Department of

Mechanical Engineering

LAB MANUAL

FM LAB

B.Tech– IV Semester

KCT College OF ENGG AND TECH.
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EXPERIMENT-1

To study the flow through a variable area duct and verify Bernoulli's Energy Equation.

1. Objective:

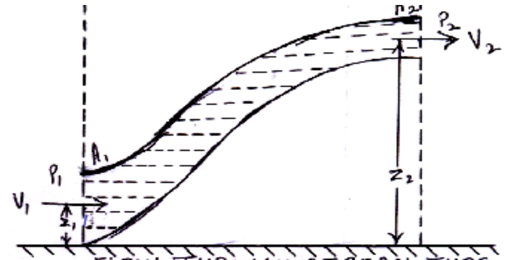
To aware the students about energy principle and its experimental verification.

2. Apparatus:

It consists of conduit of varying cross- sectional area as shown in fig3b given below. Transparent acrylic metallic sheets are joined together to form first converging then diverging rectangular conduit of 50X25 on upstream side, 15 X25 in the middle and 50 X 25 downstream side . The length of the conduit pipe is 0.5m.Graduated piezometeric tubes are fitted on the conduit pipe to measure the Piezometric head at each gauge point.
This conduct is connected to an inlet tank. A Piezmetric tube is also connected to the collecting tank for recording the water level in tank. An outlet valve is fitted at the down stream end of the pipe.

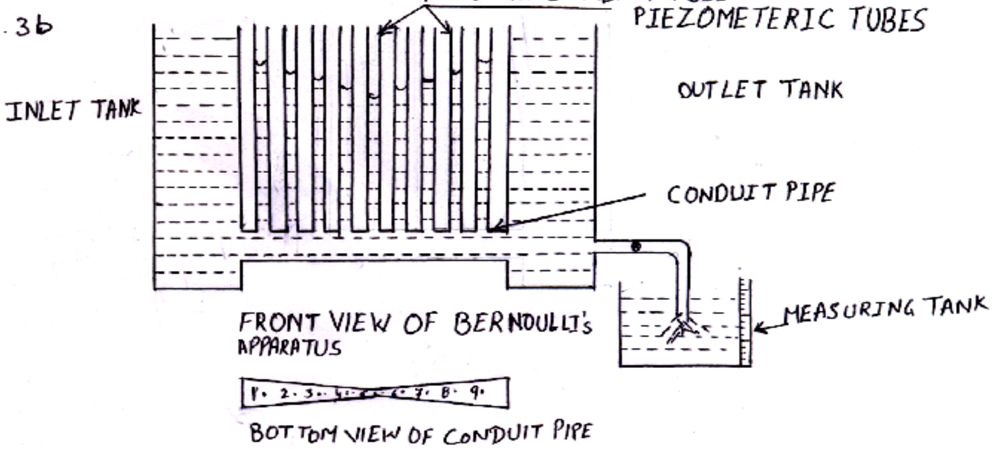
3. Diagram:

Fig. 3a



FLOW THROUGH STREAM TUBE

Fig. 3b



4. Theory:

Daniel Bernoulli enunciated in 1738 that in any s1ream flowing steadily without friction the total energy contained in a given mass is same at every point in its path of flow. This statement is called Bernoulli's theorem.

With reference to section 1-1 and 2-2 along the length of steady flow in the stream tube shown in the figure 3a the total energy at section 1-1 is equal to the total energy at section 2-2 as stated in Bernoulli's theorem.

With usual notations, the expression for total energy contained in a unit weight of fluid at section 1-1 and 2-2 is given by

Total energy at section 1-1 = $P_1/w + V_1^2/2g + Z_1$

Total energy at section 2-2 = $P_2/w + V_2^2/2g + Z_2$

P_1/w = Pressure energy at section 1-1
$V_1^2/2g$ = Kinetic energy at section 1-1
Z_1 = Potential energy at section 1-1
P_2/w = Pressure energy at section 2-2
$V_2^2/2g$ = Kinetic energy at section 2-2
Z_2 = Potential energy at section 2-2

Thus applying Bernoulli's theorem between section 1-1 and 2-2

$$P_1/w + V_1^2/2g + Z_1 = P_2/w + V_2^2/2g + Z_2 \qquad \text{(i)}$$

In MKS system, the pressure energy, kinetic energy and potential energy are measured fluid column per unit weight of fluid. Equation (i) is modified for taking into account the loss of friction between section 1-1 and 2-2 and is written as

$$P_1/w + V_1^2/2g + Z_1 = P_2/w + V_2^2/2g + Z_2 + (\Delta H)_{1,2}$$

Where $(\Delta H)_{1,2}$ represents the loss of energy between sections 1-1 and 2-2

5. Procedure:

i) Note down the area of the conduit at various gauge points.
ii) Ensure that the apparatus is horizontal with the help of spirit level.
iii) Open the supply valve and adjust the flow so that the water level in the inlet tank remains constant
iv) Measure the height of water-level (above an arbitrarily selected suitable plane) in different piezometric tubes.
v) Measure the discharge of the conduit with the help of measuring tank.
vi) Repeat steps (iii) to (v) for two more discharges.

