

Sr. No.	EXPERIMENT LIST FOR FLUID MECHANICS-II LAB	EXPERIMENT NO.
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2	TO DETERMINE THE CRITICAL REYNOLD'S NUMBER FOR FLOW THROUGH COMMERCIAL PIPES	CE-212E-02
3	TO DETERMINE THE COEFFICIENT OF DISCHARGE FOR FLOW OVER A BROAD CRESTED WEIR	CE-212E-03
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EXPERIMENT NO. :- 1

Object: - To determine the co-efficient of drag by Stroke's Law for spherical bodies

Theory: - When a small sphere falls freely in a viscous medium, the following three forces act on the sphere.

1. Gravity force (W)
2. Upward Force (U) due to buoyancy
3. Drag force (F_D)

The sphere initially accelerates under gravity. Gradually, the drag force increases and a stage is raised at some depth below the free surface at which the drag force is equal to the net downward force (W-U). At this stage there is no acceleration and the velocity of the sphere becomes constant. This velocity is called the terminal velocity (V).

$$\begin{aligned} \text{Now } F_D &= W-U \\ \text{or } F_D &= \frac{\pi D^3}{6} (w_s - w) \\ &= \frac{\pi D^3}{6} (\rho_s - \rho)g \end{aligned}$$

Where,

w_s is the specific weight of the sphere material ($=\rho_s g$), and

w is the specific weight of the fluid ($=\rho g$),

The co-efficient of drag (C_D) can be expressed as

$$\begin{aligned} C_D &= \frac{F_D}{A (\rho V^2/2)} \\ C_D &= \frac{F_D}{(\pi D^2/4) (\rho V^2/2)} \\ \text{or } C_D &= \frac{4D (\rho_s - \rho)g}{3\rho V^2} \end{aligned} \quad \text{Eq. (1)}$$

The terminal velocity V is determined from the recorded time during which the sphere travels through the marked distance L. Because Stokes' Law is applicable when the fluid medium is infinite, a correction is required for a finite medium, such as glycerin in the cylinder. The correction is given by.

$$V = V' [1 + 2.4 \{D/D_1\}]$$

Where,

D_1 is the diameter of the cylinder; D is the diameter of spherical ball.

V' is the measured velocity

V is the corrected velocity.

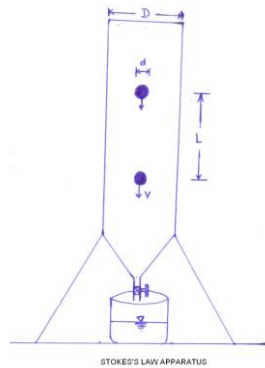
C_D , the coefficient of drag is also given by:-

$$C_D = \frac{24}{Re} \quad \text{Eq. (2)}$$

Knowing D, w_s , w , ρ , and, the value of C_D can be calculated from Eq (2) and compared with the theoretical value given by Eq. (1)

Procedure:-

1. Measure the diameter (D) of the spherical balls, Record the specific weights (or mass densities) of the sphere material (w_s) and glycerine (w). Measure the diameter (D_1) of the cylinder.
2. Fill the cylinder with the liquid (Glycerine) and close its mouth with a cork. Insert the brass tube into the cork.
3. Mark two lines on the cylinder so that the vertical distance (L) is adequate for the measurement of the terminal velocity. The upper line should be at a depth of 100mm or more below the bottom of the brass tube so that the terminal velocity is achieved.
4. Release a ball into the brass tube carefully so that it does not touch the walls of the tube
 Note. If a brass tube is not available, the ball be released directly into the cylinder.
5. When the steel ball crosses the upper line, start the stop watch.
6. Note the time taken by the ball to reach the lower line.
7. Repeat steps 4 to 6 for balls of different diameters but of the same material.



