FLUID MECHANICS LAB
INTERSESSION SEMESTER: 2016-17

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OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through orifice experiment (Constant head)

S.No.	Head (m)	Time for H cm rise (T) - sec	Discharge (Q) m^3 / s		Coefficient of discharge, C_d
			Q_a	Q_{th}	

Diameter of orifice, d =

Dimensions of collecting tank, A =

Experiment No: Roll No:
Date :

1. DETERMINE THE DISCHARGE FROM A GIVEN TANK PRESENT IN TATA CHEMICAL LABORATORY (using ORIFICE)

AIM

To determine the coefficient of discharge of orifice by constant head method

BASIC CONCEPT

An orifice is an opening having a closed perimeter, made in the walls or in the bottom of the tank containing fluid, through which fluid may be discharged. The discharging fluid from the tank through the orifice comes out in the form of a free jet. In the process, the total energy of the fluid in the tank is converted to kinetic energy as the jet issues out into the atmosphere. The shape of the jet is function of the geometry of the orifice. The jet cross-section contracts to minimal and then expands partly due to viscous resistance offered by the surrounding atmosphere and partly due to inertia of the fluid particles. The jet cross-sectional area at which it is having minimum area is known as "Vena Contracta".

The following formulae are employed to fine the coefficient of discharge of an orifice.

Theoretical discharge, $Q_{th} = a\sqrt{2gh}$

a = area of cross section of the orifice = $\frac{\pi}{4} \times d^2$

h = head of the liquid above the centre of the orifice in the tank

g = acceleration due to gravity

Actual discharge, $Q_a = AH/T$

A = Internal plan area of collecting tank

H = Rise of liquid in collecting tank

T = Time taken to collect liquid in the collecting tank

Coefficient of discharge, $C_d = Q_{at}/Q_{th}$

MODEL CALCULATIONS

APPARATUS

1 Orifice fitted to a tank
2 Piezometers
3 Meter scale
4 Calipers
5 Stop watch
6 Collecting tank fitted with a valve

PROCEDURE

1. The diameter of the orifice and the internal plan dimensions of the collecting tank are measured.
2. The supply valve of the orifice tank is regulated and water is allowed to fill the orifice tank to a constant head (h)
3. The out let valve of the collecting tank is closed tightly and the time taken for “H ” rise of water in the collecting tank is noted.
4. The above procedure is repeated for different heads and the readings are tabulated.

GRAPHS

The following graph is drawn by taking Q_a on y – axis and $\sqrt{h}$ on x - axis.

Q_a vs $\sqrt{h}$

RESULT

The coefficient of discharge of orifice, C_d = ------------------

(From experiment)

The coefficient of discharge of orifice, C_d = --------------------

(From Q_a vs $\sqrt{h}$ graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through Mouthpiece experiment (Variable head)

S.NO	Head (m)		Time (t) sec	$\sqrt{h_1}-\sqrt{h_2}$ (m)	Coefficient of discharge, C_d
	h_1	h_2			

Diameter of Mouthpiece, d =

Dimensions of balancing tank =

Experiment No: Roll No:

Date :

2. DETERMINE THE DISCHARGE FROM A GIVEN TANK PRESENT IN TATA CHEMICAL LABORATORY (using MOUTHPIECE)

AIM

To determine the coefficient of discharge of mouth piece by variable head method

BASIC CONCEPT

A mouth piece is a short tube fitted to a circular orifice provided to the bottom of the tank. The length of the tube is usually two to three times its diameter. It is usually required to know the actual flow rate and the time required for emptying a tank through a mouth piece

Time required for the liquid to descend from h_1 to h_2, (t) = $\dfrac{2A(\sqrt{h_1}-\sqrt{h_2})}{C_d a\sqrt{2g}}$

a = cross –sectional area of orifice

h_1 = initial liquid level in the orifice tank

h_2 = final liquid level in the orifice tank

g = acceleration due to gravity

A = internal plan area of the balancing tank = L x B =

C_d = coefficient of discharge of orifice

APPARATUS

Mouth piece fitted to a tank

Piezometer

Meter scale

Callipers

Stop watch

MODEL CALCULATIONS

PROCEDURE

1. The diameter of the mouth piece and the internal plan dimensions of the mouth piece tank are measured.
2. Water is allowed in to the mouthpiece tank so that the head above the centre of the mouth piece is h_1.
3. The supply valve is completely closed and the water level in the mouth piece tank is allowed to descend to h_2.
4. Note down the time taken (t) to descend the water level from h_1 to h_2
5. The above procedure is repeated for different values of h_1 and h_2.