6. Observations & Calculations:

i) Discharge

Run No.	Initial Vol. V_1	Final vol. V_2	Volume Collected $V=V_2 - V_1$	Time Taken t	Discharge $Q = V/t$
Units					
1					
2					
3					

ii) Total head

Piezometric tube No.		1	2	3	4	5	6	7	8	9
Area of cross-section of conduit at each Gauge point, A										
Run No.1	$V=Q/A$ $V^2/2g$ $P/w + V^2/2g + Z$									
Run No.2	$V=Q/A$ $V^2/2g$ $P/w + V^2/2g + Z$									
Run No.3	$V=Q/A$ $V^2/2g$ $P/w + V^2/2g + Z$									

7. Result:

As the conduit is horizontal the total energy at any section with reference to the datum line of the conduit is the sum of P/w & $V^2/2g$ energy should be constant for each of the piezometric tube.

8. Precautions:

i) Before taking reading, take care that steady flow conditions are established in the conduit.
ii) Check that air is not entrapped in the piezometric tube.
iii) There should be no leakage between u/s and d/s end of the conduit.

EXPERIMENT-2

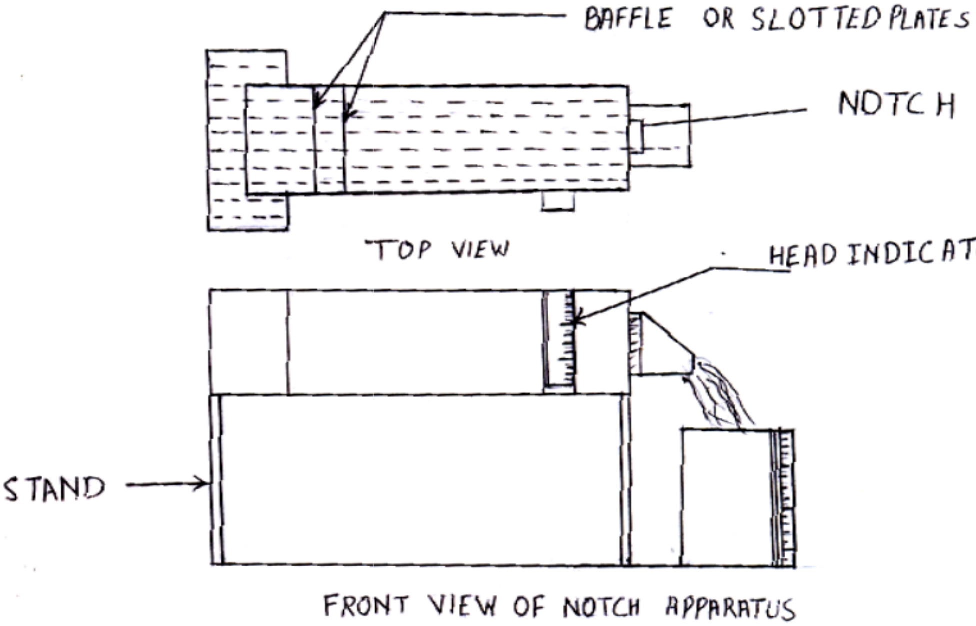
To determine the coefficient of discharge for a Vee Notch and a Rectangular Notch.

1. **Objective:**

   To aware the students about Vee notch or rectangular notch and their use in measuring coefficient of discharge.

2. **Apparatus:**
   - 2.1 A weir tank with baffle plates to reduce the velocity of approach
   - 2.2 A Vee-notch or
   - 2.3 A rectangular notch
   - 2.4 A collecting tank

3. **Diagram:**



4. Theory:

Notches are commonly used to regulate flow in rivers and other open channels. The relationship between the water- level upstream of the notch and the discharge over it is, generally, known so that the discharge at any time may be found by observing the upstream water level. Notches usually have sharp edges so that the water springs clear of the plate as it passes through the notch.

With the usual notations, the equation for discharge past a sharp-edged notch can be derived in the following form:

For the rectangular notch:

$Q = 2/3\sqrt{2g}\ \ bh^{3/2}$ (i)

For the triangular notch:

$Q = 8/15\ \sqrt{2g}\ \ \tan \Theta/2 h^{5/2}$ (ii)

Where h, b, Θ are as shown in fig.3a & 3b

The preceding equations are based upon the assumptions listed as follows: a) The height of the water level at the plane of the notch opening is h.

b) The velocity of flow is normal to the plane of the notch opening at all points.

c) The velocity in the approach channel is negligible.

d) There is no contraction of the stream as it passes through the notch.

In practice, however, none of these assumptions are satisfied. It is, therefore, customary to rewrite the equations in the form:

For the rectangular notch:

$Q = 2/3\sqrt{2g}\ \ bh^{3/2}$ (iii)

For the triangular notch:

$Q = 8/15\ \sqrt{2g}\ \ \tan \Theta/2 h^{5/2}$ (iv)

Where C_d is coefficient of discharge of the notch. It is a non-dimensional number and the dependable way of its determination is by experimentation. A convenient way of finding C_d and the exponent of h in either of these expressions is as follows. Either of Eqs. (iii) & (iv) may be written in the form:

$Q = K(h)^n$ (v)

$\text{Log } Q = \log K + N \log h$ (vi)

If experimental results are plotted on a graph having log h as abscissa and log Q as ordinate, then provided that K and n are constant over the range of the results, they will lie on a straight line having slope n and intercept log K on the axis of log Q as indicated in fig 3c.

5. Procedure:

i) Record the width of the rectangular notch.
Or
ii) The angle of V-notch.
iii) Level the apparatus by using spirit level.