Observations:

Mass density of fluid (Glycerine) = 1262.70 Kg/m³
 Kinematic Viscosity of fluid (ν) = 1174.40 x 10⁻⁶ m²/sec.
 Dynamic viscosity of fluid (μ) = 1188.00 x 10⁻³ N-s/m²

S.No	Diameter of sphere	Mass density of sphere	L	Recorded time t	Actual velocity $V'=L/t$	Corrected velocity (V)	C_D from Eq. (1)	$Re = \rho VD / \mu$	C_D from Eq.(2)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1										
2										
3										
4										

Graph: - Plot the computed values of C_D from Eq. (2) and Re on a log-log paper, with C_D as ordinate. For $Re \leq 0.20$, compare values of C_D with those obtained from Eq. (1)

Precautions:-

1. Release the ball very gently and make sure that it falls vertically.
2. Make sure that balls have attained the terminal velocity when it reaches the top mark line.
3. As the viscosity depends upon the temperature, the temperature should be kept constant.
4. The sphere should be wetted before releasing into the brass tube.

Measure the diameters of the sphere in two perpendicular directions and take the average.

EXPERIMENT NO. :- 2

Object: - To determine the critical Reynold's no. for flow through commercial pipes.

Equipment: - Supply tank with Elliptical bell mouth entry, coloured dye injector arrangement, Perspex tube with means of varying flow rate and collecting tank.

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

The motion is laminar or turbulent according as the value of Re is less than or greater than a certain value. If a liquid such as water is allowed to flow through a glass tubes, and if one of the liquid filament is made visible by means of dye, then by watching this filament we may get insight in to the actual behaviour of the liquid as it moves along. After the water in the supply tank has stood for several hours to allow it to come completely to rest. The out let valve is slightly opened. The central thread of dye carried along by the slow stream of water in the glass tube is seen to be nearly as steady and well defined as the indicating column in an alcohol thermometer. But when as a result of further opening of the valve, the water velocity passes a specific limit, a change occurs, the rigid thread of dye begins to break up and to group momentarily ill defined. The moment the dye deviates from its straight line pattern corresponds to the condition when the flow in the conduit is no longer in laminar conditions. The discharge Q flowing in the conduit at this moment is measured and the Reynold's number = $4Q / \pi d \nu$ (in which d is the diameter of the conduit and ν is the Kinematic viscosity of water) is computed. This is the lower critical Reynolds number. Finally, at high velocities is the dye mixes completely with the water and the coloured mixtures fills the tube.

Procedure:-

1. Note down the relevant dimensions as diameter of Perspex tube, Area of collecting tank, room temperature etc.
2. By maintaining suitable amount of steady flow or near by steady flow in the Perspex tube, open inlet of the dye tank so that dye stream moves as a straight line in the tube which represents the laminar flow.
3. The discharge flowing in the Perspex tube is recorded.
4. This procedure is repeated for other values of discharge.
5. By increasing the velocity of flow in the Perspex tube, again open the inlet of dye tank so that the eye stream begins to break up in the tube which shows fluid is no more in the laminar conditions. Hence transition stage occurs.
6. The discharge flowing in the Perspex tube is recorded.
7. This procedure is repeated for other values of discharge.
8. On further increase in the velocity of flow in the Perspex tube, again open the inlet of dye tank so that dye mixes completely in the tube which shows fluid is no more in the transition stage, Hence turbulent flow occurs in the tube.

9. The discharge flowing in the Perspex tube is recorded.
10. This procedure is repeated for other values of discharge.

Observations:-

Inner diameter of conduit D = 2.5cm
 Room temperature E =
 Kinematic viscosity of water ν =
 Area of collecting tank = cm²

SNO.	Discharge measurement				$Re = 4Q / \pi d \nu$
	Initial (cm)	Final (cm)	Time taken (Sec)	Discharge Q (cm ³ /sec.)	

EXPERIMENT NO. :- 3

Object: - To determine co-efficient of discharge of broad crested weir, and relationship between Q and H.

