NAAC B+ Accredited Institute

Dr. A. D. Shinde College of Engineering

Bhadgaon- 416502

Manual

FLUID MECHANICS

Name of Faculty

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Department of Civil Engineering

CERTIFICATE

This is to certify that,

*Mr. / Ms.*____

*Roll No.*______*of*_____*year*_______*semester of Degree in* ***Bachelor of Technology***

has completed the term work satisfactory in the subject ______________________

*under*_________ *Branch for the academic year*__________*to*__________*as*

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*Place:*________________ *PRN No:* __________________

Date: _______________ *Exam Seat No:* ________________

Subject Teacher Head of Department Principal

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Sr. No.	Name of Experiment	Date	Page No.	Mark	Sign
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	NAAC B+ Accredited Dr. A. D. Shinde College of Engineering Bhadgaon- 416502		
	Department of Civil Engineering		
	Subject: Fluid Mechanics		
Experiment No:	**Marks Obtain:**	**Sign:**	
Title: Pressure Measuring Devices		**Performed date:**	**Submitted Date:**

AIM: Study of different Pressure measurement devices

THEORY: Pressure is defined as force per unit area and the standard unit is the Pascal

Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure pressure are called pressure gauges or vacuum gauges.

A manometer could also be referring to a pressure measuring instrument, usually limited to measuring pressures near to atmospheric. The term manometer is often used to refer specifically to liquid column hydrostatic instruments.

A vacuum gauge is used to measure the pressure in a vacuum which is further divided into two subcategories: high and low vacuum.

When we talk about pressure in Science we use it as a measure of the ratio of how much push or force there is acting on a given surface area.

$$P = \frac{F}{A}$$

Force (N, Newton)

Pressure (N/m² or N/cm²)

Area (m² or cm²)

Difference between Force, stress and Pressure

Force= Mass x acceleration *Pressure = Force/Area*

Pressure vs. Force

• Force is a push or a pull that induces motion, changes state of motion, or stops a moving body when applied. On the other hand, pressure is force spread over a surface area or force per unit area.

• Force is a vector quantity while pressure is a scalar quantity.

Pressure is the external force acting over a surface area of a material.

Stress is an internal force acting over a cross sectional area within the material.

▶ 2.4 ABSOLUTE, GAUGE, ATMOSPHERIC AND VACUUM PRESSURES

The pressure on a fluid is measured in two different systems In one system, it is measured above the absolute zero or complete vacuum and it is called the absolute pressure and in other system, pressure is measured above the atmospheric pressure and it is called gauge pressure. Thus :

1. **Absolute pressure** is defined as the pressure which is measured with reference to absolute vacuum pressure.

2. **Gauge pressure** is defined as the pressure which is measured with the help of a pressure measuring instrument, in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero.

3. **Vacuum pressure** is defined as the pressure below the atmospheric pressure.

The relationship between the absolute pressure, gauge pressure and vacuum pressure are shown in Fig. 2.7.

Mathematically :

(*i*) Absolute pressure

= Atmospheric pressure + Gauge pressure

or $$p_{ab} = p_{atm} + p_{gauge}$$

(*ii*) Vacuum pressure

= Atmospheric pressure − Absolute pressure.

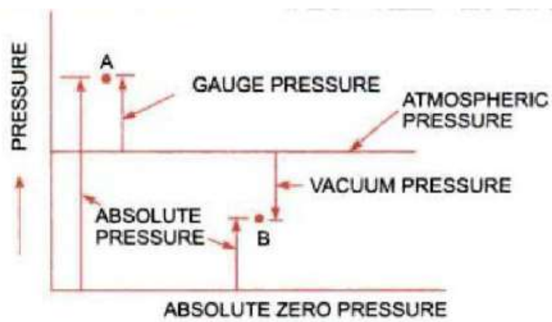


Fig. 2.7 *Relationship between pressures.*

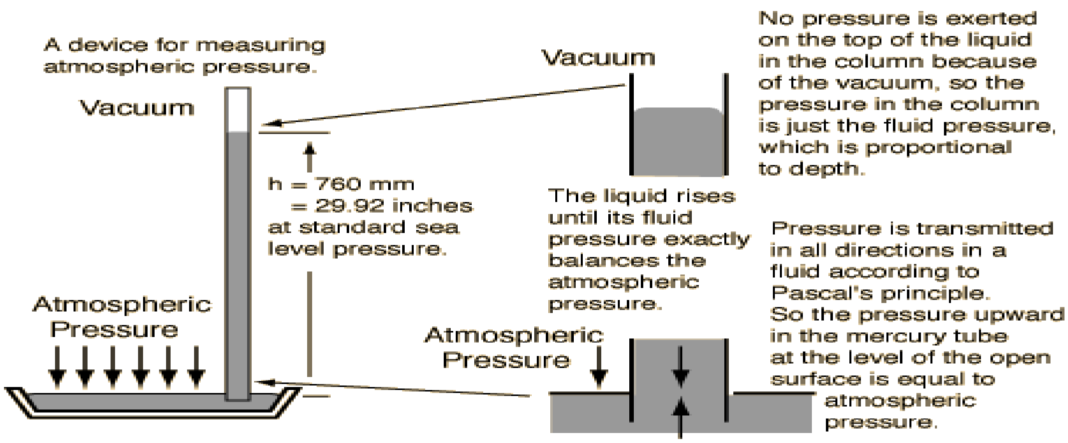
Note. (*i*) The atmospheric pressure at sea level at 15°C is 101.3 kN/m^2 or 10.13 N/cm^2 in SI unit. In case of MKS units, it is equal to 1.033 kgf/cm^2.

(*ii*) The atmospheric pressure head is 760 mm of mercury or 10.33 m of water.