Take a series of measurements of discharge and head on the notch by regulating

iv) the flow. It is recommended that the rust reading be taken at maximum discharge and subsequent readings with roughly equal decrements in head.
v) Discontinue readings when the level falls to a point at which the stream ceases to spring clear of the notch plate. This is likely to occur when the head is reduced to about 1 cm for a rectangular notch and about 2.5 cm for a triangular notch.
vi) About 3 different discharges for each notch should be noted.

6. Observations and Calculations:

A) Rectangular Notch

Width of notch, b =

Sr. No.	Gauge reading h	Quantity of water collected, V_o	Time t	Discharge Q		Calculation of C_d $A_{ct.}/Th_e$
				Actual = V_0/t	Theoretical= 2/3 $\sqrt{2g}$ $bh^{3/2}$	
Unit	(m)	(m$^{3)}$	(s)	(m^3/s)	(m^3/s)	
1.						
2.						
3.						

From graph slope n =
Intercept on log Q axis i.e. log k =
The relationship between log Q and log h is thus, Log Q = log k + n log h = Comparing this with Q = C_d2/3 $\sqrt{2g}$ $bh^{3/2}$
Cd = ---

B) Triangular Notch:

Sr. No	Gauge reading h	Quantity of water collected, Vo	Time t	Discharge Q		Calculation of C_d = $Q_{act.}/Q_{th}$
				Actual = V_0/t	Theoretical = 2/3 $\sqrt{2g}$ $bh^{3/2}$	
Units	(m)	(m^3)	(s)	(m^3/s)	(m^3/s)	
1.						
2.						
3.						

7. Result:

The graph between log Q and log h is a straight line.

8. Precautions:

i) As the correct discharge measurements are very important for this experiment, there should be no leakage at any of the regulating valves.

ii) The width of notch or the angle of the V - notch should be carefully recorded.

iii) The apparatus should be leveled.

EXPERIMENT-3

To determine the Friction Coefficient for pipe of different diameters.

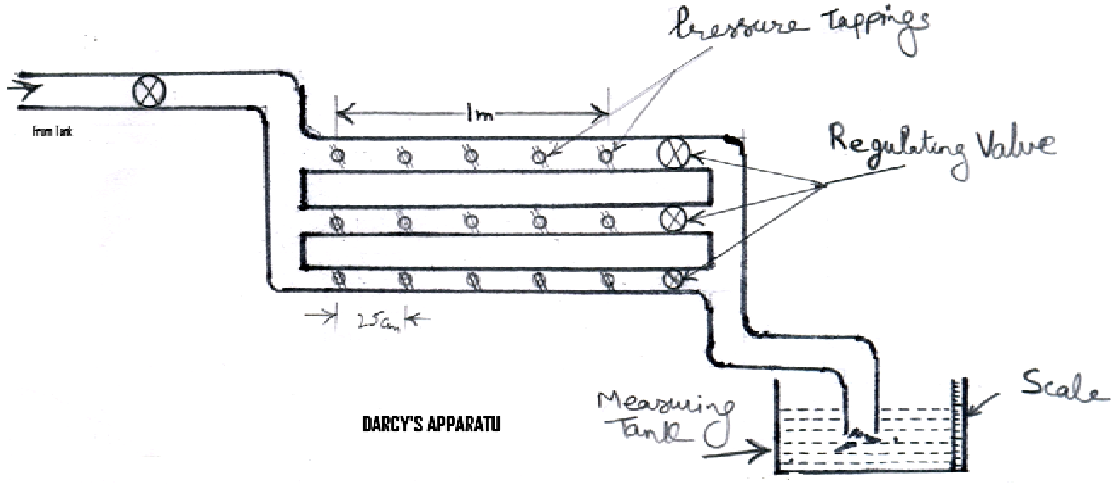
1. Objective:

To aware the students about variation of friction coefficient by changing the dia & length of the pipe.

2. Apparatus:

2.1 Darcy's apparatus consists of three pipes having the diameter 25 mm, 19 nun and 15mm. The pipes may be 100cm long.
2.2 One common inlet valve is provided in the main supply line for the whole apparatus.
2.3 Five-pressure tapping is provided at a distance of25cm from the previous one on each the pipe.
2.4 Five Piezometric tubes.
2.5 A measuring tank.
2.6 A stopwatch

3. Diagram:



4 Theory:

While the nature of flow depends upon the Reynolds Number, the frictional resistance offered to the flow of fluids depends essentially on the roughness of the surface of the conduit carrying the flow. In laminar flow this frictional resistance is mostly due to viscous resistance of fluid to flow. In turbulent flow it is due to resistance offered by viscosity of fluid and surface roughness of the conduct This frictional resistance causes loss of head ~ which is given by Darcy and Weisbach equation:

$h_f = 4fLV^2/2gD$

Where f is called Darcy's friction factor and given by f = 64/Re for laminar flow and depends upon relative roughness of pipe in case of turbulent flow.

5. Procedure:

i) Connect the Piezometric rubber tubes to gauge points of one of the pipelines.
ii) Open the inlet valve, keeping the outlet valve closed.
iii) Check if there is any air bubbles in the Piezometric tube. Remove air bubbles if any.
iv) Open partially the outlet valve, keeping the common inlet valve fully open.
v) Allow the flow to get established and then take Piezometric reading.
vi) Measure the discharge.
vii)Repeat steps (iv) to (vii) for other pipes.