Apparatus: - Pointer gauge, stopwatch, Scale

Theory:-

Formula

$$Q = Cd Bh [2g (H-h)]^{1/2}$$

Where

cd = Coefficient of discharge if B.C.W.

L = Length of broad crest weir

D = Depth of water at before entering crest of weir

B = Width of B.C.W

Note:

1. Conditions to work as a broad crest weir
B > 2.5 H and B < 10 H
2. Maximum discharge form B.C.W, will be available when $h = 2/3H$

Observation:-

S.No.	Discharge Measurement			Q	H	Cd
	Area of container	Height of water depth in container	Time (t)			

Procedure:-

1. Locate a section in the channel upstream of the weir where the water surface will have almost no curvature even at the maximum discharge. This can be done by opening the sluice gate fully and observing the water sure face.
2. Adjust the position of the sluice gate and when the flow becomes steady take the pointer gauge reading for the water surface elevation at the section fixed in step (1) above.
3. Measure the discharge.
4. Repeat step (1) and (3) for other different positions of the sluice gate i.e discharge.

Plot (1) H V/s Q (H on x axis) on a log-log graph paper fit in a straight line with a slope of 1.5 to the data points estimate value of c in equation.

Results:-

The value of co-efficient of discharge is _____.

EXPERIMENT NO. :- 4

Object: - To study the characteristics of Hydraulic jump of horizontal floor and sloping glacis

Theory: - When super critical flow meets sub critical flow where forms which are known as hydraulic jump which is accompanied by violent turbulence, eddy formation air entrainment and surface undulations. Hydraulic jump is very useful means to dissipate to excess energy of flowing water which otherwise would cause damage downstream. Consider the flow situations in which section 1 is in super critical zone and section 2 is in sub critical zone. Assuming the channel bed to be 2 dimensional, one can write using moment equation $P_1 - P_2 = Pq (v_2 - v_1)$ ----- (1)

Where $q = Q_1/B$ in which B is width of channel and P represents the hydraulic static force writing down the values of P_1 and P_2 for rectangular channel in Eq. (1) get

$$Pgh_1^2/2 - Pgh_2^2/2 = pg (v_2 - v_1) \text{----- (2)}$$

Continuity eqn. $q = v_2 h_2 = v_1 h_1$ ----- (3)

Combined eqn. (2) and (3) and then solving for h_2/h_1

$$h_2/h_1 = \frac{1}{2} \left[-1 + \sqrt{1 + 8Fr_1^2} \right]$$

In which $Fr_1 = \frac{v_1}{\sqrt{gh_1}}$ and is termed as Froude's no. of the incoming flow at section (1) h_2 and h_1 are

related by eq. (4) are known as conjugate or sequent depth. A jump from eq. (4) is satisfied because of eddies and flow deceleration that accompany the jump. Consider head loss occurs. This loss h_x may be calculated by using energy eqn.

$$h_x = (h_1 + v_1^2/2g) - (h_2 + v_2^2/2g) \text{----- (5)}$$

from eq. (3) and (5), it can be shown that

$$h_x = (h_2 - h_1)^3 / 4h_1 h_2$$

Ht. of jump is defined as difference between the depth after & before the jump.

Experimental setup:- it consists of a walled rectangular flume having a sluice gate at the inlet end, a tail gate at the downstream end and top rails for the moments of pointer gauge. A sluice valve is provided near the outlet end of supply pipe. Scale is also required.