GRAPHS

A graph is drawn by taking t on y - axis and $\sqrt{h_1} - \sqrt{h_2}$ on x-axis.

t vs ($\sqrt{h_1} - \sqrt{h_2}$)

RESULT

The coefficient of discharge of mouth piece, C_d=

(from experiment)

The coefficient of discharge of mouth piece, C_d=

(from graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through Triangular/Rectangular notch

S.NO	Hook gauge reading (mm) at sill level during zero discharge in channel, h_o (m)	Hook gauge reading (mm) at free Surface, h_1 (m)	Head over the notch ($h=h_1-h_o$) m	Time for H cm rise, T sec	Discharge (Q) m^3/s		Coefficient of discharge (C_d)
					Q_{th}	Q_{act}	

Vertex angle of the triangular notch, θ =

Dimensions of collecting tank =

Experiment No: Roll No:
Date :

3. DETERMINE THE DISCHARGE PASSING THROUGH A PALAR RIVER (using TRIANGULAR / RECTANGULAR NOTCH)

AIM

To study the flow over a triangular notch and to calibrate it for the discharge measurement for a free surface flow.

BASIC CONCEPT

A weir is an obstruction placed across a free surface flow such that the flow takes place over it. The weir with a sharp edge is commonly referred to as a notch. Generally, notches are opening cut in metallic plates and installed in flumes to measure the discharge. The free surface flow taking place over it acquires steady state condition such that the discharge is uniquely related to the head over the crest of the notch and its geometry. In actual practice, the discharge over a notch is considerably less than the theoretical discharge. This is due to real – flow effects like viscosity, end-contraction, nappe suppression, ventilation of notches, etc. The actual discharge is obtained by multiplying the theoretical discharge by a factor called Coefficient of Discharge, C_d

The following formula is employed.

Theoretical discharge (Q_{th}) = $\frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}h^{5/2}$ (Triangular Notch)

h=head over the sill of the notch

θ = Vertex angle of the notch

g= acceleration due to gravity

Theoretical discharge (Q_{th}) = $\frac{2}{3}\sqrt{2g}Lh^{3/2}$ (Rectangular Notch)

L = length of the crest

h=head over the sill of the notch

g= acceleration due to gravity

Actual Discharge (Q_a) = AH/t

A= Internal plan area of the collecting tank

H= Time required for a rise of “H” cm in the collecting tank

t= time required for rise of ‘H’ cm in the collecting tank.

Coefficient of discharge for a triangular notch (C_d) = Q_a/Q_{th}

MODEL CALCULATIONS

APPARATUS

1. Flume with a Triangular / Rectangular notch
2. Hook gauge
3. Collecting tank.
4. Stop watch
5. Piezometer
6. Scale.

PROCEDURE

1. The internal plan dimensions of the collecting and the vertex angle of the notch are measured.
2. The supply valve is opened and the water is allowed to rise up to sill of the notch and then the supply valve is closed.
3. The tip of the pointer of the hook gauge is adjusted such that the tip coincides with free water surfaces.
4. The sill level of the notch (h_o) is noted in the hook gauge.
5. The supply valve is opened and the water is allowed to flow through. The tip of the pointer is adjusted to coincide with the water surface.
6. The reading of the hook gauge (h_1) is noted down.
7. The outlet valve of the collecting tank is closed and the time taken for a rise of "H" in the collecting tank is noted down.
8. The above procedure is repeated for different heads of flow.