6. Observations and Calculations:

Diameter of pipes
D_1= 25mm
D_2= 19mm
D_3 = 15mm
f= $2gDh_fA^2/4LQ^2$

Pipe	Run No	Discharge measurement			Piezometric reading			f= $2gDh_fA^2/4LQ^2$
		Volume Vo	Time t	Discharge Q=V/t	h_1	h_2	$h_f=h_1- h_2$	
Units								
Length= Dia.=	1							
	2							
	3							
Length= Dia.=	1							
	2							
	3							
Length= Dia.=	1							
	2							
	3							

7. Result:

i) As the diameter of pipe is increased the value of Darcy's friction factor Increases.
ii) As the length of pipe increases the value of Darcy's friction factor decreases.

8. Precaution:

i) Take care that there is no air bubbles in the apparatus when taking piezometric readings.
ii) There should be no leakage.

EXPERIMENT-4
To determine the hydraulic coefficient for flow through an ORRIFICE.

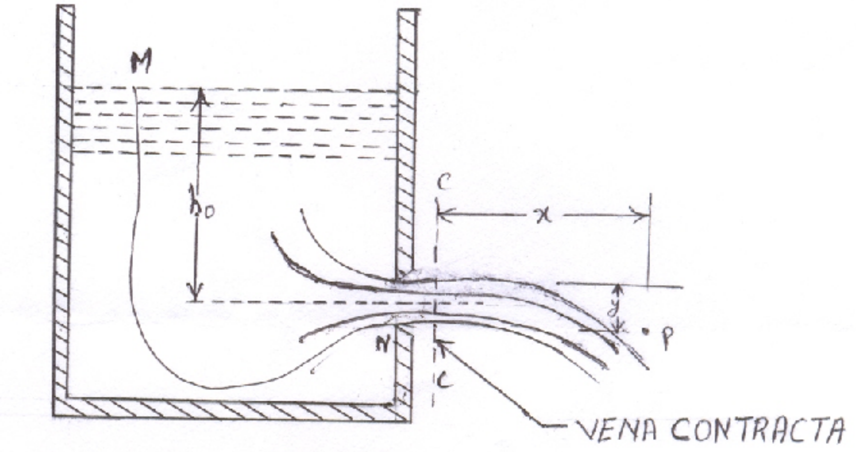
1.Objective:

To visualizes the physical significance of Vena-Contracta & also hydraulic coefficient of the orifice.

2. Apparatus:

2.1 An orifice tank provided with:
a) A regulate supply.
b) A piezometer tube to measure the head.
c) A horizontal graduated scale with a hook gauge at measure the coordinates of any point on the jet.
2.2 Micrometer contraction gauge.
2.3 Stopwatch.
2.4 Measuring tank.

3. Diagram:



FLOW THROUGH AN ORIFICE

4. Theory:

Fig.3a shows the essential features of flow through an orifice /mouthpiece. The tank is assumed to be sufficiently large for the velocity of flow in it to be negligibly small except close to the orifice. In the vicinity of the orifice the flow accelerates towards the center of the hole so that as the jet emerges, it suffers a reduction of area due to the curvature of the streamlines, as typified by the streamlines MN indicated in the fig3a. The reduction of area due to this local Curvature may be taken to be complete at about half an orifice diameter downstream of the plane of the orifice; the reduction is usually referred as the vena-contracta.

The coefficient of contraction C_c is defined as the ratio of the cross-section of the vena-contracta 3c to the cross- section of the orifice, a_o i.e.

$$C_C = a_c / a_o \qquad \text{(i)}$$

Because of the energy loss, which takes place as the water passes down the tank and through the orifice the actual velocity V c in the plane of the vena-contracta, will be less than the theoretical velocity V_o.

The ratio of the actual velocity V_c and the ideal velocity V_o is often referred as the coefficient of velocity C_v of the orifice i.e.

$$C_v = V_c / V_o \qquad \text{(ii)}$$

The theoretical velocity in the plane of vena- contracta V_o can be calculated from the equation.

$$V_o/2g = h_o \text{ i.e.}$$

$$V_o = \sqrt{2g\, h_o} \qquad \text{(iii)}$$

The actual velocity in the plane of vena- contracta is given by the equation.

$$V_c = \sqrt{(gx^2/2y)} \qquad \text{(iv)}$$

Where x, & y measured positive downward represents the horizontal & vertical coordinates of point P on the trajectory of the jet (origin being taken at the lowest point of the jet at vena- contracta).

Substituting he values of V_o & V_c in the equation (ii) we get

$$C_v = \sqrt{(x^2/4y\, h_o)} \qquad \text{(v)}$$

Finally, the coefficient of discharge C_d is defined as the ratio of the actual discharge to that which would take place if the jet is discharged at the ideal velocity without reduction of area. The actual discharge Q is given by

$$Q = V_c a_c \qquad \text{(vi)}$$

& Can be measured with the help of measuring tank and if the
Thus the coefficient of discharge C_d is given

$$Cd = Q/Q_o = (V_c a_c)/(V_o a_o) = Q/(a_o \sqrt{2g\, h_o}) \qquad \text{(vii)}$$

$$= (a_c/a_o)(V_c/V_o) = C_c\, C_v \qquad \text{(viii)}$$

5. Procedure:

i) Fix the orifice! Mouth piece of desired shape & size is connected to the opening in the sidewall of the intake tank, near its bottom.

ii) Allow the water to enter the intake tank through the regulating valve &

wait till the water level in the tank becomes steady.

iii) Measure the head h using a piezometric tube fixed to the inlet tank.

iv) Measure the discharge corresponding to each value of h.

