the channel in the form of a nappe is then directed into the calibrated collection tank. The volumetric flow rate is measured by recording the time taken to collect a known volume of water in the tank.

A vertical hook and point gauge, mounted over the channel is used to measure the head of the flow above the crest of the notch as shown in Fig. 2.1. Hook gauge can be moved vertically to measure vertical movements.

APPARATUS REQUIRED:

i. Hydraulic bench
ii. Notches – Rectangular,
iii. Hook and point gauge
iv. Calibrated collecting tank
v. Stop watch

FORMULAE USED:

(A) RECTANGULAR NOTCH

Coefficient of discharge

$$Q_{th} = \frac{2}{3}\sqrt{2g}\,B\,H^{3/2}$$

$$C_d = \frac{Q_{act}}{\frac{2}{3}\sqrt{2g}\,B\,H^{3/2}}$$

Where,

$$Q_{act} = \frac{\text{Volume Collected}}{\text{Time Taken}}$$

PROCEDURE:

Preparation for experiment:

1.Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.

2.Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level 'h_o' the hook and point gauge. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

Experiment steps:

3.After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.

4. Move hook and point gauge vertically and measure the current water level 'h1' to find the water head 'H' above the crest of the notch.

5. Note the piezometric reading ‘z_o’ in the collecting tank while switch on the stopwatch.

6. Record the time taken ‘T’ and the piezometric reading ‘z_1’ in the collecting tank after allowing sufficient water quantity of water in the collecting tank.

7. Repeat step 3 to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until 5 sets of data have been taken. If collecting tank is full, just empty it before the step no 3.

8. To determine the coefficient of discharge for the other notch, repeat from step 1.

After entering the readings in the Tabulation 2.1 and Tabulation 2.2, compute the necessary values.

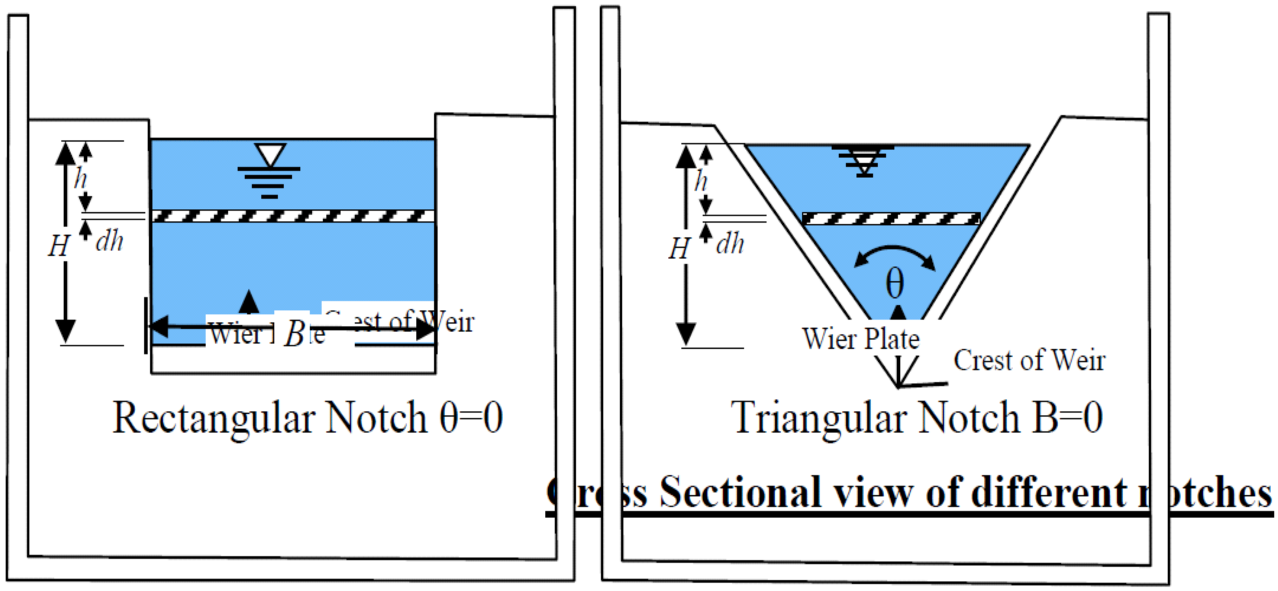


fig.-Cross Sectional view of different notches

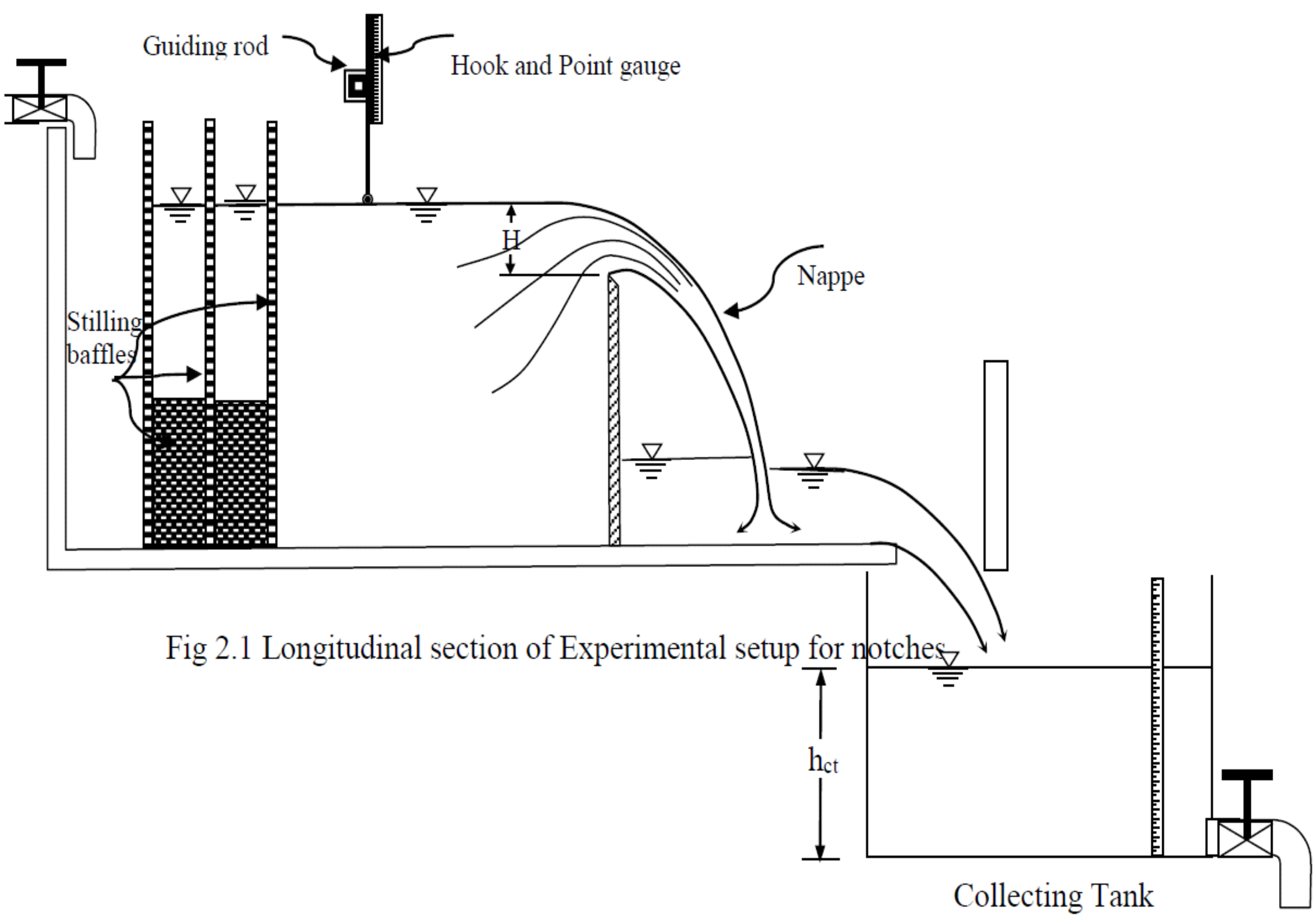


Fig 2.1 Longitudinal section of Experimental setup for notches

OBSERVATION AND COMPUTATIONS – I

A) For Rectangular notch

Notch breadth 'B' = Initial reading of hook and point gauge h_o=

Area of collecting Tank, A_{ct} = × = m^3

Tabulation 2.1 – Determination of Cd of rectangular notch.