GRAPHS

The following graphs is drawn with Q_a on y- axis and $(h)^{5/2}$ on x – axis, $Q_a$vs $(h)^{5/}$

RESULT

The coefficient of discharge of the Triangular / Rectangular notch, (C_d)=

(from experiment)

The coefficient of discharge of the Triangular / Rectangular notch, (C_d)=

(from Q_a vs $(h)^{5/2}$ (or) $(h)^{3/2}$graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through Venturimeter

S.No.	Manometric reading in cm of mercury		Equivalent head in meters of water (h)	Time for H rise sec	Discharge (Q) m^3 / s		Coefficient of discharge, C_d
	h_1	h_2			Q_{act}	Q_{th}	

Diameter of inlet of venturimeter, d_1 =
Diameter of throat of venturimeter, d_2 =
Dimensions of collecting tank =

Table 2. Results of flow through Orificemeter

S.No.	Manometric reading in cm of mercury		Equivalent head in meters of water (h)	Time for H rise sec	Discharge (Q) m^3 / s		Coefficient of discharge, C_d
	h_1	h_2			Q_{act}	Q_{th}	

Diameter of pipe, d_1 =
Diameter of orificemeter, d_2 =
Dimensions of collecting tank =

Experiment No: Roll No:
Date :

4. ESTIMATE THE RATE OF FLOW FOR A PIPE LINE SUPPLYING WATER TO HOUSTON REFINERY, TEXAS (using Venturimeter / Orificemeter)

AIM

To determine the coefficient of discharge of given Venturimeter / Orificemeter

BASIC CONCEPT

Flow rate measurement is a fundamental necessity in almost all flow situation of engineering importance. For confined flows the main devices used are a class of meters called obstruction meters. The basic principle in all these obstruction meters is that the flow undergoes a change in its cross-sectional area as it passes along the channel. It results in creation of difference of pressure across the channel which is uniquely related to the flow rate and geometry of the obstruction together with the fluid properties. Venturimeter consists of a converging section, a cylindrical throat and a divergent cone. A differential mercury manometer is connected between the inlet section and the throat of venturimeter to measure the pressure difference between these two sections.

The following expressions are used to compute the discharge through a venturimeter.

Theoretical discharge, $Q_{th} = \dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{(a_1^{\,2} - a_2^{\,2})}}$

a_1 = Cross- sectional area of inlet

a_2 = Cross- sectional area of throat

g = acceleration due to gravity

h = Pressure head in terms of flowing liquid $= \dfrac{(h_1 - h_2)}{100}\left(\dfrac{s_m}{s_l} - 1\right)$

h_1 = Manometric level in one limb of manometer.

h_2 = Manometric level in another limb of manometer.

S_m= Specific gravity of manometric liquid (for Mercury = 13.6)

S_1 = Specific gravity of the flowing liquid (for Water = 1.0)

Actual discharge, Q_a = AH / t

A = Internal plan area of collecting tank.

H = Rise of water level in the tank

t = Time taken for rise of " H" cm in the collecting tank.

Coefficient of discharge of the venturimeter, $C_d = Q_a / Q_t$

MODEL CALCULATIONS

APPARATUS

1. Pipe fitted with Venturimeter / Orificemeter
2. Differential U – tube mercury manometer
3. Collecting tank fitted with piezometer and gate valve
4. Stop watch
5. Meter scale

PROCEDURE

1. The diameter of the inlet section, throat and internal plan dimensions of the collecting tank are measured.
2. The control valve in the pipe line is opened for maximum discharge.
3. The pressure difference between the inlet section and throat of the venturimeter is measured
4. The outlet valve of the collecting tank is closed and time taken for a rise of "H" cm in the collecting tank is noted down
5. The above procedure is repeated for different discharges by controlling the gate valve.

GRAPH

The following graph is drawn by taking Q_{act} on y – axis and $\sqrt{h}$ on x-axis

Q_{act} vs $\sqrt{h}$

RESULT

The coefficient of discharge of Venturimeter / Orificemeter (C_d) =
(from experiment)

The coefficient of discharge of Venturimeter / Orificemeter (C_d) =
(from Q_a vs $\sqrt{h}$ graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of Flow through pipes

S. No	Manometric Reading (cm)		Equivalent head of water (h) m	Time for 'H' cm rise T, sec	Discharge (Q) m^3/sec	Velocity (V) m/s	Friction factor, f
	h_1	h_2					

Diameter of the pipe, d =

Dimensions of the collecting tank =

Length of the tube, l =

Experiment No: Roll No:
Date :

5. DETERMINATION OF FRICTION FACTOR FOR A GIVEN PIPE LINE SUPPLYING WATER TO KONDAPALLI THERMAL POWER PLANT, VIJAYAWADA

AIM

To determine the friction factor of the pipe material

Basic concept

Transportation of fluids through pipes is frequently dealt by engineers. Distribution of water and gas to domestic consumers through conduits, supply of steam through pipes in thermal power plants and gases in process plants, offshore pumping of oil, etc are some of the examples of transportation of fluids through pipes. In order to design such systems, it is necessary to study the friction – flow characteristics through the pipes. The loss of head through the pipe is major loss and it is to be considered for designing pump capacity to supply the fluid. The prediction of frictional losses through the pipes lines enables the designer to estimate the power consumption and hence the type and size of the pumps required for a given application and length of the pipe.