v) Measure x & y co-ordinates of the lower surface of the jet trajectory at four different points of the jet at vena- contracta.

vi) Plot graph for Q vs $\sqrt{h}$

6. Observation & Calculations:

Area of cross- section of orifice, a_o =

Reading on the piezometric scale at the
Level of the center of the orifice, h_1=

Determination of C_d

S. No	Quantity of water collected V	Time taken t	Q	$C_d = Q/(\sqrt{2gh_o})\, a_o$	h_o
1 2 3					

Average value of Cd = --

Determination of C_v

S.No	x_0	y_0	x'	y'	x= x'- y'	y=y'-y_0	$C_v = x/2\sqrt{yh_0}$	Remarks
1 2 3								

Average value of C_v= --

Then $C_c = C_d / C_v$ = ---

7. Result:

The variations of $\sqrt{h_o}$ with Q should be linear provided C_d remains constant over the range of the experiment.

8. Precautions:

i) When taking reading with the piezometric tube check that air is not trapped in this tube.

ii) Take care that water level in the inlet tank is fairly constant when taking a reading.

EXPERIMENT-5

To determine the Metacentric height of a given Vessel under:
(a)Unloaded Condition
(b)Loaded Condition

1. Objective:

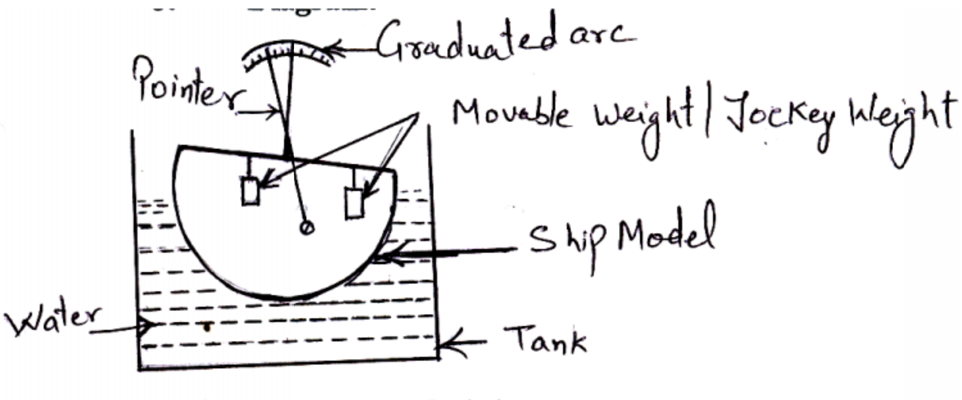
TO DETERMINE THE METACENTRIC HEIGHT OF A GIVEN VESSEL UNDER:

a) Unloaded Condition
b) Loaded Condition

2. Apparatus:

2.1 A Pontoon floating in tank
2.2 Removable strips.
2.3 Graduated arc with pointer.
2.4 Movable hangers set of weight.

3. Diagram:



METACENTRIC HEIGHT APPARATUS

4. Theory:

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

a) The downward force of gravity acting on each particle that goes to make up the weight of body W_c acting through the center of gravity G.

b) The upward buoyant force of the fluid acting on the various elements of submerged surface of the floating object F_B acting through the center of buoyancy.

For a body to be in equilibrium on the liquid surface, the two forces must be Wc & F_B must lie in the same vertical line i.e. these two forces must be collinear and opposite. When the pontoon has been tilted through an angle of Θ, the center of gravity of body G, is usually remained unchanged in its position, but B i.e. center of buoyancy will generally unchanged in its position, thus Wc and F_B forms a couple. The line of action of F_B in the new position at axis of the body at M, which is called the metacentre and the distance GM, is called 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

$$= \frac{Wm \times d}{(Wc + Wm) \tan \theta}$$

Here Wc is weight of pontoon, Wm is weight of unbalanced mass causing moment on the body, d is the distance of the unbalanced mass from the centre of crossbar.

5. Procedure:

i) Note down the relevant dimensions as area of collecting tank, mass density of water etc.

ii) Note down the water level in the tank when pontoon is not in the tank.

iii) Pontoon is allowed to float in the tank. Note down the reading of water level in the tank. The help of Archimidie 's principle can obtain Mass of pontoon.

iv) Position of unbalanced mass, weight of unbalanced mass and the angle of heel can be noted down calculate the Metacentric height of the pontoon.

v) The procedure is repeated for other position and value of unbalanced mass. Also the procedure is repeated while changing the number of strips in the pontoon.

6. Observations and Calculations:

A) Loaded Condition:
Area of tank =
Rise in water level =
Weight of ship =

Sr. No	Unbalanced mass Wm	Distance of Unbalanced mass	Angle of heel ϴ	Metacentric height $\frac{Wm \times d}{(Wc + Wm) \tan \theta}$
1				
2				
3				

B) Unloaded condition:

Area of tank = 50 X 49 Cm^2

Rise in water level =
Weight of ship =9810X.50X.49 X Rise in water level

Sr. No	Unbalanced mass Wm (N)	Distance of Unbalanced Mass (m)	Angle of heel = l/r Θ	Metacentric height $\frac{Wm \times d}{(Wc + Wm) \tan \Theta}$
1				
2				
3				

7. Result:

i) In case of loaded,
Average Metacentric height = ---
ii) In case of unloaded,
Average Metacentric height = -----

8. Precautions:

i) Apparatus should be in leveled condition.
ii) Reading must be taken in steady condition of water. iii) Measure the angle of tilt accurately.