Procedure:-

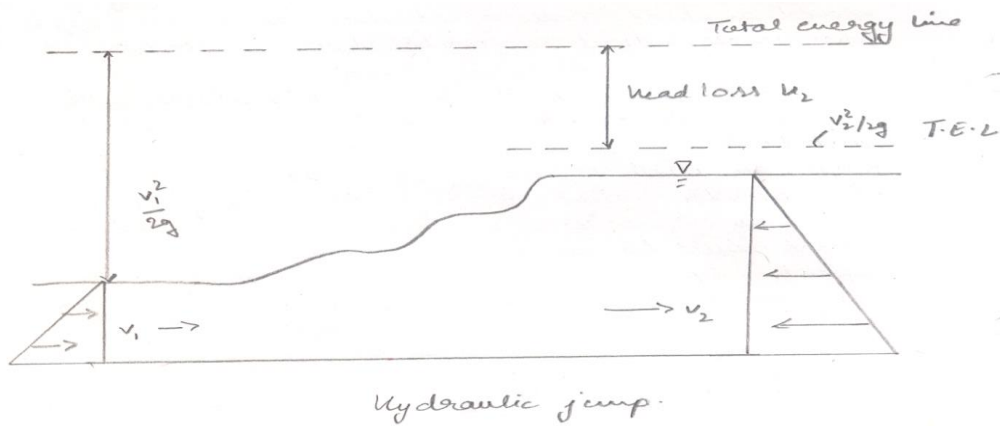
1. Adjust the supply valve, sluice gate and the tail gate so that these form a stable hydraulic jump in the flume.
2. Take the pointer gauge reading for bed level and water waves elevations at pre-jump section and post jump section
3. Measure the discharge
4. Repeat steps (1) to (3) for other positions of valve, sluice gate and tail gate.

Observations:-

Dimensions of collecting tank =

Width of channel sec. B=

Run No.	Discharge Measurement				Pre jump Depth H1	Post jump Depth H2	V1= Q/BH1	h2/h1	V2= Q/Bh2	Fri= $\frac{v_1}{\sqrt{gh}}$	E1= $h1 + \frac{v_1^2}{2g}$	E2= $h2 + \frac{v_2^2}{2g}$
	Initial level H1	Final level H2	Time t	Discharge Q								



EXPERIMENT NO. :- 5

Object:- To study the scouring phenomenon around a bridge pier model

Apparatus:- A tilting bed flume, Model of pier, A pointer gauge, a scale

Theory:- Scour around obstructions like bridge pier is a local phenomenon arising out of three dimensional suppression of flow upstream of the obstruction giving use to horse shoe vortex system. This horse shoe vortex system is responsible for removing the material from upstream of the pier and releasing it in suspension at the rear of the pier thus causing the scouring around the pier. Thus foundation for bridge pier in an erodible river bed should be deep enough to provide minimum anchorage length for the safety of the foundation.

Procedure:-

1. Initially level the sand bed across and along the direction of flow
2. Switch on the motor. Allow the water to flow in the flume so that the velocity is closed to incipient condition, by opening the tailgate i.e by decreasing the flow depth of channel. The incipient motion can be visually observed by noting the movement of bed material
3. Now pier model is placed symmetrically inside the flume as per the equipmental setup as shown in fig.1
4. The experiment is run for 1 hour.
5. The tail gate is closed completely and the motor is switched off to stop the flow in the flume.
6. Allow the water to drain off slowly by opening the tail gate slightly so that scour pattern developed is not disturbed.
7. Note down the scour profile by making a grid and plot it on a graph sheet.
8. Repeat the experiment with different shapes of pier model.

Observations:

Dimension of Model =

Discharge in the channel =

Incipient velocity of flow =

Flow depth in the channel =

Characteristics of bed material =

EXPERIMENT NO. :- 6

Object: - To study the scouring phenomenon for flow past a spur.

Apparatus: - A tilting bed flume, model plates of spur, a pointer gauge, a scale

Theory: - Spurs are the structures constructed transverse to the river flow extending from the bank into the river. These are aligned either perpendicular to the bank line or at an angle pointing upstream or downstream. These are most widely used in river training works.

Functions of spur:

1. Protects riverbank
2. Improves river depth
3. Trains the river flow in certain distance
4. Silting up area in the vicinity

Types of spur: These are classified according to methods & material of construction, height of spur, function served etc.