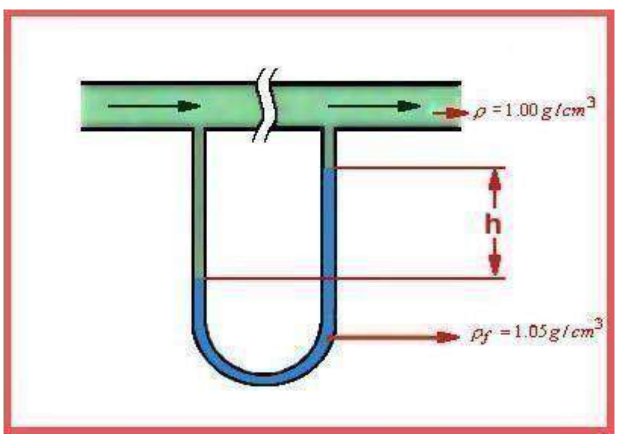
Atmospheric Pressure

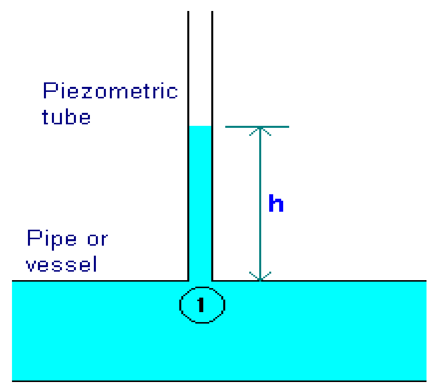
Atmospheric pressure is the force per unit area exerted on a surface by the weight of air above that surface in the atmosphere of Earth (or that of another planet). In most circumstances atmospheric pressure is closely approximated by the hydrostatic pressure caused by the weight of air above the measurement point. The surface of the earth is at the bottom of an atmospheric sea. The standard atmospheric pressure is measured in various units:

1 atmosphere = 760 mmHg = 29.92 in Hg = 14.7 lb/in^2 = 101.3 KPa.



Differential Manometer: It is used to measure the pressure difference between two points or between two systems. It is again a U-tube manometer with the two ends of the U-tube connected to the two systems between which pressure difference is to be measured. Depending on the range of pressure difference to be measured, a suitable liquid or combination of liquids can be filled in the two arms of the U-tube. If large pressure differences are to be measured a heavy manometer liquid is filled in the U-tube. And to measure very small pressure difference U-tube with long arms is used and two light liquids are filled in the two arms of the U-tube.





Piezometer

A piezometer is either a device used to measure static liquid pressure in a system by measuring the height to which a column of the liquid rises against gravity, or a device which measures the pressure (more precisely, the piezometric head) of groundwater [1] at a specific point. A piezometer is designed to measure static pressures, and thus differs from a pitot tube by not being pointed into the fluid flow.

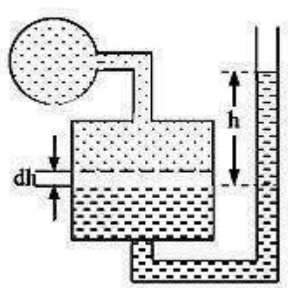
Why mercury is used as manometeric liquid?

The mercury is used as manometric liquid for following reasons:

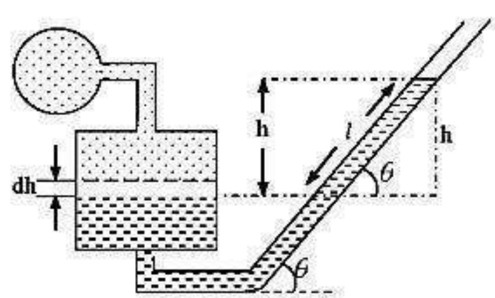
1. It has high density so that mercury rise is reasonable for a pressure.
2. It is immiscible with the liquid flowing in the pipes.
3. It does not stick to the surface of the tubes of the manometer.
4. The vapour pressure is negligible at room temperature.
5. It does not react chemically with most of the liquids flowing through pipes.

Inclined or Sloping U-tube Manometer: It is basically the same U-tube manometer just the tube is inclined at certain angle this time. This results in more deflection in the liquid level in the tube for the same change in pressure. This enables the measurement of small pressure changes with increased accuracy.

Vertical Single Columns Micrometer	Inclined Single Columns Micrometer
1. Narrow limb is vertical as shown in the figure.	1. Narrow limb is kept inclined (angle θ) to the horizontal.
2. The distance moved by the liquid in the narrow limb is small	2. The distance moved by the liquid in the narrow limb is more.
3. The distance moved by the liquid is h	3. The distance moved by the liquid is l where $l = \dfrac{h}{\sin\theta}$. As $\theta < 1$, hence $l > h$.
4. Less sensitive	4. More sensitive.
5. Fixed sensitiveness	5. Sensitiveness can be improved by inclining more the narrow limb



Vertical Single Column Micrometer

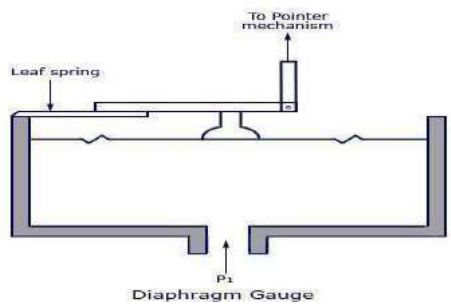


Inclined Single Column Micrometer

Mechanical Pressure Measurement Gauges

Mechanical Pressure Measurement Devices do not read pressure of any system by deflection of liquid level in some sort of tube. Instead they use some solid object, such as tube, plate, or diaphragm to measure pressure. The system whose pressure is to be measured is connected to the deflecting object. Any change in pressure causes the object to deflect and this deflection is mechanically amplified, by using a suitable gear and linkage mechanism, and indicated on the calibrated dial.

Bourdon Gauge: The Bourdon Gauge has a coiled tube whose one end is connected to the system under consideration and other end is sealed. With the application of the pressure in the tube it straightens up causing deflection of the sealed end. The sealed end is connected to the indicating needle through a gear and linkage mechanism. The deflection of the sealed end results in movement of the needle which moves on a calibrated dial. Bourdon gauges can be used to measure a wide range of pressures.