EXPERIMENT-6

To determine the bead loss in the Pipeline due to sudden expansion, Sudden Contraction and bends.

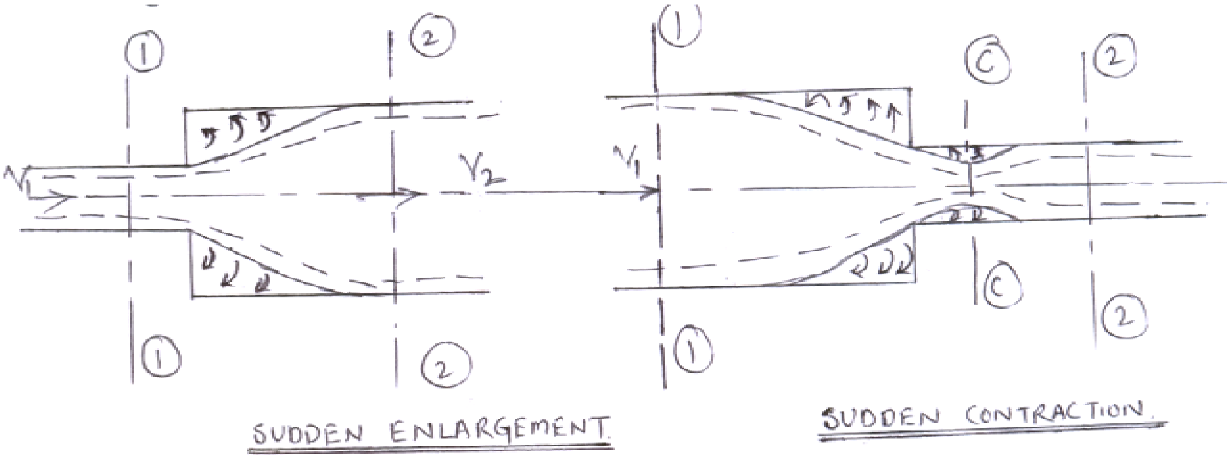
1. Objective:

To aware students about minor losses of the pipes.

2. Apparatus:

2.1 The apparatus consists of a bend, an elbow, a gate valve, a globe valve, a sudden contraction, and a sudden enlargement.
2.2 A "u" tube manometer.
2.3 A stopwatch
2.4 A measuring tank.

3. Diagram:



4. Theory:

The frictional resistance causes loss of head h_f, which is given by Darcy & Weisbach Equation.

$$h_f = 4fLv^2/2gD$$

Where f is called Darcy's equation & is given by f = 64/Re for laminar flow & depends upon relative roughness of pipe in case of turbulent flow. But the head losses due to change of section, bend elbows; valves & fittings of all types are classified as minor losses in pipe lines.

Minor losses usually result from rather abrupt changes (in magnitude & direction) of velocity. In general, increase of velocity (acceleration) is associated with small head loss but decrease of velocity (deceleration) causes large head loss because of the production of large-scale turbulence.

Early experiments with water (at high Reynolds Number) indicated that minor losses very approximately with the square of velocity & lead to the proposal of the basic equation.

$h_L = kv^2/2g$

In which k, the loss coefficient is practically constant Loss of head for

A bend = $k\,v^2/2g$
An elbow = $k\,v^2/2g$
Gate valve = $k\,v^2/2g$
Globe valve = $k\,v^2/2g$
Sudden contraction = $1/2v^2/\,2g$
Sudden enlargement = $(v_1-v_2)^2/\,2g$

5. Procedure:

i) Open the inlet valve, keeping the outlet valve closed.
ii) Connect the manometer rubber tubing to one of the pipe/pipes fittings & check that there is no air bubbles entrapped.
iii) Open partially the outlet valve, keeping the common inlet valve fully open.
iv) Allow the flow to get constant & then take manometer reading.
v) Measure the discharge.
vi) Take at least three readings.
vii) Repeat steps (i) to (vi) for different fittings.

6. Observation and Calculation:

Diameter of main pipe, D =
Diameter of enlarge pipe, D_l =
Area of cross- section of main pipe,a =
Area of cross- section of enlarged pipe, a_l =
Length of main pipe between pressure tapping, L =

Pipe/s fittings	Run No.	Discharge measurement			Velocity of flow in		k	h_f / h_L	
		Volume of water collected Vo	Time t	Discharge Q	$V = Q/a$	Enlarged Pipe $V_l = Q/a_l$		Calculated	Measured
Bend Elbow Gate valve Globe valve Sudden Enlargement Sudden Contraction									

7. Result:

The friction resistance varies:

i) with the degree of roughness of surface with which fluid comes in contact

ii) with the extent of area of surface coming in contact with fluid

8. Precautions:

i) Take care that there is no air bubble entrapped in the apparatus when taking manometer reading.

iii) There should be no leakage from any of the pipe fittings.

EXPERIMENT-7

To study the transition from Laminar to Turbulent flow and to ascertain the lower critical Reynolds number.