Procedure:-

1. Initially level the sand bed across and along the direction of flow.
2. Switch on the motor. Allow the water to flow in the flume so that the velocity is closed to incipient condition by opening the tailgate in order to decrease the flow depth of channel. The incipient motion can be visually observed by noting the movement of bed material
3. Take the MS plate model of a spur length 10cm and height 20cm. Fix it on the one side of steel flume keeping it perpendicular to the direction of flow. It is called as deflecting spur.
4. The experiment is run for one hour
5. The tailgate is closed completely and motor is switched off to stop the flow in the flume.
6. Allow the water top drain off slowly by opening the tailgate slightly so that scour pattern developed is not disturbed.
7. Note down the scour profile by making a grid and plot it on a graph sheet.
8. Repeat the experiment with different orientations of spur with respect to the direction flow.

Observations:-

Dimension of model =

Discharge in the channel =

Incipient velocity of flow =

Flow depth in the channel =

Characteristics of bed material =

EXPERIMENT NO. :- 7

Object:- To draw the performance characteristics of centrifugal pump operating at various heads, flow rates and speed.

Apparatus:- Centrifugal pump with energy meter and spring balance (dial type), control valves, , pressure gauge, vacuum gauge, rump tank and measuring tank.

Theory:- A plumb may be defined as mechanical device which interpose in pipe line, converts the mechanical energy supplied to it from external source into hydraulic energy thus resulting in the flow of liquid from lower potential to higher potential. In centrifugal pump, the liquid is made to rotate in a closed chamber which is called volute casing. Thus creation centrifugal action, which gradually builds pressure gradient towards outlet, thus resulting the continuous flow of liquid

Procedure:-

1. Fill the rump tank with clean water.
2. Select the desired speed for pump using speed controller knob in increasing order.
3. Now, for a particular value of a charge opening note down the value of suction pressure and delivery pressure.
4. Using hopper fixed at a measuring tank, collect water in measuring tank for specific time and calculate volumetric flow of water.
5. Note down the delivery head and suction head.
6. Note down the time taken for no. of rev. of energy meter disc.
7. Repeat the experiment for different speed of pump and repeat the step from 4 to 8
8. Calculate the result using formulas
- 9.

Precautions:

1. The water in the pump should be free from foreign particles
2. Open both control valves at the delivery and suction line before switch on the mains
3. Always start from lower speed.

Observations:-

Area of collecting tank =

Diff. in elevation of Pressure & vacuum gauge =

Head =

$$\text{Input} = \frac{3600 \times (\text{no. of rev of energy meter}) \times n_m}{(\text{energy meter constant}) \times \text{time}}$$

$$\text{Output} = (W_w QH)$$

R.P.M	Discharge Reading				Gauge's Reading			Watt meter reading 5 Revo. Of EM Disk	Input SHP	Output BHP	Efficiency 100 x input/output %
	Initial (m)	Final (m)	Time (sec)	Q (lit/sec)	Vacuum gauge reading	Pressure gauge reading	Head (H) (m)				

Experiment No 8:

Objective: - To study the momentum characteristics of a given jet.

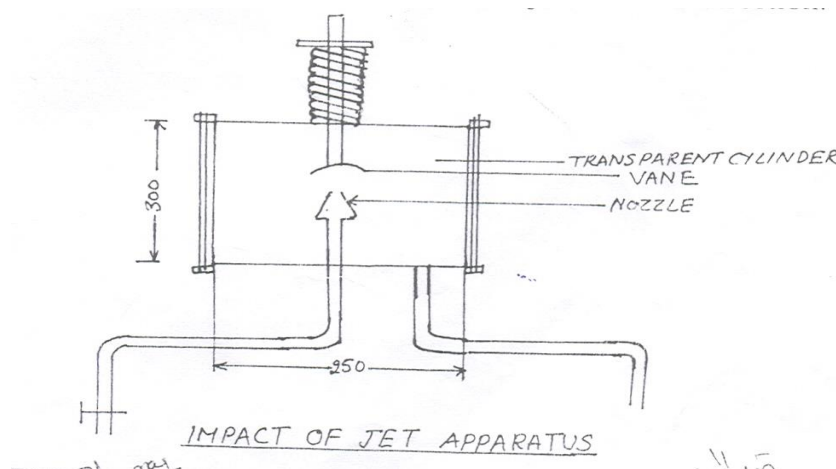
Equipment used: -

Connecting tank, transparent cylinder, a nozzle of 10 mm dia, flat vane, a curved vane and a set of weight