No. ↓	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*						Cd
	h_1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{2}{3}\sqrt{2g}\, B H$	Time T (sec)	z_1 (m)	z_0 (m)	Collecting Tank h_{ct} (m)	Volume (m^3) $A_{ct} * h_{ct}$	Discharge, Q_{act} (9)/(5)	$\frac{Q_{act}}{Q_{th}}$ (10)/(4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1										
2										
3										
4										

Rectangular notch : Average Value of C_d= ………………..….

GRAPH:

A). For rectangular Notch:

1. Q_{act} versus H and Q_{act} versus $H^{3/2}$ are drawn taking H and $H^{3/2}$ on *x* -axis and Q_{act} on *y* – axis.

2. C_d versus H is drawn taking H on *x* -axis and C_d on *y* – axis.

3. C_d versus H is drawn taking H on x -axis and C_d on y – axis.

RESULTS:

Load test on flow through rectangular notch is carried out and the readings and results are tabulated and the graphs are drawn.

PRECAUTIONS

1. Ensure and read initial water level reading just above the crest.
2. Make the water level surface still, before taking the readings.
3. Reading noted should be free from parallax error.
4. The time of discharge is noted carefully.
5. Only the internal dimensions of collecting tank should be taken for considerations and calculations.

(B) FLOW THROUGH TRIANGULAR NOTCH

OBJECTIVES: To determine the coefficients of discharge of the triangular and notch.

APPARATUS REQUIRED:

i. Hydraulic bench
ii. Notches – Rectangular, triangular,
iii. Hook and point gauge
iv. Calibrated collecting tank
v. Stop watch

b) TRIANGULAR NOTCH

Coefficient of discharge

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

So,

$$C_d = \frac{Q_{act}}{\frac{8}{15}\sqrt{2g}\ H^{5/2} \tan\frac{\theta}{2}}$$

PROCEDURE:

Preparation for experiment:

1.Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.

2.Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level 'h_0'using the hook and point gauge. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

Experiment steps:

3.After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.

4.Move hook and point gauge vertically and measure the current water level 'h_1' to find the water head 'H' above the crest of the notch.

5.Note the piezometric reading 'z_0' in the collecting tank while switch on the stopwatch.

6.Record the time taken 'T' and the piezometric reading 'z_1' in the collecting tank after allowing sufficient water quantity of water in the collecting tank.

7.Repeat step 3 to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until 5 sets of data have been taken. If collecting tank is full, just empty it before the step no 3.

8. To determine the coefficient of discharge for the other notch, repeat from step.

After entering the readings in the Tabulation 2.1 and Tabulation 2.2, compute the necessary values.

For Triangular notch

Notch angle ‘θ’ = Initial reading of hook and point gauge h_0=

Area of collecting Tank A_{ct} = x = m^2

Tabulation 2.2 – Determination of Cd of triangular notch.

No.↓	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*						Cd
	h_1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{8}{15}\sqrt{2g}\,H^{5/2}\tan\frac{\theta}{2}$	Time T (sec)	z_1 (m)	z_0 (m)	Collecting Tank h_{ct} (m)	Volume (m^3) $A_{ct} * h_{ct}$	Discharge, $\mathbf{Q_{act}}$ (9)/(5)	**Q_{a}/Q_{t}** (10)/
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11
1										
2										
3										
4										

Triangular notch: Average Value of Cd = ……………...….

GRAPH:

A). For triangular Notch:

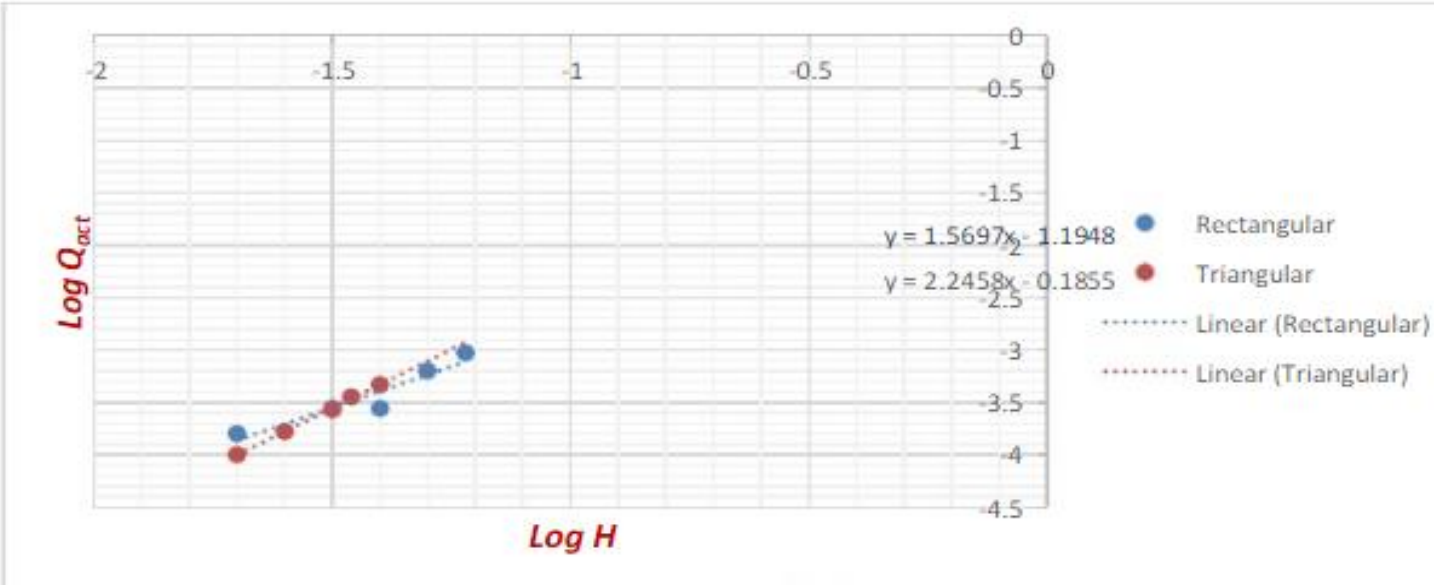
4. Q_{act} versus H and Q_{act} versus $H^{5/2}$ are drawn taking H and $H^{5/2}$ on *x* -axis and Q_{act} on *y* – axis.