Diaphragm Gauge: Similar to the Bourdon Gauge, but has a Diaphragm which deflects on pressure changes and the deflection is indicated on the calibrated scale.

Bellows Gauge: In such gauges indicating needle is driven by the deflection of bellows chamber. This gauge is suitable for measurement of very low pressures.

<u>STUDY OF PRESSURE MEASUREMENT DEVICES</u>

Pressure is defined as the force exerted over the unit area. Measurement of pressure is essential at many places, e.g. given fluid flowing through pipe, boiler etc. Depending upon the pressure and accuracy of measurement required various devices are used for pressure measurement.

1] Pressure Gauge.
2] Vacuum Gauge.
3] U - Tube manometer.
4] Differential manometer.
5] Single Tube manometer.

6] Inclined Tube (micro) manometer.

EXPERIMENTAL PROCEDURE:-

1] Water supply pipe connect to inlet of the piping.
2] Open the gate valve (exhaust) completely.
3] See that mercury is filled in the manometers and bypass cocks are open.
4] Now, remove the air bubbles and observe the observations of manometer and gauges as follows-

[1] Vacuum gauge- Vacuum gauges are used for measurement of pressures below atmospheric, i.e. negative pressure. Negative pressure is created at suction side of pump. The vacuum gauge used is bourdon tube type. All the vacuum gauges are available in 0 to 760 mm. and 30 of Hg range. (Take the supply for vaccum gauge from suction section of the pump.)

[2] Pressure gauge: - When the pressure is above atmospheric, bourdon tube type pressure gauge is the simplest way of pressure measurement, because it gives direct reading of pressure. Pressure gauges are available in various ranges, e.g. 0 to 1.05 Kg/cm^2 (15 psi g), 0 to 2.1, 10.5, 21.2 Kg/cm^2 etc. and in various dial sizes, like 65 mm, 100 mm, 150 mm. etc.

For observation of pressure, close the connection to all other devices (a t the back side) and slowly go on closing the gate valve. As the gate valve is being closed, pressure will go on rising, which will be indicated on the pressure gauge. Observe the pressure gauge reading while closing the valve.

[3] U - Tube manometer: - See that mercury is filled in the U - tube. Now open the inlet cock slowly, observing the mercury (sudden opening of the cock may cause mercury to be forced out of tube). By operating the cock provided at the „T‟ remove the air between water and mercury and note the rise of mercury level in the limb which is open to atmosphere. The difference in the mercury levels in the two limbs is the pressure of water at the tapping.

Pressure, if measured in terms of mercury head, can be directly expressed in cms of Hg. If it is to be measured in kg / cm^2 , 760 mm. of equal to one atmosphere i.e. 1.0332 kg / cm^2 (1.014 bar)

[4] Single Tube well manometer: - For measuring the pressure with higher accuracy, well typed manometers are used. It consists of a shallow reservoir (or well) having large cross - sectional area as compared to that of the limb connected to it. For any pressure variation, change in the level of manometric liquid is appreciable; hence pressure can be measured accurately.

For observations, fill up sufficient mercury in the well. (Approximately 5 to 8 mm. from the bottom of the reservoir.) Open the cock slowly and remove the air in the reservoir. As we go on closing the gate valve, pressure begins to rise. Measure the level of the mercury initially and note down the rise of level for different gate valve openings.

The reservoir inside diameter is 66 mm and tube inside diameter is 7.5mm. Which is very small, hence change in the level of liquid (i.e. Hg) in reservoir is negligible. Hence, if

P = Pressure to be measured, N/ $m^{2.}$
W =ρg = Sp. weight of water = 9810 N /m^3.
h = Rise of manometric liquid level above initial level, mtr.
S= Sp. gravity of .... = ...

Then ,

$$P=\rho gh$$

h=………mm of ....

h=………*. ......mm of water

$\frac{}{\rho g}$= h… ....pressure head in mm or m

= ρgh.................................N/ m^2

[5] <u>Inclined tube manometer</u> - For very accurate readings of small pressures, inclined tube well type manometers are used, because greater length of limb is available for the same vertical rise of manometric liquid level. The manometer is provided with the limb inclined at 60 ^{0} with horizontal. The inclination up to 10^0 with horizontal is also used, depending upon the pressure.

To take the observations, follow the same procedure as for vertical tube well manometer.

Then,

$$P = \rho gh$$

h=………mm of.............(h = Lsinθ)

h=………*. ....mm of water

$\frac{}{\rho g}$= h… ....pressure head in mm or m

= ρgh.................................N/ m^2

Where, θ= Inclination of limb with horizontal.
= 60 ^{0}

[6] <u>Differential manometer</u>: - Fill up sufficient mercury in the manometer. Follow the same procedure as for U - Tube manometer, for opening the cocks and observe the difference in the mercury levels.

The differential manometer is used for measuring the difference of pressure at two points. The two limbs of the manometer are connected at inlet and outlet of an orifice, so that the manometer directly shows the pressure drop across the orifice, in terms of mercury head.