When fluid flows through a pipe the frictional resistance offered to the flow depends on the roughness of the inner surface of the pipe carrying the liquid. The frictional resistance is mostly due to viscous resistance of fluid in case of laminar flow. In turbulent flow it is due to resistance offered by viscosity of the fluid and surface roughness of the pipe.

The following formula is employed

The head loss due to friction (h_f) = $fLV^2/(2gd)$

h_f = Pressure head in terms of flowing liquid = $\frac{(h_1 - h_2)}{100}\left(\frac{s_m}{s_l} - 1\right)$

h_1 = Manometric level in one of the limb of manometer.

h_2 = Manometric level in one of the other limb of manometer.

S_m= Specific gravity of manometric liquid (for Mercury = 13.6)

S_1 = Specific gravity of the flowing liquid (for Water= 1.0)

f = friction factor of the pipe material

L = length of pipe between the pressure taps

D = diameter of the pipe

V = Velocity of flow in the pipe (Q_a/a)

MODEL CALCULATIONS

Q_a = actual discharge (AH/t)

a = cross-sectional area of the pipe

H = rise of water level in the collecting tank

t = time taken for a rise "H" in the collecting tank

g = acceleration due to gravity

APPARATUS

1. Pipe fitted with gate valve
2. Differential U – tube mercury manometer
3. Collecting tank fitted with piezometer and gate valve
4. Stop watch
5. Meter Scale

PROCEDURE

1. The diameter of the pipe, internal plan dimensions of the collecting tank and the length of the pipe between the pressure tapping's are measured.
2. The gate valve is fully opened control valve in the pipe line is opened for maximum discharge.
3. The manometric heads in both the limbs of manometer are noted down.
4. The outlet valve of the collecting tank is closed and time taken for a rise of "H" cm in the collecting tank is noted down.
5. The above procedure is repeated for different discharges by controlling the gate valve and reading are noted down in table.

GRAPHS

The following graph is drawn by taking h_f on y – axis and V^2 on x-axis
h_f vs V^2

Result

The friction factor for the pipe material, (f) =
(from experiment)

The friction factor for the pipe material, (f) =
(from h_f vs V^2 graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Diameter of smaller pipe, d =

Diameter of larger pipe, D =

Area of smaller pipe, *A* =

Area of larger pipe , *A1* =

Area of measuring tank, a =

(i) Sudden enlargement

S. No	Manometric Reading		Equivalent head of water (h) m	Time for 'H' cm rise, sec	Discharge (Q) m^3/sec	Velocity (V) m/s, V=*Q* /A	$K_L = \frac{h_L}{\left(V^2/2g\right)}$
	h_1	h_2					

Average K_L =

Theoretically, $K_L = \left(1 - \frac{A}{A_1}\right)^2$

(ii) Sudden contraction

S. No	Manometric Reading		Equivalent head of water (h) m	Time for 'H' cm rise, sec	Discharge (Q) m^3/sec	Velocity (V) m/s, V=*Q* /A	$K_L = \frac{h_L}{\left(V^2/2g\right)}$
	h_1	h_2					

Average K_L =

Experiment No: Roll No:
Date:

6. ESTIMATE MINOR LOSSES DUE TO SUDDEN EXPANSION AND CONTRACTION, AND BEND FOR TWO PIPE LINES, WHICH ARE PART OF CHENNAI METRO WATER SUPPLY SYSTEM

OBJECTIVE

To determine the loss of coefficient for flow through pipes due to sudden enlargement, sudden contraction and due to pipe fittings like bend and elbow.

Basic concept

When fluid flows through a pipe, it is subjected to hydraulic resistances which are of two types, viz. (1) viscous-frictional resistance and (2) local resistance. Viscous-frictional resistance associated with the fluid flow is called major loss of energy, whereas local resistances are called minor losses energy

Local resistances are essentially due to change of velocity either in magnitude or direction, or both. This change of velocity generates large-scale turbulence due to formation of eddies, in which a portion of energy possessed by the fluid gets dissipated as heat energy. Losses due to change in cross-section, bends, valves and fitting of all types are categorized as minor Losses. In short pipes, minor losses may sometimes be more than the friction losses and hence are required to determine.