5. C_d versus H is drawn taking H on *x* -axis and C_d on *y* – axis.

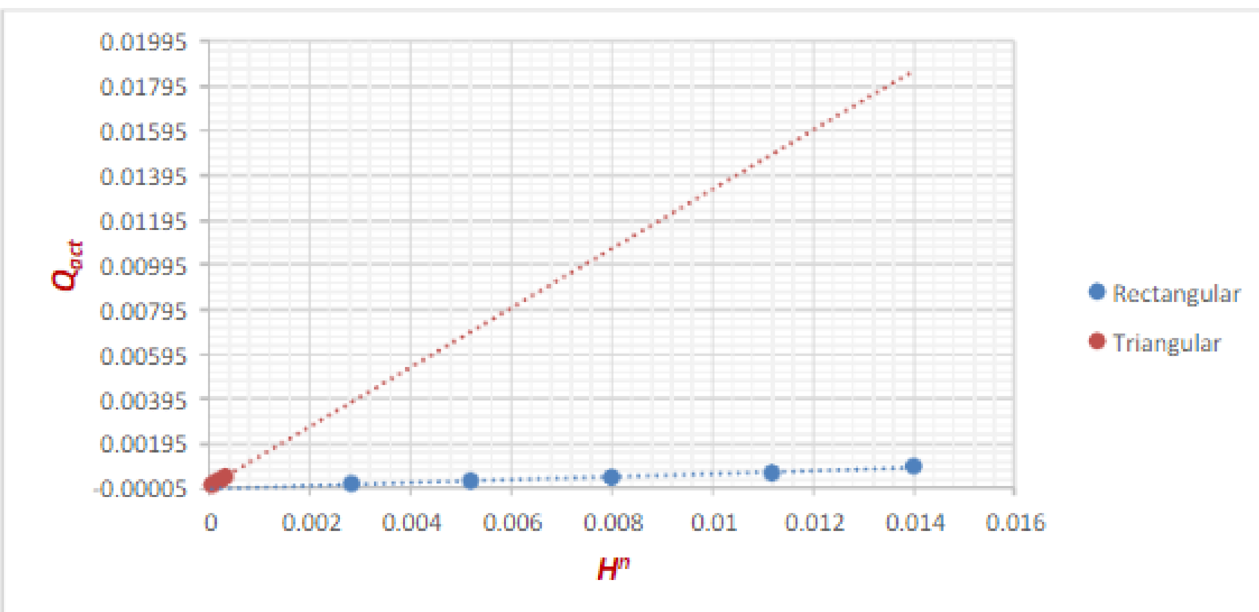
RESULTS:

Load test on flow through triangular notch is carried out and the readings and results are tabulated and the graphs are drawn.

$log\ Q_{act}\ Vs\ log\ H$

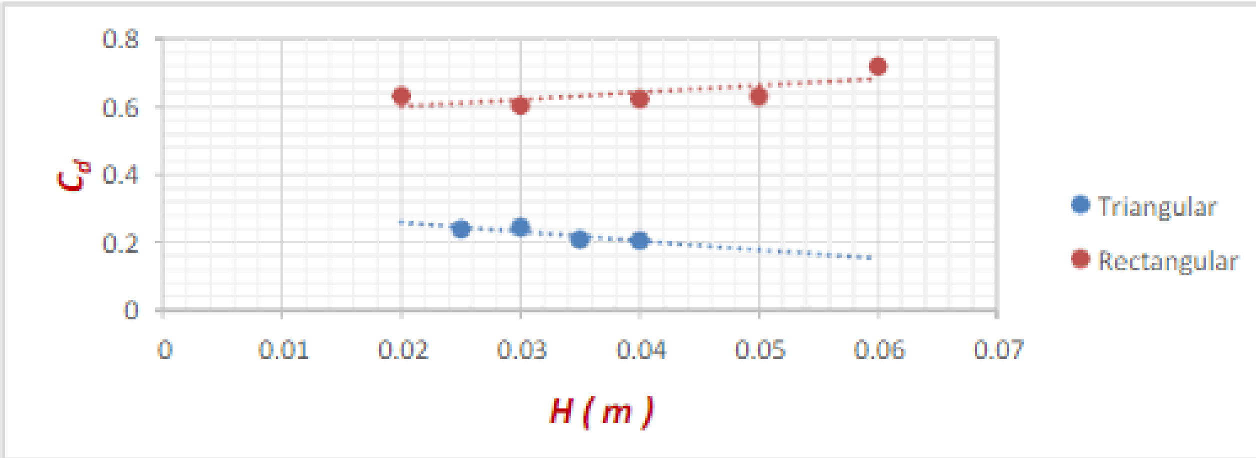


$Q_{act}\ Vs\ H^n$:



Where (n) equals (5/2) for the triangular weir and (3/2) for the rectangular weir .

C_d derived from the actual flow Vs H :



PRECAUTIONS

1. Ensure and read initial water level reading just above the crest.
2. Make the water level surface still, before taking the readings.
3. Reading noted should be free from parallax error.
4. The time of discharge should be noted carefully.
5. Only the internal dimensions of collecting tank should be taken for considerations and calculations.

QUESTIONS

1. Differentiate between
    a. Uniform and non-uniform flow
    b. Steady and unsteady flow
2. Define notch.
3. What is co-efficient of discharge?

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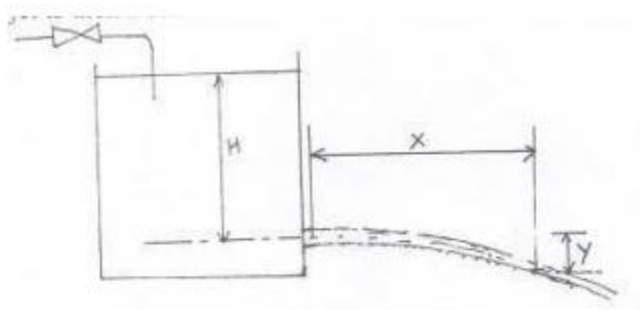
DETERMINATION OF COEFFICIENTS OF AN ORIFICE (C_D, C_C, C_V)

THEORY:

An orifice is an opening in the wall of the tank, while a mouth is a short pipe fitted in the same opening. Orifice is used for discharge measurement. The jet approaching the orifice continues beyond the orifice till the streamline becomes parallel. This section is the jet approaching the orifice, continue to coverage beyond parallel. This section of the jet approaching the orifice continue to coverage beyond the orifice till the streamlines become parallel. This section of jet is then a section of minimum area and is known as vena contracta.



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

$$Y = \frac{g}{2V_c^2}X^2$$

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

$V_o = \sqrt{2gh}$

Now co-efficiency of velocity

$$C_v = \frac{X}{2\sqrt{Yh}}$$

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

The actual discharge Q when divided by a $\sqrt{2gh}$ yields the coefficient of discharge C_d. Here a is the area of cross section if the orifice and g is the acceleration due to gravity.
Once C_d and C_v are know, the coefficient C_c can be obtained by dividing C_d by Cv, $C_c = C_d/C_v$

APPARATUS REQUIRED:

1. Supply tank with overflow arrangement and provision of fitting of orifice or mouth piece installed in the vertical plane of the tank side,
2. scale and sliding apparatus with hook gauge,
3. orifice 10 mm dia.

EXPERIMENT SET-UP:

The experimental setup consists of a 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 mouthpiece (interchangeable) installed in a vertical plane of the tank side. 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. This hook gauge can be moved as well as vertically in x and y direction and its corresponding movement can be read on horizontal and vertical scale respectively. A collecting tank is used to find the actual discharge of water through the jet.