$$P = \rho g h$$

Pressure head =h=x $\left[\frac{S_h}{S_l} - 1\right]$ mm or m of water

$= \frac{h}{\rho g}$ .... pressure head in mm or m

$= \rho g h$.................................N/ m^2

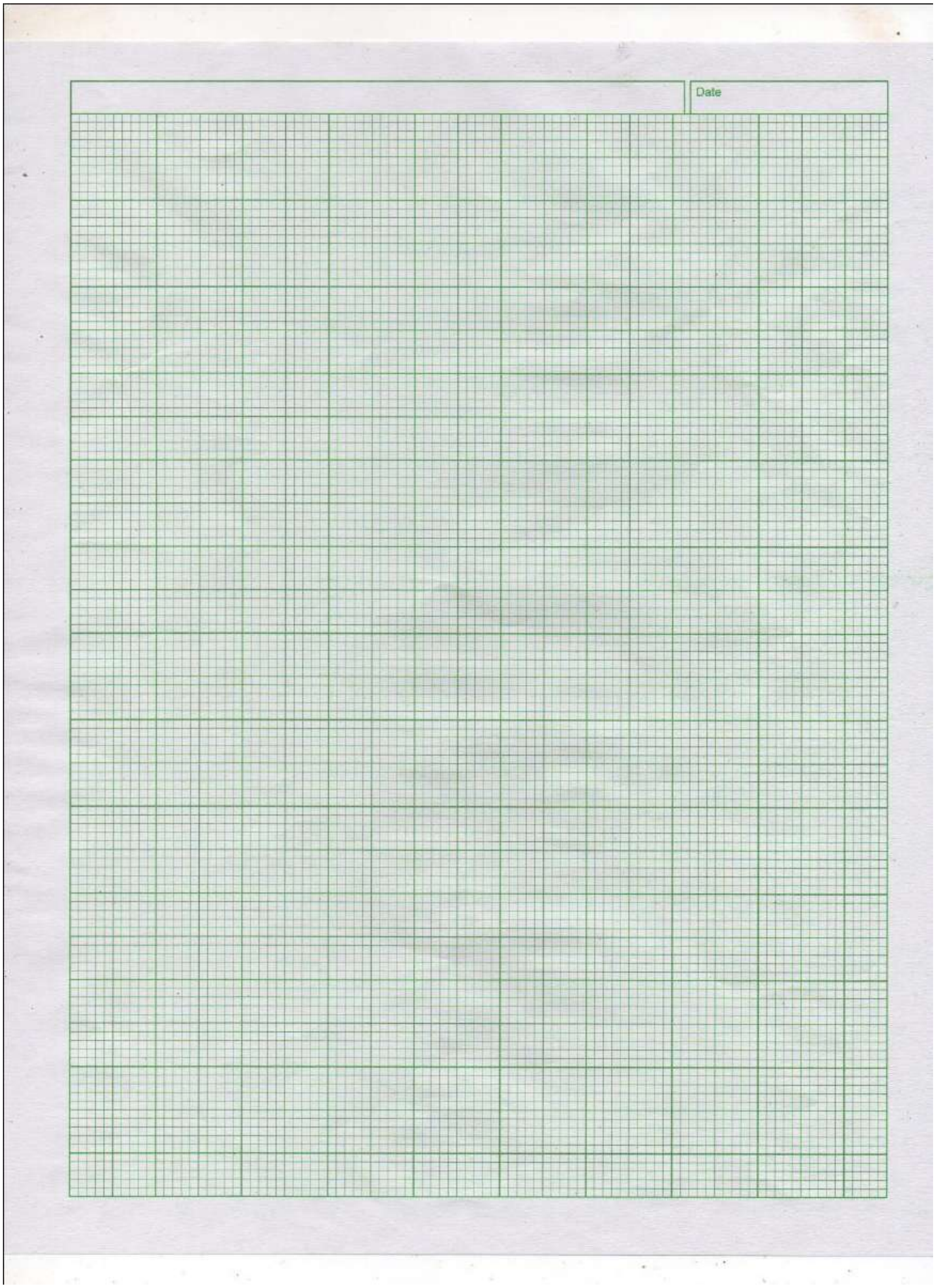
S_h=Specific gravity of mano metric fluid= ......

S_l=Specific gravity of flowing fluid=......

P = Pressure to be measured
x = Manometer difference Meter.
ρg =W = Specific weight of water 9810 N /m^3

PRECAUTIONS

1) For all mercury manometers, it is necessary to remove air bubbles.
2) While closing the gate valve for increasing pressure, always keep watch on mercury otherwise it may escape at higher pressures.


Date

	NAAC B+ Accredited **Dr. A. D. Shinde College of Engineering** **Bhadgaon- 416502**		
	Department of Civil Engineering		
	Subject: Fluid Mechanics		
Experiment No:	**Marks Obtain:**	**Sign:**	
Title: Calibration of Venturimeter		**Performed date:**	**Submitted Date:**

AIM: To determine the coefficient of discharge (Cd) using the Venturimeter.

OBJECTIVES:

- To use the Venturimeter to measure the rate of discharge.
- To determine the coefficient of discharge Cd for the Venturimeter

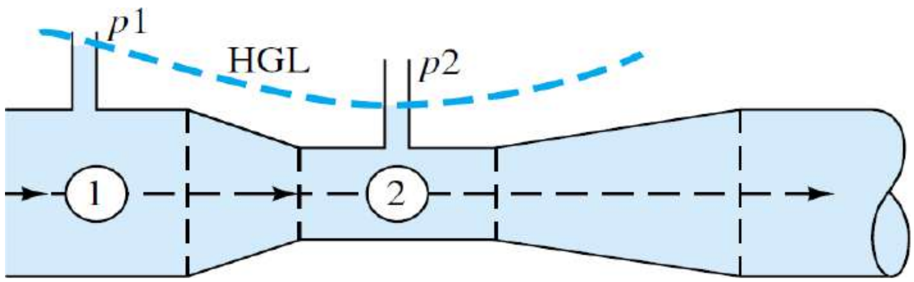
Apparatus: Venturimeter fitted across a pipeline leading to a collecting tank, Stopwatch, U-Tube manometer connected across entry and throat sections etc.

THEORY:

Venturimeter are used for measuring the flow rate of both compressible and incompressible fluids in a pipeline. The pressure in the first measuring tube (1) is higher than at the second (2), and the fluid speed at "1" is lower than at "2", because the cross-sectional area at "1" is greater than at "2". A flow of air through a venturimeter, showing the columns connected in a U-shape (a manometer) and partially filled with water. The meter is "read" as a differential pressure head.

Principle-

It is based on Bernoulli's principle that is the velocity head increase by reducing the cross-section area of the flow passage. Due to which the pressure head is reducing at that the section and velocity head increase. The pressure difference is created which enable to the determination of the discharge through the pipe. When the velocity increases, the pressure decreases and vice versa.



The hydraulic grade line (HGL) shows the height corresponding to elevation and pressure head. The HGL is the height to which liquid would rise in tube attached to the flow.