Introduction and theory:

Momentum equation is based on Newton's second law of motion which states that the algebraic sum of external forces applied to control volume of fluid in any direction is equal to the rate of change of moments in that direction, the external force include the components of the weight of the fluid and of the force exerted externally upon the boundary surface of the control volume.

If the vertical water jet moving with velocity V is made to strike a target, which is free to move in the vertical direction, then a force will be exerted on the target by the impact of jet. According to momentum equations this force (which is also equal to the force required to bring back the target in its original position) must be equal to the rate of change of momentum of the jet flow that direction.



Applying momentum equation in x direction

$$-F_x = \rho Q [v \cos\beta - V]$$

$$\rho Q [v \cos\beta - V]$$

$$F_x = \rho Q v [1 - \cos\beta]$$

For Flat plate, $\beta = 90^\circ$

$$F_x = \rho Q v$$

For Hemispherical Cup, $\beta = 180^\circ$

$$F_x = 2\rho Q v$$

Here, ρ is the Mass Density, Q the Discharge through the Nozzle, V the Velocity at the exit of nozzle i.e. (Q/a) and 'a' is the area of cross section of nozzle.

$$F_x = \dots\dots\dots$$

While for curved hemispherical vane the force is

$$F_x = \text{-----}$$

Experimental set up:

The experimental set up primarily consist of nozzle through which a water jet images vertically in such a way it may be conveniently observed through the transparent cylinder, it strikes the target vane positioned above it. The force applied on the vane by jet can be measured by applying weight to counteract the reaction of the jet. Vanes are interchangeable i.e. flat or curved vane.

Arrangement is made for the movement of the plate under the action of the jet and also because of the weight placed on the loading pan. A scale for the jet strikes the vane. A collecting tank is used to find the actual discharge and velocity through the nozzle.

Experiment procedure:

Note down the relevant dimension as area of collection tank, mass density of water and dia of nozzle.

The flat plate is installed.

When the jet is not running, note down the position of upper disc.

The water supply is admitted to the nozzle and the flow rate is adjusted to its maximum value.

As the jet strikes the vane, position of the upper disc is changed. Now place the weight to bring back the upper disc to original position.

At this position find out the discharge as well as note down weights placed on the upper disc. The procedure is repeated for each value of flow rate by reducing the water supply in steps.

The procedure is repeated with the installation of curved vane in the apparatus.

Observation and computation sheet:

- i. Dia of nozzle (mm) =
- Mass density of water ρ =
- Area of collecting tank =
- Area of nozzle, a =

Horizontal flat plate:

When jet is not running, position of upper case disc is at:

Run No.	Discharge measurement				Balancing		Theoretical force $F' = \frac{\rho Q^2}{a}$ (dyne)	Error in % $= \frac{F-F'}{F'}$
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm ³ / sec) Q	Mass W (gm)	Force F (dyne)		

Curved hemispherical vane

When jet is not running, position of upper case disc is at:

Run No.	Discharge measurement				Balancing		Theoretical force $F' = \frac{2\rho Q^2}{a}$ (dyne)	Error in % $= \frac{F-F'}{F'}$
	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm ³ / sec) Q	Mass W (gm)	Force F (dyne)		

Experiment No. 9:-

Objective: To determine the head loss due to various pipe fittings.

Equipment used:- A flow chart circuit of 25 mm dia with sudden enlargement from 25 mm dia to 50 mm dia and sudden contraction from 50 mm dia to 25 mm dia, with 25 mm dia, with a means of varying the flow rate, inverted U-tube differential manometer, collecting tank.