All minor losses have be found to vary as the square of the mean velocity of flow and, hence, they are generally expressed fraction of velocity head, i.e. $h_L = K_L V^2 / 2g$ Where h_L is the loss of energy per unit weight, V is the average velocity of flow in the pipe, g is the acceleration due to gravity, and K_L is constant called loss coefficient (K_L) is constant at high Reynolds number and for particular flow geometry,

For sudden enlargement of the pipe section, the head loss is given by the following expression

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

Where V is the velocity in smaller pipe and V1 is the velocity of flow in larger pipe. This expression is further simplified to

(iii) Elbow

S. No	Manometric Reading		Equivalent head of water (h), m	Time for H rise, Sec	Discharge (Q) m^3/sec	Velocity (V) m/s, V=**Q** /**A**	$K_L = \frac{h_L}{\left(V^2 / 2g \right)}$
	h_1	h_2					

Average K_L =

(iv) Bend

S. No	Manometric Reading		Equivalent head of water (h), m	Time for H rise, Sec	Discharge (Q) m^3/sec	Velocity (V) m/s, V=**Q** /**A**	$K_L = \frac{h_L}{\left(V^2 / 2g \right)}$
	h_1	h_2					

Average K_L =

$$h_L = \frac{K_L x V^2}{2g}$$

where $K_L=1/(A-A_1)^2$

Here, A is the area of smaller pipe and $A_1$is the area of larger pipe.

The value of h_L can be determined by writing the gauge equation between the two gauge points and mercury – water column manometer

$$h_L=12.6\times\Delta x$$

Where Δx is the difference of mercury levels in the manometer.

EXPERIMENTAL SET-UP

The apparatus consists of two pipes connected through a common manifold. These pipes are fitted with bend, elbow, glob valve, and gate valve etc. The sudden enlargement and sudden contraction are also provided in the pipe. Water is supplied to the manifold through an inlet valve provided in the supply pipeline connected to a constant overhead water tank. Pressure taping is provided on upstream and downstream ends of each fitting for the measurement of pressure head difference across the fitting and to compute the head loss through the fittings. The pressure tapings are connected to a multi tube U-tube differential manometer containing mercury. The discharge through each pipe is regulated by means of a valve provided near the outlet end of each pipe.

PROCEDURE

1. Take one fitting at a time of a particular pipe and open pressure valves corresponding to it. And keep close valves of all other fittings as well as other pipes. Remove air in the manometer for this fitting.
2. Open the inlet valve fully and regulate the flow with the help of exit valve.
3. When the flow becomes steady, measures pressure head difference (Δx) across the fitting.
4. Measure the discharge, Q.
5. Repeat steps (2) to (5) for three different discharges by regulating the flow with the exit valve.
6. Repeat the above steps for other types of fittings.

MODEL CALCULATIONS

RESULT

The loss coefficient for various fittings

i) For sudden Enlargement =________________

ii) For sudden contraction =________________

iii) For 90^0 bend =________________

iv) For 90^0 elbow =_________________.

INFERENCE:

OBSERVATIONS AND CALCULATIONS

S.No.	Time for 2 cm rise of water (sec)	Q =Ah/t (m^3/s)	V=Q/a, m/s	Re= $\frac{\rho VD}{\mu}$	Type of flow

OBSERVATIONS

Area of the collecting Tank A =

Diameter of the perplex tube d =

Area of conduit /pipe a =

Density of water ρ =

Viscosity of water μ =

Experiment No : Roll No:
Date:

7. CLASSIFY THE TYPE OF FLOW USING REYNOLD’S APPARATUS IN PLYMOUTH MARINE LABORATORY, U.K.

AIM

To study the flow transition from laminar to turbulent using Reynold’s method.

APPARATUS

Reynold’s apparatus

BASIC CONCEPT

Reynold’s explained the distinction between the types of flow, i.e. laminar flow and turbulent flow. At low flow rates the water flows in parallel straight lines without any cross current or mixing and it is called as laminar flow. When the flow rates was increased a velocity called critical velocity was reached at which the flow become wavy and the water flows in erratically in the form of cross current and eddies. This type of flow is called as turbulent flow.