COMPARISON OF VENTURIMETER AND ORIFICEMETER:

Feature	Venturimeter	Orificemeter
Design	Gradual converging–diverging	Sharp-edged orifice plate
Accuracy	High	Moderate
Energy loss	Very low	High
Cost	Expensive	Cheap
Cd value	~0.95–0.99	~0.60–0.65
Maintenance	Low	Higher
Installation	Complex	Simple

CONSTRUCTION-

It consists of a *short converging conical tube* which has a total included angle of 21 ± 1° leading to a *cylindrical portion of short length*, Known as *throat*, diameter of throat varies between $\frac{1}{3}$ to $\frac{3}{4}$ of main pipe diameter, (preferable $\frac{1}{2}$) which is followed by a *diverging section Known as diffuser* having total included angle 5° to 7° (preferably 6°) which is again connected to the main pipe lines.

Angle of diversion cone is smaller because when water is passing through throat, its velocity is more since area as throat is less.

As this water passes through diversion cone there is chance of separation of fluid flow from boundary of diversion cone causing cavitation. That is why to increase area of flow gradually, the angle of divergent cone is less and its length is more.

The pressure difference from which the volume rate of flow can be determined is measured between the entry section 1 and the throat section 2, often by means of a U-tube manometer.

The axis of venturimeter may be horizontal or inclined or vertical.

Calculation formula=

1) Actual discharge

$$Q_{act=}$$

2) **When the loss of energy is not considered the theoretical discharge is given by**

$$Q_{th}=\frac{a_1 a_2}{\sqrt{a_1^2-a_2^2}}\sqrt{2gh}$$

d_1=Diameter of inlet of venturimeter=21.5mm

a_1= Area of venturimeter at inlet =$3.63 \times 10^{-4} m^2$

d_2= Diameter of throat of venturimeter=12.5mm

a_2=Area of venturimeter at throat=$1.23\times 10^{-4} m^2$

Pressure head =h=x $\left[\frac{s_h}{s_l}-1\right]$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

3) **Coefficient of Discharge**

- The **coefficient of discharge** C_d is always less than unity and is defined as

$$C_d=\frac{Qact}{Qth}$$

EXPERIMENTAL PROCEDURE

Before starting the experiment please see that;

1. Clean water in the sump tank is filled to approx. ¾ of its height.
2. The pressure relief valves above the manometer tubes are fully open.
3. The pressure valves of both the meters are fully closed.
4. The bypass gate valve, drain valve of the measuring tank and the gate valve of the venturimeter which is to be calibrated is kept open while that of the gate valve of the other meter is kept fully closed. Now, start the flow.
5. Open the manometer pressure cocks of the venturimeter. Let the water flow through the pressure relief valves above the manometer. Remove all the air bubbles and then lose both

the pressure relief cocks slowly and simultaneously so that mercury does not get lifted out from the manometer. Observe the mercury head difference in the manometer.

6. Close the gate valve of measuring tank and measure the time required for 10 cm rise of the water in the measuring tank.

7. Repeat the procedure by changing the discharge.

OBSERVATIONS:

1. Volume of tank=……….
2. d_1=Diameter of inlet of venturimeter=
3. d_2= Diameter of throat of venturimeter=
4. S_h=Specific gravity of manometric fluid=13.6
5. S_l=Specific gravity of flowing fluid=1

Observation table -

Sr. No.	"x" In m of Hg	"h" in m of water	Vol. In m^3	Time In Sec	Q_{act} in m^3/s	Q_{th} in m3/sec	Cd
1							
2							
3							

CALCULATIONS-

CONCLUSION:

Calibrated value of coefficient of discharge for venturimeter =

PRECAUTIONS-

1) Open both the manometer cocks slowly and simultaneously, otherwise the mercury will run away from the manometer.
2) Operate the valves gently. Do not forcely rotate them.
3) Always use clean water for the experiment.
4) Drain all water from the sump tank after completion of the experiment.

Fig. Experimental Set-up

Date

	NAAC B+ Accredited **Dr. A. D. Shinde College of Engineering** **Bhadgaon- 416502**		
	Department of Civil Engineering		
	Subject: Fluid Mechanics		
Experiment No:	**Marks Obtain:**	**Sign:**	
Title: Bernoulli's theorem.		**Performed date:**	**Submitted Date:**

AIM: Verification of Bernoulli's theorem

OBJECTIVES:

1. To demonstrate the variation of the pressure along a converging-diverging pipe section.

2. The objective is to validate Bernoulli's assumptions and theorem by experimentally proving that the sum of the terms in the Bernoulli equation along a streamline always remains constant.

Apparatus: Bernoulli's apparatus, controlling valve at inlet and outlet, Discharge Measuring Tank, Scale, Stopwatch etc.

THEORY:

When an incompressible fluid is flowing through a closed circuit, is may be subjected to various forces, which cause change of velocity, acceleration or energies involved. The major forces involved are pressure and body forces. Due to elevation of circuits, pressure may change or due to change of cross section, velocity of fluid may change. But though there is change of velocity, pressure also changes accordingly.

In other words, if velocity energy of fluid is raised, its pressure will drop, i.e. total energy of fluid is constant at any two points in the path of flow. The theorem is known as Bernoulli's theorem. Hence, when applied to steady irrotational flow of incompressible fluids.