Introduction and Theory: In long pipes, the major loss of energy in pipe flow is due to friction while the minor losses are those which are caused on account of the change in the velocity of flowing fluid. Losses due to changes in cross section are categorized as minor losses. In short pipes minor losses something outweigh the friction losses. The minor energy head loss H_1 in terms of velocity head can be expressed as

$$HL = \frac{Kv^2}{2g}$$

where K is loss coefficient which is practically constant at high Reynolds number for a particular flow geometry. V is velocity of flow in the pipe and g is acceleration due to gravity.

For sudden enlargement value of K is $(1-a/A)^2$

Where a is area of cross-section of smaller dia and A is area of cross-section of larger dia. For sudden contraction value of K is $(1/C_c-1)^2$ where C_c is coefficient of constriction i.e. $C_c = A_c/A_2$

Where A_c is Area of cross section at vena contracta.

Pressure taping at up-stream and down stream ends of each of sudden enlargement & sudden contraction enables the measurement of pressure head difference across the fitting to compute the head loss through the fitting.

Procedure:-

1. Noted down the dimension of collecting tank etc. pressure taping of a fitting is kept open while for other fitting it is closed.
2. The flow rate is adjusted to its maximum value.
3. By maintaining suitable amount of steady flow in the pipe circuit, there stabilize a steady non-uniform flow in the circuit. Time is allowed to stabilize the levels in the two limbs of a manometer.

- The flow rate is reduced in stage by means of flow control valve and the discharge & reading of manometer are recorded. This procedure is repeated by closing the pressure tapping of the fitting and opening of other fitting.

Precaution:-

- Apparatus should be in leveled condition.
- Reading must be taken in steady or near by steady conditions.
- There should be no initial difference of the water levels in the manometer limbs was observed to be zero.

Observation & Calculations:-

Diameter of smaller pipe, $d = 2.5 \text{ cm}$

Area of smaller dia pipe, $a = \frac{\pi}{4} d^2 \text{ cm}^2$

Diameter of larger dia pipe, $D = 5.0 \text{ cm}^2$

Area of collecting tank, $a_c = \text{cm}^2$

For sudden enlargement

Sr. No.	Discharge measurement			Discharge (cm^3/sec) $Q = a_c(h_2 - h_1)$	Difference of pressure head in cm of water Δh	$V_2 = Q/a$ cm/sec	$V_1 = Q/A$ cm/sec		
	Initial h_1 (cm)	Final h_2 (cm)	Time t (sec)						

Average loss coefficient for sudden enlargement $k =$

EXPERIMENT NO. 10

Object: - To study the phenomenon of cavitation in pipe flow.

Apparatus: - The cavitation rig with a venturi made of Perspex to allow flow visualization. A 5 HP pump draws water from a storage tank and pumps through the ventureries which discharges it back to the storage tank. A pressure gauge, water meter and Control valve are fitted before venturi. A manometer is connected to the throat of the venturi to fine the pressure.

Theory: - When the pressure in a flowing liquid is reduced below the vapour pressure of the liquid, the vapour cavities are formed. These cavities are transported by the liquid to regions of higher pressure where they condense into water again causing the collapse of the water cavities. The liquid implodes with high pressure. If the collapse of the cavities occurs very near to a solid boundary it causes intense stresses of tension & compression on the boundary at small time intervals and cause failures by fatigue. The boundary gets pitted. This process of formation, transportation and collapse of paper cavities and the pitting it causes is called cavitation.

Procedure:-

1. Switch on the Electric motor allowing water to flow through the venturi
2. Regulate the control valve so that there is cavity formation at the throat of venturi
3. Reduce the discharge by adjusting the control valve until the cavities disappear
4. Do verify adjustment of the control valve until the cavity just appear
5. Find the pressure at the throat of the venturi

Note: - Note the temperature of water and compare with paper pressure of water that temperature.