PROCEDURE:

1. Note down the relevant dimensions as area of collecting tank and supply tank.
2. Attach an orifice and note down its diameter.
3. The apparatus is leveled.
4. The water supply was admitted to the supply tank and conditions are allowed to steady, to give a constant head.
5. The lowest point of the orifice is used as the datum for the measurement of h and y.
6. The discharge flowing through the jet was recorded together with the water level in the supply tank.
7. A series of reading of dimensions x and y was taken along the trajectory of the jet.
8. The procedure is repeated by means of flow control valve.

OBSERVATIONS AND TABULATIONS:

Area of cross section of collecting tank =

Size and shape of orifice =

Area of cross section of orifice, a =

Reading on the piezometer at the level on the center of orifice h0 =

(i)Determination of Cd

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

Average C_d=

(ii) Determination of Cv

Reading of horizontal scale at exit of orifice/mouthpiece x 0 =

Reading of vertical scale at exit of orifice/mouthpiece y0 =

Sr. No.	H (cm)	Reading on Scale		$X= x'-x_0$	$Y=y'-y_0$	$C_v = \frac{x}{2\sqrt{yH}}$
		Horizontal x' (cm)	Vertical Y' (cm)			

Average C_v=

RESULT: Cc=Cd / Cv

PRECAUTIONS:

1. Take the reading of discharge accurately.
2. Take value of h without any parallax error.
3. Set the orifice and mouthpiece carefully.
4. Take reading from hook gauge carefully.

QUESTIONS:

1. Define orifice.
2. Define mouthpiece.
3. Define vena contracta.
4. Define co-efficient of velocity.

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VERIFICATION OF BERNOULLI'S THEOREM

THEORY:

Bernoulli's law indicates that, if an in viscid fluid is flowing along a pipe of varying cross section, then the pressure is lower at constrictions where the velocity is higher, and higher where the pipe opens out and the fluid stagnates. The well-known Bernoulli equation is derived under the following assumptions:

1. Fluid is incompressible.
2. Flow is steady.
3. Flow is frictionless.
4. Along a streamline.

Then, it is expressed with the following equation,

$\frac{P}{\rho g} + \frac{v^2}{2g}$ + z = h* = constant

.where (in SI units):

p = fluid static pressure at the cross section in N/m^2.

= density of the flowing fluid in kg/m^2

g = acceleration due to gravity in *m/s2* (its value is *9.81 m/s2 = 9810* mm/s^2)

v = mean velocity of fluid flow at the cross section in *m/s*

z = elevation head of the center of the cross section with respect to a datum *z=0*

*h** = total (stagnation) head in *m*

The terms on the left-hand-side of the above equation represent the pressure head *(h)*, velocity head *(hv)*, and elevation head *(z)*, respectively. The sum of these terms is known as the total head *(h*)*. According to the Bernoulli's theorem of fluid flow through a pipe, the total head *h** at any cross section is constant (based on the assumptions given above). In a real flow due to friction and other imperfections, as well as measurement uncertainties, the results will deviate from the theoretical ones.

In our experimental setup, the centerline of all the cross sections we are considering lie on the same horizontal plane (which we may choose as the datum, *z=0*), and thus, all the *'z'* values are zeros so that the above equation reduces to:

$\frac{P}{\rho g} + \frac{v^2}{2g} + z =$ h*= constant (This is the total head at a cross section).

For our experiment, we denote the pressure head as h_i and the total head as $h_i^*$where '*I*' represents the cross section we are referring to.

Apparatus:

Take tank 2/3 full of water, floating vessel or pontoon fitted with a pointed pointer moving on a graduated scale, with weights adjusted on a horizontal beam

PROCEDURE:

1. Open the inlet valve slowly and allow the water to flow from the supply tank.

2. Now adjust the flow to get a constant head in the supply tank to make flow in and out flow equal.

3. Under this condition the pressure head will become constant in the piezometer tubes.

4. Measure the height of water level "h" (above the arbitrarily selected plane) in different piezometric tubes.

5. Compute the area of cross-section under the piezometer tubes.

6. Note down the quantity of water collected in the measuring tank for a given interval of time.

7. Change the inlet and outlet supply and note the reading.

8. Take at least two reading as described in the above steps.

8. Take at least two reading as described in the above steps.

OBSERVATION:

Distance between each peizometer = 7.5cm

Density of water = 0.001 kg/cm 3

1)Note down the Sl. No's of Pitot tubes and their cross sectional areas.

2)Volume of water collected q = ……………. cm 3
3)Time taken for collection of water t = …………….sec

OBSERVATION AND RESULTS:

Tube No.	Area of the flow in cm 2	Discharge 'Q' ,in cm 3 /sec	Velocity V ,in cm/sec	Velocity head ,in cm	Pressure head ,in cm	Total H , in cm

SAMPLE CALCULATIONS:
1. Discharge Q = q / t =………….. cm 3 /sec
2. VelocityV= Q/ A= .... = ………. cm/sec
where A is the cross sectional area of the fluid flow.
3.Velocity head, **V_2 /2g=** ………….. **cm**
4. Pressure head (actual measurement or piezometer tube reading) **P/w=** ……………… **cm**
5. Total Head **H =**
Pressure head + Velocity Head **=** ……….........…….. **cm**

PRECAUTIONS:

1. When fluid is flowing, there is a fluctuation in the height of piezometer tubes, note the mean position carefully.
2. Carefully keep some level of fluid in inlet and outlet supply tank.

QUESTIONS

1. Briefly explain the various terms involved in Bernoulli's equation
2. What are the assumptions made to get Bernoulli's equation from Euler's equation?
3. What is piezometer tube?

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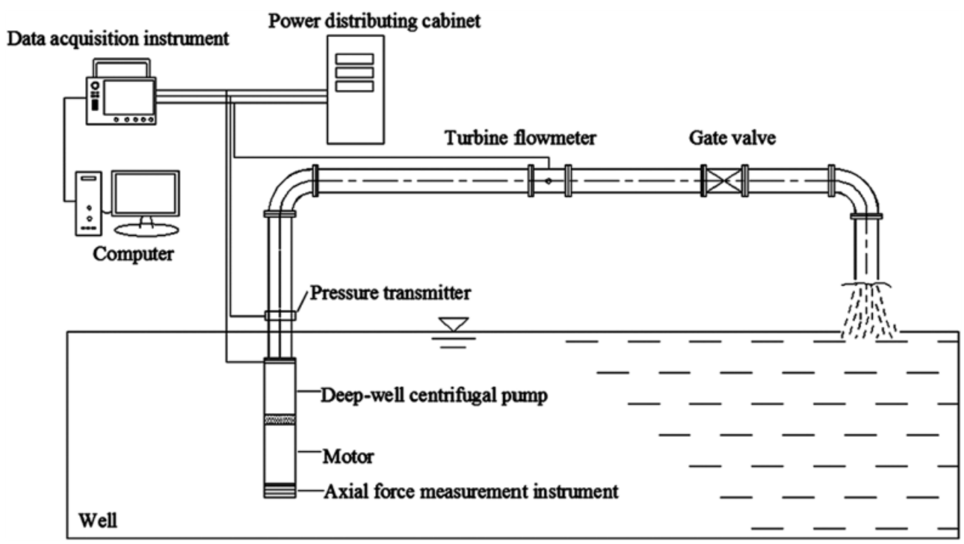
PERFORMANCE TEST ON A CENTRIFUGAL PUMP & TO DRAW GRAPHS OF (HEAD vs DISCHARGE), (HEAD vs POWER)&(HEAD vs OVERALL EFFICIENCY)

THEORY:

The test rig consists of a sump tank to store water. A centrifugal pump is fitted in the rig. Suitable piping with valves for control is provided. A measuring tank with gauge glass and scale is provided to measure the flow. Pressure and vacuum gauges are provided to find out the discharge head and suction head. An energy meter is fitted to measure the input power.