The Bernoulli theorem is an approximate relation between pressure, velocity, and elevation, and is valid in regions of steady, incompressible flow where net frictional forces are negligible. The equation is obtained when the Euler's equation is integrated along the streamline for a constant density (incompressible) fluid. The constant of integration (called the Bernoulli's constant) varies from one streamline to another but remains constant along a streamline in steady, frictionless, incompressible flow. Despite its simplicity, it has been proven to be a very powerful tool for fluid mechanics. Bernoulli's equation states that the "sum of the kinetic energy (velocity head), the pressure energy (static head) and Potential energy (elevation head) per unit weight of the fluid at any point remains constant" provided the flow is steady, irrotational, a frictionless and the fluid used is incompressible. This is however, on the assumption that energy is neither added to nor taken away by some external agency. The key approximation in the derivation of Bernoulli's equation is that viscous effects are negligibly small compared to inertial, gravitational, and pressure effects. We can write the theorem as

APPARATUS:

The apparatus consists of a rectangular flow channel, which is tapered along the length. Flow area at inlet is maximum and it goes on reducing towards outlet. Water is fed to flow channel through a supply tank. Outlet is direct collect in measuring

EXPERIMENTAL PROCEDURE:

1. Connect the water pipe to the inlet valve.
2. Reduce flow by inlet gate valve, so that there is only a small rise of water in the last pressure tapping.
3. Allow the levels to stabilize and note down the heads.
4. Close outlet valve of the measuring tank, and measure the time to raise water level by 10 cm.
5. Now, repeat the procedure by changing the discharge, and note the drop of head towards outlet for each observation.

OBSERVATIONS:

1. Width of the channel.......... m
2. Area of measuring tank: (......................) m^2
3. Time required for 100mm rise .... sec

Note- Practically, value of CONSTANT goes on reducing slightly towards outlet, due to various factors which are not considered, e.g. friction, turbulence etc.

OBSERVATION TABLE –

Piezo-meter Tube number	Flow Area at section **(m^2)**	Discharge Q = vol./t **(m^3/s)**	Velocity of water **V = Q/A (m/s)**	Pressure head= **($p/\rho g$)**	Velocity Head = **($V^2/2g$)**	Total head= **$P/\rho g + V^2/2g$**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						

CALCULATIONS-

CONCLUSION:-

1. As value of „C" is fairly constant, total energy of flow is same over the entire length.
2. As velocity of flow increases, pressure head drops.
3. Bernoulli's equation, i.e.

$$\frac{P}{W} + \frac{V^2}{2g} + Z = C$$ **is thus verified.**

PRECAUTIONS:-

1. Note down the head readings after the level has been stabilized.
2. After noting the discharge, drain the measuring tank.
3. After completion of experiment, drain all the water from the equipment

<u>Simple Schematic for Bernoulli's Theorem Apparatus:</u>

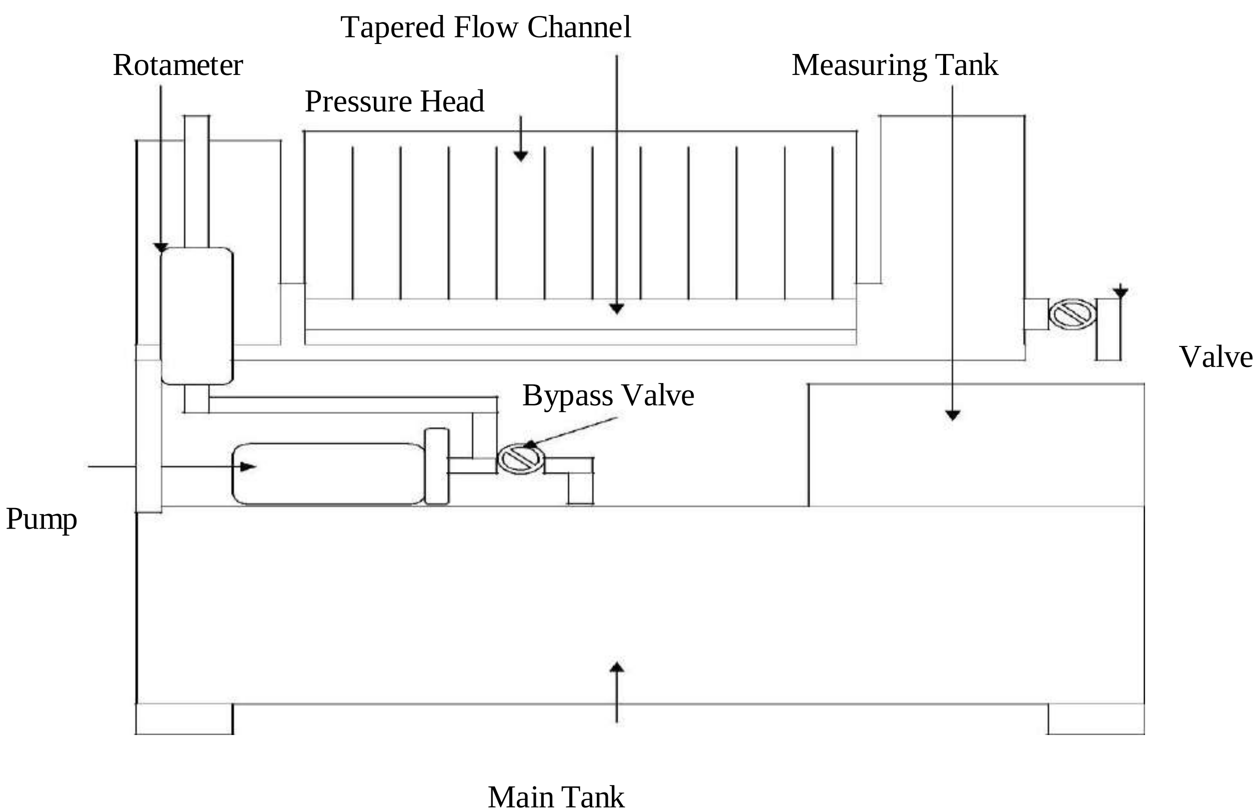


Fig: Experimental Setup

Date

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	Department of Civil Engineering			
	Subject: Fluid Mechanics			
Experiment No:	**Marks Obtain:**	**Sign:**		
Title: Calibration of Orificemeter		**Performed date:**	**Submitted Date:**	

AIM: To determine the coefficient of discharge (Cd) using the orificemeter.

OBJECTIVES:

- To use the Orifice Meter to measure the rate of discharge.
- To determine the coefficient of discharge Cd for the Orifice Meter.