The critical velocity at which laminar flow changes into turbulent flow depends on four quantities: diameter of the tube, viscosity, density and average linear velocity of the liquid. These four factors can be combined into one dimensionless group and changes occur in the flow can be relate to a definite value of a group. This dimensionless group is called Reynold’s number, Re.

FORMULA

$$\mathrm{R_e} = \frac{\rho V D}{\mu}$$

$$Q = \frac{A \times H}{t}, V = \frac{Q}{a}$$

Where,

ρ= Density of water (1000 kg/m^3)

D= Diameter of perplex tube

a= Area of perplex tube

μ= Viscosity of water (0.001 N-s/m^2)

A= Area of the collecting tank

H= Rise of liquid in a collecting tank

MODEL CALCULATIONS:

PROCEDURE:

1. Maintain a constant head in the supply tank with over flow arrangement
2. Fill the dye in the container and allow it to flow through the glass tube
3. Adjust the flow rate by controlling the outlet valve and measure the flow rate by collecting the water for known amount of time.
4. Vary the flow rates from minimum and observe the changes in the flow behaviour.

RESULT

The critical value of Re, at which fluid transition from laminar flow to turbulent flow is determined.

GRAPH

The following graph is drawn by taking Re on y – axis and V on x-axis.
Re vs V

INFERENCE

OBSERVATIONS AND CALCULATIONS

S.No.	H	$\frac{p_1}{\gamma}$	$\frac{p_2}{\gamma}$	$\frac{p_3}{\gamma}$	$\frac{p_4}{\gamma}$	$\frac{p_5}{\gamma}$	$\frac{p_6}{\gamma}$	T	Q_a	$\frac{V_1^2}{2g}$	$\frac{V_2^2}{2g}$	$\frac{V_3^2}{2g}$	$\frac{V_4^2}{2g}$	$\frac{V_5^2}{2g}$	$\frac{V_6^2}{2g}$

Area of the collecting tank, A =

Head of water in the supply tank, H=

Experiment No : Roll No:
Date :

8. PROVE THAT TOTAL ENERGY IS CONSERVED IN A GIVEN FLOW SYSTEM, THAT CARRIES WATER BETWEEN TWO RESERVOIRS

AIM

To verify the Bernoulli’s theorem for liquids.

APPARATUS

The Bernoulli’s apparatus, water collecting tank and stop watch

BASIC CONCEPT

According to Bernoulli’s theorem for an ideal steady incompressible & irrotational fluid the sum of pressure energy, kinetic energy and potential always constant.

PROCEDURE

1) Measure the internal dimensions of the collecting tank.
2) Open the inlet valve carefully so as to allow uniform through the testing pipe.
3) Eject the air bubbles in the piezometer tubes
4) Open the outlet valve of the apparatus and regulate the flow through the testing pipe so that the head (H) in the supply tank is constant i.e. inlet flow = outlet flow
5) Note pressure head $\frac{p_1}{\gamma}$, $\frac{p_2}{\gamma}$ etc. at cross sections A_1, A_2 etc.
6) Note the time in second to collect 10 cm rise of water in the collecting tank.
7) Repeat the experiment for medium and low head (H) tank supply levels.

MODEL CALCULATION

FORMULA

Total energy at any particular point along the flow path: $\frac{p}{\gamma}+\frac{V^2}{2g}+Z$

(p/γ) = Pressure head at that particular point (for water γ=1000 kg/m^3 or 9810 N/m^3)

($V^2/2g$)=Velocity head at that particular point

$Q=\frac{A\times H}{t}, V=\frac{Q}{a}$

Z= Datum head at that particular point

where,

p= Pressure at that particular point

D= Diameter of perplex tube

a= Area of perplex tube

A= Area of the collecting tank

H= Rise of liquid in a collecting tank

t=time take to rise water in collecting tank

RESULT

At minimum cross section of pipe

$\frac{p}{\gamma}+\frac{V^2}{2g}+Z$ value for medium head tank level =

$\frac{p}{\gamma}+\frac{V^2}{2g}+Z$ value for low head tank level =

Average value of total head for medium head tank level =

Average value of total head for low head tank level =

GRAPH

The following graph is drawn: $\frac{p}{\gamma}+\frac{V^2}{2g}$ (y – axis) vs *Position of tube* (x-axis) for different value of ***H*** .