APPARATUS REQUIRED:

1. Centrifugal Pump test rig consisting of :
   a. Centrifugal pump
   b. An electric motor to drive the pump
   c. Pressure and vacuum gauges to measure the head
   d. Flow measuring unit
   e. Suitable capacity sump tank with piping
   f. Energy meter to measure the input to the motor
2. A stop clock.

FORMULAE USED:

Output power = $\frac{\gamma QH}{1000}$ kW

where,

γ – Specific weight of water 9810 N/m^3

Q – Discharge in m^3/sec

H – Total head in m

Input power $= \frac{n}{te} \times \frac{3600}{K}$ kW

Where, n – No of revolutions of energy meter disc

t_e – Time for 'n' revolutions in 'sec'

K – Energy meter constant in Rev/kW-hr

Overall Efficiency = Input/Output

PROCEDURE:

1. Ensure that the delivery valve is in closed position.
2. Ensure that the isolation valves of the pressure/vacuum gauges are closed.
3. Prime the pump and start it. Allow it to attain the rated speed.
4. Open the valve fitted to the pressure gauge fitted at the outlet of the pump.
5. Note the following readings at no load:
   a. Vacuum gauge reading at inlet to the pump.
   b. Pressure gauge readings at outlet of each stage.
   c. Time to collect 100 mm height of water in the measuring tank.
   d. Time for 5 revolutions of the disc of energy meter.
6. At different gate valve opening note the readings.
7. Tabulate the readings.
8. Do the calculations and draw the graphs.

TABULATIONS AND CALCULATIONS:

Area of measuring tank = 0.5 × 0.5 m^2

Energy meter constant, K = 200 Rev/kW-hr

Datum head, Z = 0.7 m of water

Suction head, $H_s = (V / 1000) \times 13.6$ m of water

Discharge head, $H_d = (p \times 10)$ m of water

Total head delivered by the pump, $H = Z + H_s + H_d$ m of water

Discharge, $Q = (0.5 \times 0.5 \times 0.1)/t$ m^3/s

Output power, $OP = \frac{\gamma QH}{1000}$ kW

Input power, IP $=\frac{n}{te} \times \frac{3600}{K}$ kW

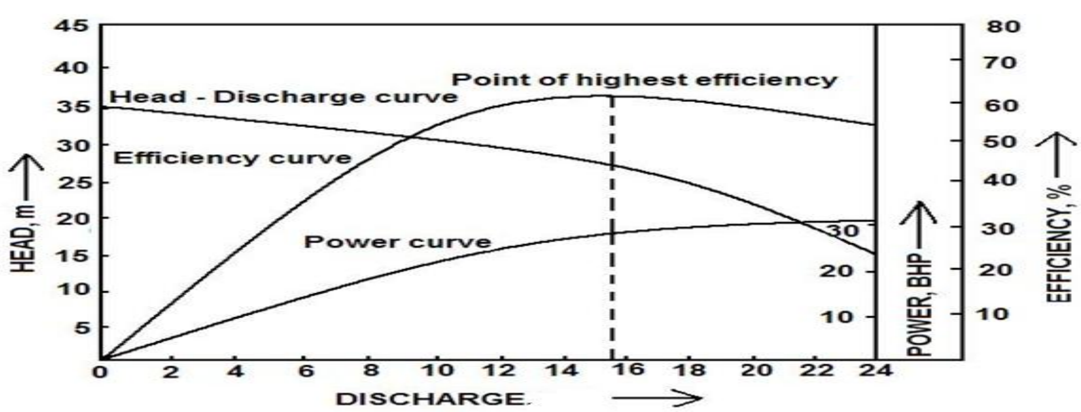
Efficiency, η = (OP / IP) × 100

TABULATIONS: CENTRIFUGAL PUMP

Sl No	Vacuum Gauge Reading	Pressure gauge Reading	Suction Head	Discharge Head	Total Head	Time for 5 revolutions of Energy meter	Time for 5 revolutions of Energy meter	Discharge	output	Input	Overall efficiency
	mm of Hg	kg/cm^2	m of water	m of water	m of water	sec	sec	m^3/s	kW	kW	ŋ
	V	P	H_S	H_d	H	t_e	t	Q	OP	IP	%
1											
2											
3											
4											
5											

RESULT:

Performance test on the centrifugal pump is carried out and the readings and results are tabulated and the graphs are drawn.



PRECAUTIONS:

1. Do not let a pump run at zero flow
2. Use pressure gauges

3. Do not let a pump run dry, use a check valve
4. If you need to control the flow, use a valve on the discharge side of the pump, never use a valve on the suction side for this purpose.
5. Avoid pockets or high point where air can accumulate in the discharge piping
6. Be aware of potential water hammer problems.

QUESTIONS:

Q. Where and why do we use centrifugal pump?

Q.What is priming why is it neccessary?

Q.what if the the blade is not to create vacuum but directly lifting water.?

Q.what would happen if the vapour pressure is lower than atmospheric pressure?

Q.Working Head of centrifugal pump and dishcharge as well.?

DEPARTMENT OF CIVIL ENGINEERING, JORHAT ENGINEERING COLLEGE

HYDRAULIUCS LABORATORY

DETERMINATION OF THE SURFACE PROFILE OF VORTEX APPARATUS.

THEORY:

When a liquid contained in a cylindrical vessel is given the rotation either due to rotation of the vessel about vertical axis or due to tangential velocity of water, surface of water no longer remains horizontal but it depresses at the center and rises near the walls of the vessel. A rotating mass of fluid is called vortex and motion of rotating mass of fluid is called vortex motion. Vortices are of two types viz. forced vortex and free vortex. When a cylinder is in rotation then the vortex is called forced vortex. If water enters a stationary cylinder then a vortex is called a free vortex.

DESCRIPTION OF THE APPARATUS:

The apparatus consists of a Perspex cylinder with drain at centre of bottom. The cylinder is fixed over a rotating platform which can be rotated with the help of a D.C. motor at different speeds. A tangential water supply pipe is provided with flow control valve. The whole unit is mounted over the sump tank. Water is supplied by a centrifugal pump.

PROCEDURE:

A. Forced Vortex

1. Close the drain valve of the cylindrical vessel. Fill up some water (say 4-5 cm height from bottom) in the vessel.

2. Switch “ON” the supply and slowly increase the motor speed. Do not start the pump.

3. Keep motor speed constant and wait till the vortex formed in the cylinder stabilizes. Once the vortex is stabilized note down the co-ordinates of the vortex and completes the observation table.

4. With the surface speed attachment of the tachometer, measure the outside rotational speed of vessel and note down in the observation table.

B. Free Vortex

1. Open the bypass valve and start the pump.

2. Slowly close the water bypass valve & drain valve of the cylinder. Water is now getting admitted through the tangential entry pipe to the cylinder.

3. Properly adjust the bottom drain valve so that a stable vortex is formed.

4. Note down the co-ordinates of the vortex. Also measure the time required for 10 litrelevel rise in the measuring tank and complete the observation table.