Apparatus: An Orifice meter fitted across a pipeline leading to a collecting tank, Stop Watch, U-Tube manometer etc.

THEORY:

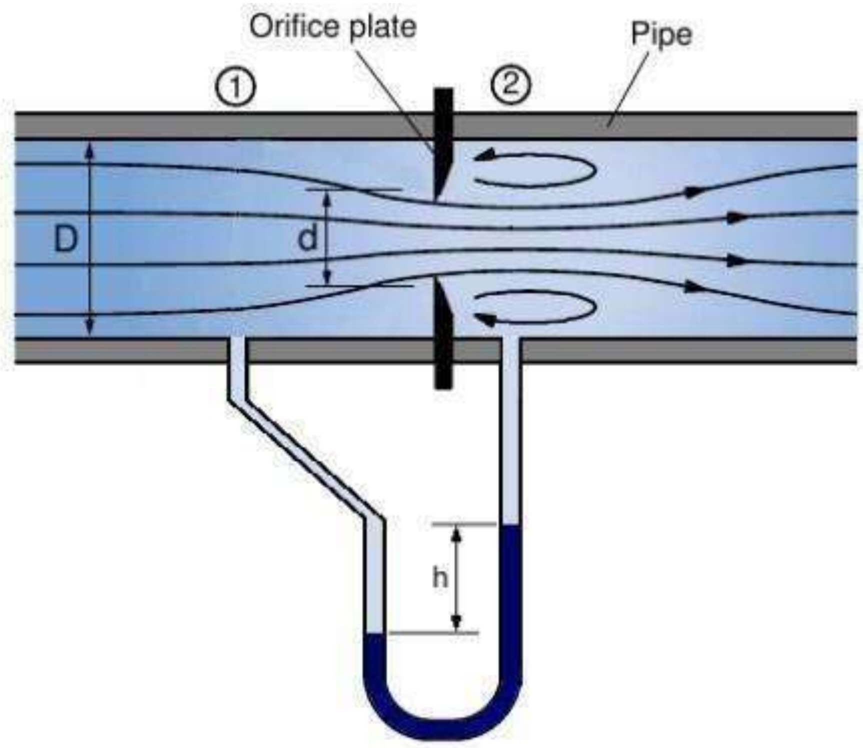
An orifice plate is a device used for measuring flow rate. An orifice plate is a thin plate with a hole in the middle. It is usually placed in a pipe in which fluid flows. When the fluid reaches the orifice plate, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called vena contracta point (see drawing to the right). As it does so, the velocity and the pressure changes. Beyond the vena contracta, the fluid expands and the velocity and pressure change once again. By measuring the difference in fluid pressure between the normal pipe section and at the vena contracta, the volumetric and mass flow rates can be obtained from Bernoulli's equation.

Principle-

It uses the same principle as a Venturimeter, namely Bernoulli's principle which states that the velocity head increase by reducing the cross section area of the flow passage. Due to which the pressure head is reducing at that the section and velocity head increase. The pressure difference is created which enable to the determination of the discharge through the pipe. When the velocity increases, the pressure decreases and vice versa.

Construction-

An orificemeter provides a simpler and cheaper arrangement for the measurement of flow through a pipe. An orificemeter is essentially a thin circular plate with a sharp edged concentric circular hole in it.



CALCULATION=

1) Actual discharge

$Q_{act=}$

2) When the loss of energy is not considered the theoretical discharge is given by

$$Q_{th} = \frac{a_1 a_o}{\sqrt{a_1^2 - a_o^2}} \sqrt{2gh}$$

d_1=Diameter of inlet of orificemeter=

a_1= Area of orificemeter at inlet =

d_0= Diameter of orifice plate of orificemeter =

a_0=Area of orifice plate of orificemeter =

$$\textbf{Pressure head =h=x}\left[\frac{S_h}{S_l}-1\right]$$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

3) Coefficient of Discharge

- The **coefficient of discharge** C_d is always less than unity and is defined as

$$C_d=\frac{Qact}{Qth}$$

EXPERIMENTAL PROCEDURE

Before starting the experiment, please see that;

1. Clean water in the sump tank is filled to approx. ¾ of its height.
2. The pressure relief valves above the manometer tubes are fully open.
3. The pressure valves of both the meters are fully closed.
4. The bypass gate valve, drain valve of the measuring tank and the gate valve of the orificemeter which is to be calibrated is kept open while that of the gate valve of the other meter is kept fully closed. Now, start the flow.
5. Open the manometer pressure cocks of the orificemeter. Let the water flow through the pressure relief valves above the manometer. Remove all the air bubbles and then lose both the pressure relief cocks slowly and simultaneously so that mercury does not get lifted out from the manometer. Observe the mercury head difference in the manometer.
6. Close the gate valve of measuring tank and measure the time required for 10 cm rise of the water in the measuring tank.
7. Repeat the procedure by changing the discharge.

OBSERVATIONS:

1. Volume of tank=

2. d_1=Diameter of inlet of venturimeter=
3. d_2= Diameter of throat of venturimeter=
4. S_h=Specific gravity of manometric fluid=13.6
5. S_l=Specific gravity of flowing fluid=1

OBSERVATION TABLE -

Sr. No.	"x" In m of Hg	"h" in m of water	Vol. In m^3	Time In Sec	Q_{act} In m^3/sec	Q_{th} In m^3/sec	cd
1							
2							
3							