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of Flow through Water meter

S.No.	Details	Units	Number of observations				
			1	2	3	4	5
1	Time taken for 5cm rise, t	s					
2	Rate of actual discharge, Q_a	litres/sec					
3	Time taken for 2 litres of water water to flow through the meter (as read in meter), t_m	s					
4	Rate of discharge through meter (as read in meter), Q_m	litres/sec					
5	Error in meter, (E/Q_m)x100	%					

Size of watermeter, d =

Dimensions of the collecting tank =

‘

Experiment No: Roll No:
Date:

9. ESTIMATE THE FLOW RATE IN A PIPE LINE SUPPLYING WATER TO BOKARO STEEL PLANT (using WATER METER)

AIM

To calibrate the given water meter and determine the error percentage in discharge measurement.

BASIC CONCEPT

The water meter is an instrument which provides directly the volume water (in litres) passing through a pipe line at any section for a known period of time. The given water meter is fitted at any intermediate section of a pipe line to measure the rate of flow passing through it. At the upstream end of a pipe line control valve is fixed and at the outlet end connected with 90° bend to direct water to the collecting tank of size 0.4m x 0.4m x 0.6m.

The following formulae are employed to find the percentage error in water meter reading.

Actual discharge, $Q_a = \frac{AH}{t} \times 1000 \; litres/\sec$

A = Internal plan area of collecting tank
H = Rise of liquid in collecting tank
t = Time taken to collect liquid in the collecting tank

Time taken for a flow of 2 litres (as read in water meter) t_m = sec

Rate of discharge through the water meter, Q_m = $\frac{2}{t_m} \; litres/\sec$

Error of the water meter = $E = |Q_a - Q_m|$

Percentage error $= \frac{E}{Q_m} \times 100$

Repeat the above procedure for different discharges, i.e. 4, 6, 8 and 10 litres respectively.

MODEL CALCULATIONS

APPARATUS

1 Water meter
2 Control valve
3 Stop watch
4 Collecting tank fitted with a valve

PROCEDURE

1. Open the inlet valve to allow flow through the water meter.
2. Collect the water in the collecting tank for a rise of 10 cm and note the time ‘T’ seconds.
3. Note the time ‘t_m’ in seconds for a flow of 10 litres through the given water meter.
4. Repeat the above procedure for different inlet valve openings.

GRAPHS

Plot the calibration graph by taking error percentage on y-axis to Q_m (rate of discharge through water meter) on x-axis.

RESULT

Average error percentage in water meter = ------------------
(From experiment)

INFERENCE

OBSERVATIONS AND CALCULATIONS

Table 1. Results of flow through Prandtl Pitot tube

S.No.	Manometer reading, cm			$V = \sqrt{2gh}$	Time for 10 cm rise of water, T sec	$Q_a = \frac{AH}{T}$	$V_a = \frac{Q_a}{a}$	$\phi = \frac{V_a}{V}$
	h_1	h_2	$h = \left(h_1 \sim h_2\right)\left(\frac{s_m}{s} - 1\right)$					
1								
2								
3								
4								
5								

Diameter of the pipe, d =

Dimensions of collecting tank=

‘

Experiment No: Roll No:
Date :

10. ESTIMATE THE FLOW RATE IN A PIPE LINE SUPPLYING WATER TO BOKARO STEEL PLANT (using PRANDTL PITOT TUBE)

AIM

To determine co-efficient of discharge of the Pitot tube.

BASIC CONCEPT

The pitot tube can be used to measure the velocity of water in an open channel as well as in a closed pipe. For an open channel, a simple pitot tube will serve the purpose. However for a closed pipe in which the water is flowing under pressure, it is necessary to measure the static pressure also. Then the velocity head will be equal to the total Pitot-tube reading minus the static pressure. The static pressure is measured by inserting another L-shaped tube with its end pointing towards the flow downstream. The water will be drawn in this tube by means of suction. If, now, the tubes are connected by an inverted U-tube manometer, the difference of water height 'h' will give the velocity head. Such an arrangement is known as ''Pitot-meter". The static pressure can also be measured by inserting the other end of inverted U-tube to the pipes.