OBSERVATIONS:

A. Forced Vortex

Sl No.	**Radius r (x co-ordinate) cm**	**Height (z) (y co-ordinate) cm**	**Rotational speed (rpm)**

B. Free Vortex

Discharge (m^3/sec)	**Radius (x co-ordinate) r cm**	**Height (y co-ordinate) z cm**	**C**
Q_1	**r_1**	**z_1**	
	r_2	**z_2**	
	r_3	**z_3**	
	r_4	**z_4**	
	r_5	**z_5**	

	r_6	z_6	
Q_2	r_1	z_1	
	r_2	z_2	
	r_3	z_3	
	r_4	z_4	
	r_5	z_5	
	r_6	z_6	
Q_3	r_1	z_1	
	r_2	z_2	
	r_3	z_3	
	r_4	z_4	
	r_5	z_5	
	r_6	z_6	

Inner diameter of the cylinder= 300mm
Length of the cylinder= 145 mm

CALCULATIONS:

A) Forced Vortex

Rotational speed = rpm

Angular velocity, $\omega = \frac{2\pi N}{60}$ rad/sec

For forced vortex,

$Z = w^2r^{2/}2g$

$Z_1= w^2r_1^2/2g$

$Z_2= w^2r_2^{2/}2g$ etc.

B) Free Vortex

Discharge $Q = \frac{0.01}{t} m^3/$ sec

For free vortex,

vr = C

And $z_2 - z_1= C^2/ 2g\ (1/r_1^2 - 1/r_2^2)$

Similarly calculate values of z at different r.

PRECAUTIONS:

1. While making the experiment of forced vortex, see that water does not spill away from the vessel. Do not increase the speed of rotation excessively.
2. Do not run the pump at low voltage i.e. less than 180 Volts.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, rum pump at least once in a fortnight.
5. Frequently Grease/Oil the rotating parts, once in three months.
6. Always Use Clean Water.

7. If the Apparatus is not in use for more than one month, drain the apparatus completely, and fill pump with cutting oil

QUESTIONS:

1. What is free and forced vortex flow?
2. What is the vorticity in the core region?
3. In vortex fluid flow velocity is inversely proportional to the distance from the axis line.why?

DEPARTMENT OF CIVIL ENGINEERING, JORHAT ENGINEERING COLLEGE

HYDRAULICS LABORATORY

DETERMINATION OF METACENTRIC HEIGHT

THEORY:

Metacentre is the point, where the line of buoyant force and the perpendicular passing through the centre of gravity intersect.

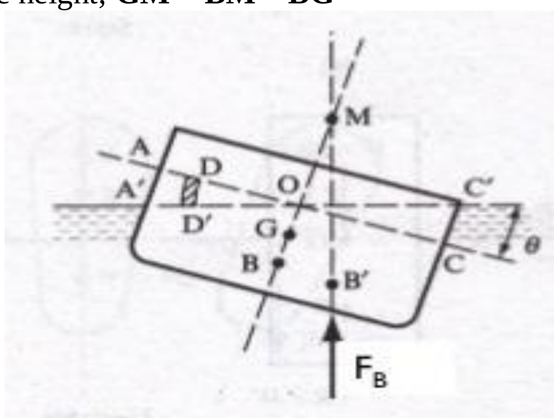
The metacentric height, **GM = w x/W tanθ**

where, GM = metacentric height in mm, w is the mass of the slider in kg, x is the distance to the movable weight from the central position in mm, W is the mass of the trough and the slider in kg, θ is the angle of inclination.

The distance between the buoyancy and the metacentre, **BM = I/V**

where, V is the volume in the displaced water, I is the moment of inertia of the plane of water respect to the longitudinal axis = lb3 / 12

Hence, the metacentric height, **GM = BM – BG**



APPARATUS REQUIRED:

1. Metacentric height instrument
2. Measuring scale etc.

PROCEDURE:

1) Weight the adjustable transversal mass as well as the floating prismatic base and assembly.

2) Displace the sliding mass up to upper part of the mass in such a way that the gravity center be in the upper part of the floating assembly.

3) Fill the volumetric tank with water.

4) Move the adjustable mass to the right of the center in 10mm steps of x, until the end of the scale, recording the angular displacement for every position.

OBSERVATIONS

Mass of movable slider w = 0.302
Mass of trough W''= 1.649
Mass of slider and trough W = 1.951

OBSERVATION TABLE

Distance from the movable mass to the right of the center, X(cm)	Position of vertical slider Y (cm)	Inclination angle θ	tan θ	Metacentric height GM(cm)
2				
4				
6				
8				
-2				
-4				
-6				
-8				

SAMPLE CALCULATION

RESULTS

PRECAUTIONS

1. The reading should be taken carefully without parallax error.
2. Put the weight on the hanger one by one.
3. Wait for pontoon to be stable before taking readings.
4. Strips should be placed at equal distance from the centre.

QUESTIONS

1. Define Buoyancy.
2. Define Meta-centre.
3. Define Meta-centric height.
4. With respect to the position of metacentre, state the condition of equilibrium for a floating body.

DEPARTMENT OF CIVIL ENGINEERING, JORHAT ENGINEERING COLLEGE

HYDRAULICS LABORATORY

DETERMINATION OF COEFFICIENT OF AN ORIFICEMETER AND TO PLOT $\sqrt{(H)}$ vs Q_a & H vs Q_a GRAPHS

THEORY:

Orifice meter is a device used to measure the flow through a pipe line. The pressure difference between the upstream and downstream side of the orifice meter is measured by using a differential U – tube manometer. The time taken to collect a fixed quantity of the liquid is noted. The theoretical discharge and actual discharge are calculated, from which the coefficient of discharge of the orifice meter can be calculated.

APPARATUS REQUIRED:

1. Pipe line setup with orifice meter fitted in the pipe line.

2. A manometer to measure the pressure drop between the entrance and throat of the orifice meter.

3. A tank to collect water.

4. A stop watch.

FORMULAE USED:

Coefficient of discharge, c_d $= \frac{Q_a}{Q_t}$

Theoretical discharge, Q_t =

$$\sqrt{2gH} \text{ x } \frac{a_1 \, x \, a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$$

Actual discharge, Q_a = $(l \times b \times h) / t$

g – Acceleration due to gravity = 9.81 m/s^2

Equivalent column of water, $H = (h_1\text{-}h_2)\left(\frac{S_m - S_1}{S_1}\right)$ in 'm'

a_1 - Area of the pipe (m^2)
l – Length of the tank (m)

h – Height of liquid collection (m)
h_1, h_2 – Deflection in manometer

a_2 - Area of the orifice (m^2)
b – Breadth of tank (m)

t – time for collection (sec)

s_m, s_l – Sp. Gravity of manometer and flowing fluid respectively

PROCEDURE:

1. Check up the experimental setup.

2. Measure the length (l) and breadth (b) of the tank.

3. Note the diameter of the pipe line (d_1) and orifice diameter (d_0).

4. Ensure water flow in the pipe line.

5. Open the flow control valve to maximum. Ensure that the mercury levels in the manometer are steady.

6. Allow water to flow for some time.

7. Note the deflections in the manometer (h_1, h_2).

8. Close the tank outlet valve.

9. Note the time ('t' sec) to collect 'h' m height of water in the tank.

10. Open the tank outlet valve.

11. Close the flow control valve slightly and repeat steps 7 to 10.

12. Tabulate the observations.

OBSERVATIONS AND TABULATIONS:

Length of tank, l = ………. (m)
Breadth of tank, b = ………. (m)
Height of collection, h = 0.1 m
Diameter of the pipe, d_1 = ……….. (m)
Diameter of throat, d_2 = ……….. (m)
Specific gravity of manometric fluid (Mercury), s_m = 13.6
Specific gravity of flowing fluid (Water), s_l = 1.0