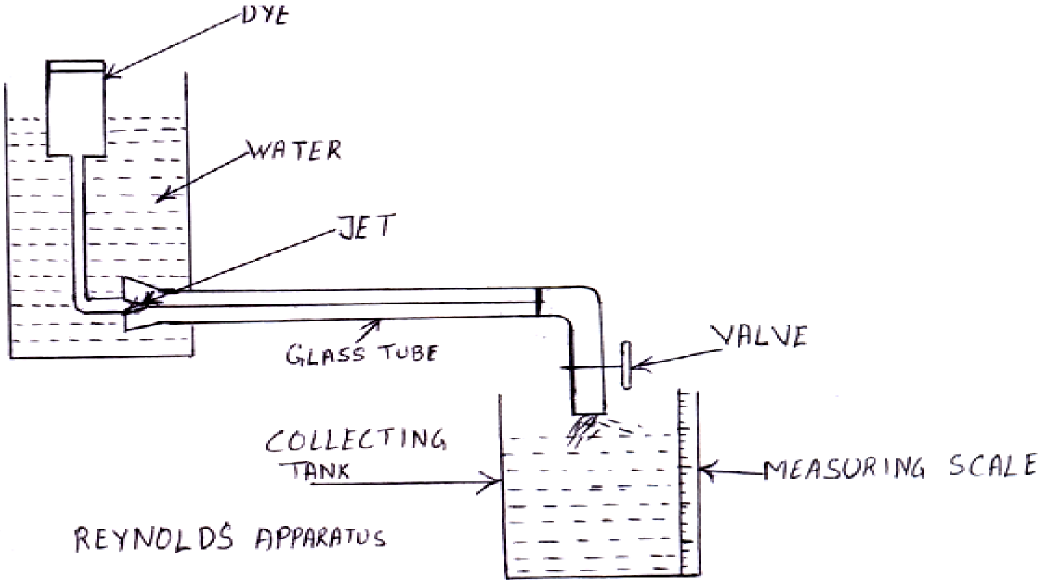
1. Objective:

To impart knowledge of laminar and turbulent flow in relation to Reynold's Number.

2. Apparatus:

2.1 A glass tube with a bell mouthed inlet leads from a large tank.
2.2 A dye container is attached to the side- wall of the tank to inject a stream of dye into the glass tube.
2.3 A measuring tank to find actual discharge
2.4 A stopwatch.

3. Diagram:



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4. Theory:

Osborne Reynolds, in 1883, conducted a number of experiments to determine the laws of resistance in pipes. By introducing a filament of dye into the flow of water along a glass pipe, he showed the existence of two different types of motion. At low velocities the filament appeared as a straight line, which passed down the whole length of the tube, indicating laminar flow. At higher velocities, the filament, after passing little way along the tube, suddenly mixed with the surrounding water, indicating that the motion had now become turbulent.

Experiments with pipes of different diameters & with water at different temperatures led Reynolds to conclude that the parameter, which determine whether the flow shall be laminar or turbulent in any particular case is:

$Re = \rho VD/\mu$

In which Re denotes the Reynolds Number of motion

ρ denotes the density of fluid

V denotes the velocity of flow

D denotes the diameter of pipe

μ denotes the coefficient of viscosity of the fluid

The motion is laminar or turbulent according as the value of Re is less than or greater than a certain value. If experiments are made with increasing rate of flow, the value of Re depends on the degree of care which is taken to eliminate disturbances in the supply or along the pipe. On the other hand, if experiments are made with decreasing flow, transition from turbulent to laminar flow takes place at a value of Re which is very much less dependent on initial disturbances. This value of Re is about 2000 for flow through circular tubes, and below this the flow is inherently laminar in nature. The velocity at which the flow in the pipe changes from one type of motion to the other is known as critical velocity and is given by:

$V = Re\ \mu / \rho\ D$

Also, the value of critical velocity corresponding to Re = 2000, also known as lower critical Reynolds Number, is called Lower Critical Velocity. The upper critical Reynolds Number (the maximum value of Re at which laminar flow is physically possible) depends largely upon the nature of disturbance present in the flow and may be as high as 40000.

5. Procedure:

i) Open the main supply valve & fill the tank of the apparatus with water, with outlet of glass tube partly open so that no air is entrapped in the glass tube.

ii) Close the outlet valve of the glass tube and the inlet valve of the tank when the tank is full.

iii) Leave the apparatus for some time so that water in the tank is at rest. No disturbance.

iv) Partially open the outlet valve of the glass tube & inlet of the tank so that velocity of flow is very small and the water level in the tank is fairly constant.

v) Open inlet of the dye-injector so that the dye stream moves as a straight line through the tube showing that the flow is laminar.

vi) Increase the velocity of flow & again measure the discharge.

vii) Take three readings till the dye filament wavers for the first time near the outlet end of glass tube.

viii) Note down the room temperature at least three times during the experiment
ix) Repeat the experiment with decreasing rate of flow & encircle the reading for which dye filament wavers for the last time near outlet end of glass tube; as the flow changes from turbulent to laminar.

6. Observation & Calculations:

Inner diameter of glass tube, D =
Cross-sectional area glass tube, A = (л/4) D^2
Mass density of water, ρ =
Average room temperature, Θ =
Dynamic viscosity of water at room temperature, μ =
Volume of water collected, V_o =

S.NO	V_o	t	Q	$V=Q/A$	$Re= \rho VD/ \mu$	Θ	Remarks
Units							
1							
2							
3							

7. Result:

Average Critical velocity = ------------
=-----

8. Precautions:

i) Don't forget remove any entrapped air in the apparatus before starting measurement.
ii) There should be no mechanical vibration near the apparatus.
iii) Don't forget to record the temperature of water at frequent intervals.
iv) Increase in velocity of flow should be in stages.

EXPERIMENT-8

To determine the coefficient of discharge for an obstruction floe meter(VENTURIMETER).