A Pitot tube is fixed inside a pipe connected to a supply water tank. The Pitot tube is connected to an inverted water manometer. The flow rate in the pipe is measured from given collecting tank of size 0.5mx0.5mx1.0m. The flow rate is varied by adjusting the delivery valve.

The following formulae are employed to find the theoretical velocity and Pitot tube coefficient.

Theoretical discharge, $V_{th} = \sqrt{2gh}$

$$h = (h_1 \sim h_2)\left(\frac{S_m}{s} - 1\right)$$

Actual discharge, Q_a = AH/T

A = Internal plan area of collecting tank

H = Rise of liquid in collecting tank

T = Time taken to collect liquid in the collecting tank

$V_a = Q_a/a$

Error of the Pitot tube, $\phi = V_a / V_{th}$

MODEL CALCULATIONS

APPARATUS

1 Prandtl pitot tube

2 Pipe

3 Manometer

4 Stop watch

5 Collecting tank fitted with a valve

PROCEDURE

1. The diameter of the orifice and the internal plan dimensions of the collecting tank are measured.
2. The supply valve of the orifice tank is regulated and water is allowed to fill the orifice tank to a constant head (h)
3. The out let valve of the collecting tank is closed tightly and the time taken for "H " rise of water in the collecting tank is noted.
4. The above procedure is repeated for different heads and the readings are tabulated.

GRAPHS

The following graph is drawn by taking V_a on y – axis and $\sqrt{h}$ on x - axis.

V_a vs $\sqrt{h}$

RESULT

Error of the pitot tube, ϕ = -------------------

(From experiment)

Error of the pitot tube, ϕ = ---------------------

(From V_a vs $\sqrt{h}$ graph)

INFERENCE

OBSERVATIONS AND CALCULATIONS

	Right				Left			
Weight of the Moving body without loading (w)								
Distance through which hanging weight moved (x mm)	25	50	75	100	25	50	75	100
Hanging weight (m)								
Total weight of the floating body , W=w+m								
Initial reading on the circular scale (θ_1^o)								
Final reading on the circular scale (θ_2^o)								
Total angular deflection $\theta^o = \theta_1^o + \theta_2^o$								
Tan θ^o								
Metacentric height of the vessel $G_m = \frac{wx}{W \tan\theta}$								
Remarks								

Dimensions of the tank =

Weight of moving body without loading =12.737 kg

Experiment No: Roll No:
Date

11. TEST THE GIVEN SHIP MODEL IN MAZAGON DOCKYARD, KOLKATTA IS STABLE OR NOT

AIM

To determine the metacentric height and radius of gyration of the floating body.

APPRATUS

i. Tank filled with water with a graduated scale.

ii. Floating vessel with points moving on a graduated scale.

iii. Weight adjustable horizontal table.

BASIC CONCEPT

The equipment consists of a vessel representing a small model ship equipped with loading and measuring device for the observation of the load of the vessel. Weights are provided for loading the vessel at known distance across the bar. The bridge bar is graduated across with fine groves carrying two swinging weights on a knife edge. The linear scale fitted to the bridge bar is used to measure the distance of loading. A graduated scale marked in degrees over which a free swinging pointer swings. This pointer is used to measure the angle of inclination of the ship float in the collecting tank.

Metacentric height, $\bar{GM} = \frac{wx}{W \tan\theta}$

where, w = weight of moving body

W = total weight of the body floating

G_m = Meta centric height

Radius of gyration, $K = \frac{T}{2\pi}\sqrt{g\,\bar{GM}}$

where, g = acceleration due to gravity.

MODEL CALCULATIONS

Time for 5 oscillation = sec

Weight of moving mass = kg

Period of oscillation = sec

Area of collecting tank = cm^2

Water level in tank with float = cm

Water level in tank without float = cm

Difference in levels = cm

Volume of water displaced = Area x difference in level

= cm^3

Weight of floating body,

$$w = \frac{density\ of\ \ water \times volume}{981}$$

$$= \qquad gms$$

Metacentric height, $\overline{GM} = \dfrac{wx}{W \tan\theta}$

Radius of gyration, $K = \dfrac{T}{2\pi}\sqrt{g\,\overline{GM}}$

GRAPH

The following graph is drawn between Metacentric height on Y-axis and ‘θ’ along X-axis.
Metacentric height vs θ

RESULT

INFERENCE