Sl.	Deflection in manometer			H	$\overline{H}$	Time	Q_a	Q_t	C_d
No.	h_1 (cm)	h_2 (cm)	$h_1 - h_2$ (cm)	(m)		't' (sec)	(m^3/s)	(m^3/s)	
1									
2									
3									
4									
5									

MODEL CALCULATION:

Area of cross section of the tank, A = I x b =…………….x……….
=……………… (m^2)

Actual discharge, Q_a = (Ah)/t
=……………………. (m^3/s)

Area of the pipe, $a_1 = \frac{\pi}{4} \times (d_1)^2$
= …………………. (m^2)

Area of the Orifice, $a_2 = \frac{\pi}{4} \text{ x } (d_2)^2$ =……………………………….
= …………………. (m^2)

Equivalent column of water, H = (h_1-h_2) $(\frac{S_m - S_1}{S_1})$ in 'm'

Theoretical discharge, $Q_t = \sqrt{2gH} \text{ X } \frac{a_1 \, x \, a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$
=…………………………………………. (m^3/s)

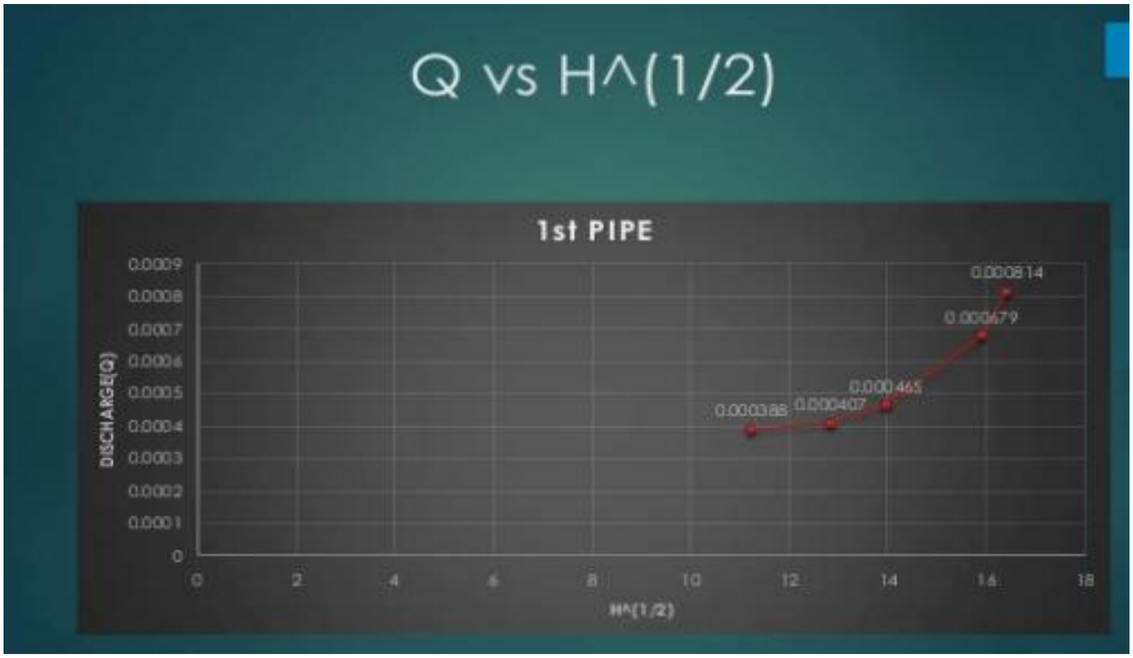
Coefficient of discharge, $C_d = (Q_a / Q_t)$
=……………….

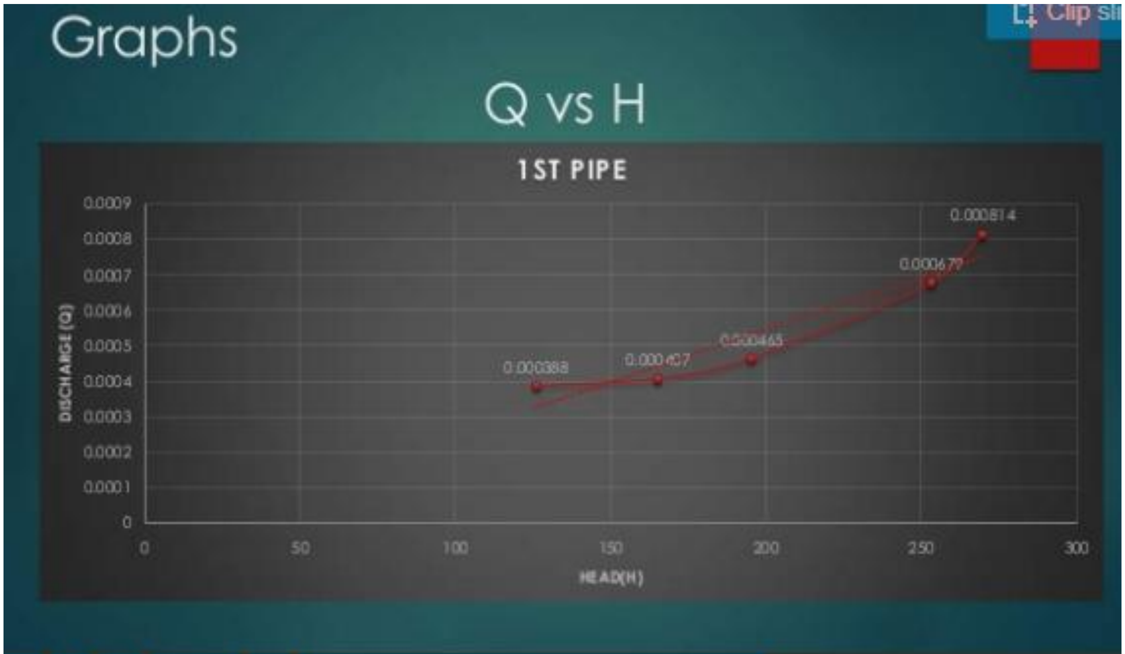
GRAPHS:

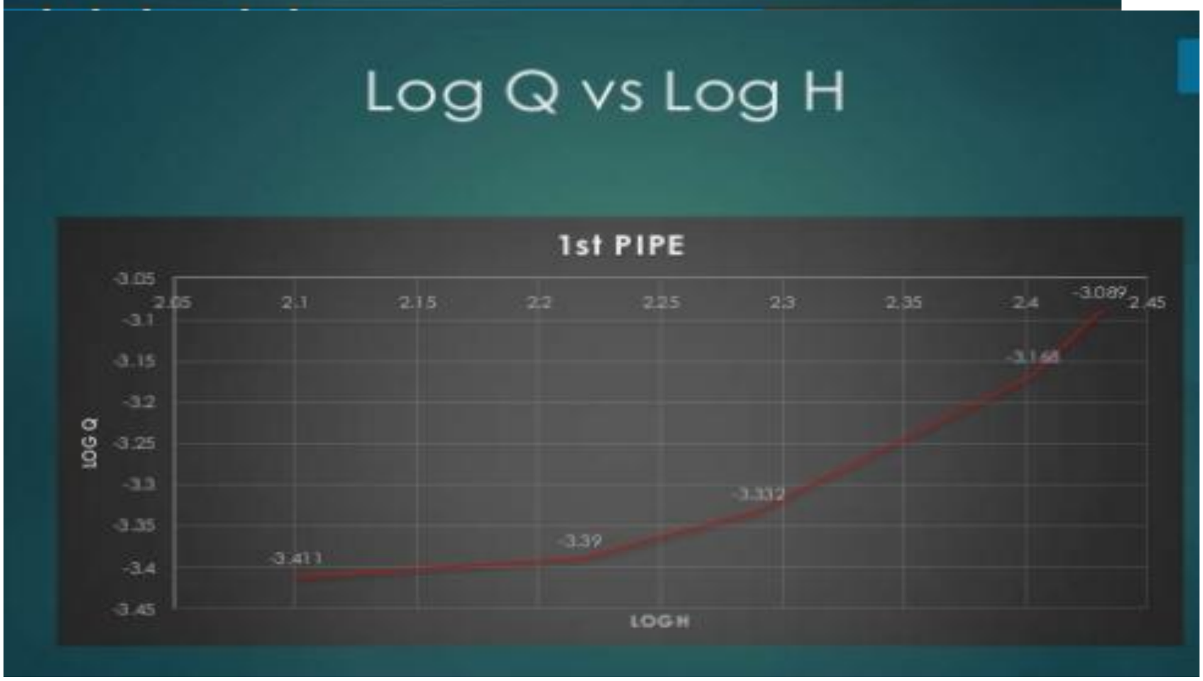
Draw the following graphs:

$\sqrt{H}$ Vs Q_a and H Vs Q_a

From the graph, the value of and $\sqrt{H}$ Q_a between any two points are found out. Using these values C_d is calculated and compared with the average value of C_d found out by calculation.







RESULT:

Average value of C_d (from calculation) =

Value of C_d (from graph) =

PRECAUTIONS:

1. Keep the other valve closed while taking reading through one pipe
2. The initial error in the manometer should be subtracted from final reading.
3. The parallax error should be avoided.
4. Maintain a constant discharge for each reading.

QUESTIONS:

1. Orificemeter are used for flow measuring. How?
2. Differentiate between orificemeter and venturimeter.

DEPARTMENT OF CIVIL ENGINEERING, JORHAT ENGINEERING COLLEGE

HYDRAULICS LABORATORY

STUDY OF DIFFERENT TYPES OF FLOW USING REYNOLD'S APPARATUS

THEORY

Consider the case of the fluid along a fixed surface such as the wall of a pipe. At some distance y from the surface the fluid has a velocity *(u)* relative to the surface. The relative movement causes a shear stress *(τ)* which tends to slow down the motion so that the velocity close to the wall reduced below u. It can be shown that the shear stress produces a velocity gradient *(∂u/∂y)* which is proportional to the applied stress. The constant of theproportionality is the coefficient of viscosity and the equation is given by,

$$\zeta = \mu(\partial u/\partial y)$$

The inertia force *(F_i)* is directly proportional to density *(p)*, square of the diameter of the pipe *(d^2)* and the velocity.

$$F_i \infty \rho d^2 u^2$$

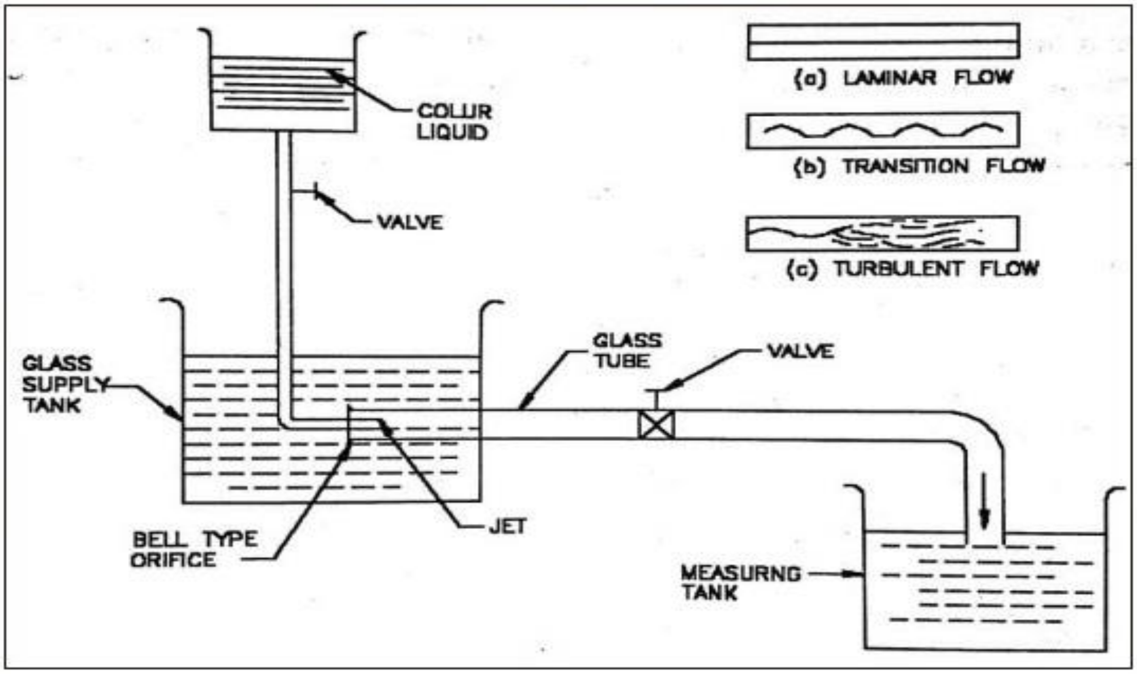
Viscous forces (F_V) are given by shear stress multiplied by area,

$$F \infty \rho d^2 u^2$$

Reynolds number is given by the ratio of inertia forces to the viscous forces

$$R_e = \frac{\rho u d}{\mu} = \frac{ud}{v}$$

APPARATUS



APPARATUS REQUIRED:

TecQuipment H215 Reynolds number and Transitional Flow Demonstration Flow

PROCEDURE

1) Set the apparatus, turn on the water supply and partially open the discharge valve at the base of the apparatus.

2) Adjust the water supply until the level in the constant head is just above the overflow pipe and is maintained at this level by a small flow down the overflow pipe.

3) Open and adjust the dye injector valve to obtain a fine filament of dye in the flow down the glass tube. A laminar condition should be achieved in which the filament of dye passes down the complete length of the tube without disturbance.

4) Slowly increase the flow rate by opening the discharge valve until disturbances of the dye filament are noted. This is regarded as the starting point of the transition to turbulent flow. Increase the water supply as required maintaining the constant head conditions.

5) Record the temperature of the water using the thermometer then measure the flow rate by timing the collection of the known quantity of water from the discharge pipe.

6) Further increase the flow rate as described above until the disturbances increase such that the dye filament becomes rapidly diffused. Small eddies will be noted just above the point where dye filament completely breaks down. This is regarded as the onset of fully turbulent flow. Record the temperature and flow rate.

7) Now decreases the flow slowly until the dye returns to a steady filament laminar flow and again record the temperature and flow rate.

OBSERVATION TABLE

Room temperature =

Diameter of the pipe, d= 12 mm

Sl. No.	Time (s)	u (m/s)	v*10 -6 m 2/s	R e	Condition

SAMPLE CALCULATIONS:

Velocity =

Reynolds number =

RESULT:

PRECAUTIONS:

1. Take reading of discharge accurately.
2. Set the discharge value accurately for each flow.

QUESTIONS:

1. State the importance of Reynolds number.
2. Describe the Reynolds number experiments to demonstrate the two types of flow.
3. Describe laminar, transition and turbulent flow.