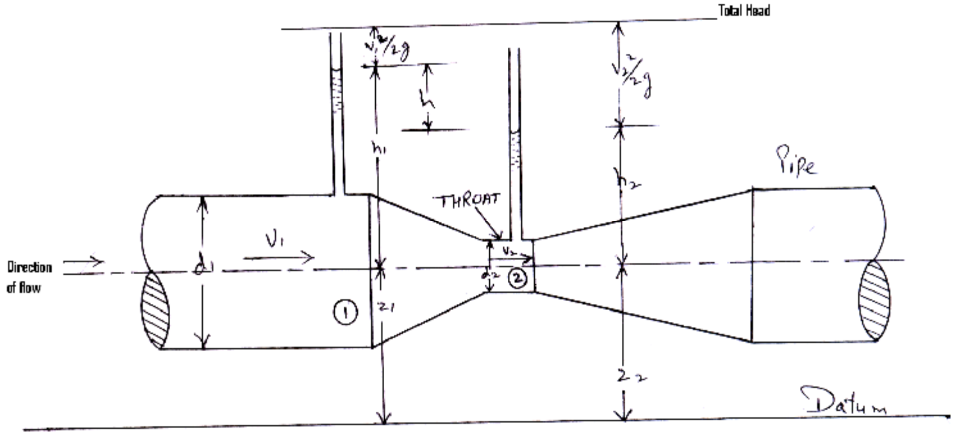
1. Objective:

To aware the students about coefficient of discharge measurement with the help of venturimeter.

2. Apparatus:

2.1 A venturimeter with tapping at the mouth and throat give connections to the manometer.
2.2 A 'U' tube manometer containing mercury.
2.3 A measuring tank to find actual discharge
2.4 A stopwatch.

3. Diagram:



VENTURIMETER

4. Theory:

The venturimeter is a device, which has been used over many years for measuring the discharge along the pipe. It consists of a convergent section which reduces in diameter to between one-half and one-fourth of pipe diameter. This is followed by a throat and then a divergent section. The convergent angle is usually 20°. For the divergent part the angle of divergence is usually 5° to 7°.

The fluid flowing in the pipe is led through a contraction section to a throat, which has a smaller cross-sectional area than the pipe. So that the velocity of fluid through the throat is higher in the pipe. This increase of velocity is accompanied by a fall in pressure, the magnitude of which depends on the rate of flow, so that by measuring the pressure drop, the discharge may be calculated.

Beyond the throat the fluid is decelerated in a pipe of slowly diverging section. The pressure increasing as the velocity falls.

With usual notations, the expression for discharge Q, through a venturimeter is given by

$$Q = \frac{a_l a_2 \sqrt{2g(h_1-h_2)}}{\sqrt{a_l^2 - a_2^2}} \qquad (i)$$

Where

$D_{1=} 2.54$ cm, $D_2 = 1.27$ cm

a_l = area of cross-section of an upstream section
a_2 = area of cross-section at throat
h_1 = piezometric head at the upstream section
h_2 = piezometric head at the throat as shown in fig
g = acceleration due to gravity

In practice there is some loss of energy between section 1 & 2 & the velocity is not absolutely constant across either of these sections. As a result, measured value of Q usually falls a little sort of those calculated from Eq. (i) & It is customary to allow for this discrepancy by writing:

$$Q = C_d \frac{a_l a_2 \sqrt{2g(h_1-h_2)}}{\sqrt{a_l^2-a_2^2}}$$

$$= [C_d\ a_l a_2/\sqrt{a_l^2-a_2^2}]\ \sqrt{2gh},\quad \text{where } h=h_l-h_2 \qquad \text{(ii)}$$

In which K is known as the venturimeter coefficient & its value varies slightly from one venturimeter to another, and even for a given venturimeter it may vary with the discharge, but usually lies within the range of 0.92 to 0.99. In case the piezometric tapping are connected to a differential manometer, then:

$h = (S_2/S_1- 1)\, h'$

h' = differential manometer reading
S_2 = sp. gr. of measuring liquid in differential manometer
S_1= sp. gr. of liquid flowing in pipeline.

5. Procedure:

i) Open the regulating valve so that water starts flowing through the venturimeter.
ii)Wait for some time so that the flow gets stabilized.
iii)Remove air bubbles, if any, entrapped in piezometeric tubes.
iv)Note differential manometer readings hl& h2 .
v)Measure the discharge of the apparatus by collecting a certain volume of water in a predetermined time.
vi)Repeat steps (iii) & (iv) for different flow rates and take at least six different sets of observations.
vii) Take another set of manometer readings for calculation of discharge of the pipeline for constant outflow.

6. Observations and Calculations:

Sr. No	Discharge measurement		Manometer reading				$C_d = Q\ a_l a_2/\sqrt{a_l^2-a_2^2}]\ \sqrt{2gh}$
	$Q=V_0/t$	t	h_1	h_2	h'	$h=(S_2/S_1 -l)h'$	
Unit							
1							
2							
3							

7. Results:

Average Value of C_d =

8. Precautions:

i) There should be no air bubble entrapped while taking reading of liquid level in piezometeric tubes.
ii) Check that the top level of measuring liquid is same in the two limbs of the differential manometer.

9. Question for discussion:

i) What suggestions do you have for the improving the value of the coefficient of discharge?
ii) What happens to manometer if the pressure in the tapping is too more?
iii) What are other liquids (more sp. gr.) can be use?