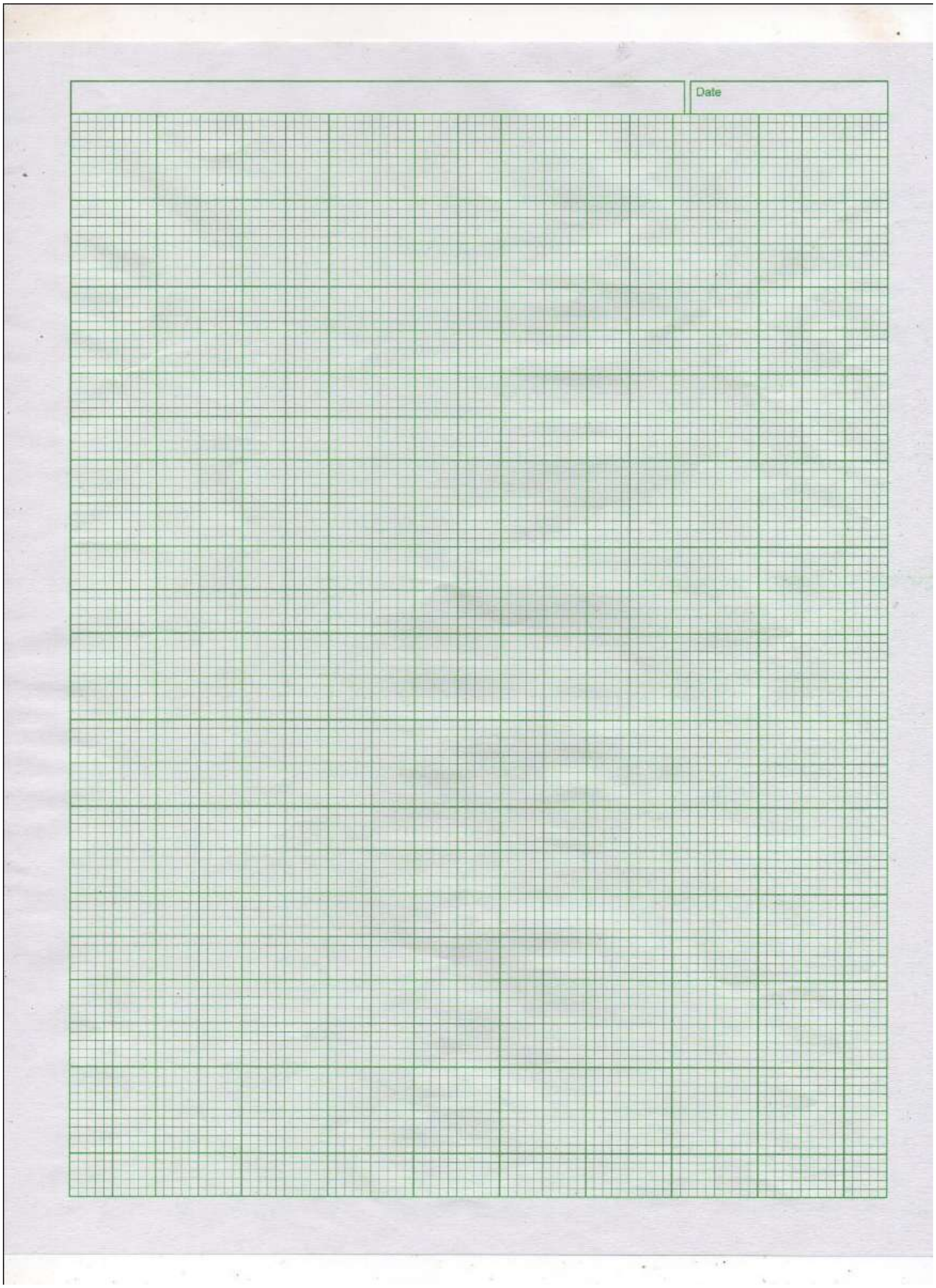
CALCULATIONS-

CONCLUSION: -

Calibrated values of co- efficient of discharge for Orificemeter is.............

PRECAUTIONS: -

- Operate manometer valve gently while removal of air bubble so that mercury in manometer does not get lifted out from the manometer.
- Drain all the water from the sump tank after completion of the experiment.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<tr><td>Experiment No:</td><td>Marks Obtain:</td><td colspan="2">Sign:</td></tr>
<tr><td colspan="2" rowspan="2">Title: Minor losses in pipe fittings</td><td>Performed date:</td><td>Submitted Date:</td></tr>
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AIM: Determination of minor losses in pipe flow

OBJECTIVES: Enable pressure loss measurements to be made on several small-bore pipe circuit components such as pipe bends valves and sudden changes in area of flow.

APPARATUS: Experimental setup with different pipe fittings, manometer, stopwatch.

THEORY:

While installing a pipeline for conveying a fluid, it is generally not possible to install a long pipeline of same size all over and straight for various reasons, like space restrictions, aesthetics, location of outlet etc. Hence, the pipe size varies and it changes its direction. Also, various fittings are required to be used. All these variations of sizes and the fittings cause the loss of fluid head. The apparatus is designed to demonstrate the loss of head due to following fittings-

1) Pipe bend (large bend)
2) Pipe elbow (small bend)
3) Sudden Expansion of the flow.
4) Sudden Contraction of the flow.

The set up consists of 15mm basic piping, in which the above fittings are installed. A pressure tapping is provided at inlet and outlet of each fitting, which is connected to a common differential manometer. A gate valve at outlet and a bypass valve at pump discharge control the flow of water.

friction losses which are considered major.

Minor Losses are proportional to– velocity of flow, geometry of device.

EXPERIMENTAL PROCEDURE: -

1) Fill up sufficient clean water in the sump tank.

2) Fill up mercury in the manometer.

3) Connect the electric supply. See that the flow control valve and bypass valve are fully open and all the manometer cocks are closed. Keep the water collecting funnel in the sump tank side.

4) Start the pump and adjust the flow rate. Now, slowly open the manometer tapping connection of small bend. Open both the cocks simultaneously.

5) Open air vent cocks. Remove air bubbles and slowly & simultaneously close the cocks. Note down the manometer reading and flow rate.

6) Close the cocks and similarly, note down the readings for other fittings.

Repeat the procedure for different flow rates.

(Note - During measuring the heads, slight variation may occur due to voltage changes, valves etc. in such cases, average readings may be taken.)

SPECIFICATIONS –

- Basic piping of ...mm size.
- ....mm small bend
- ....mm large bend
- Sudden expansion from f..... mm to f...... mm.
- Sudden contraction from f ..... mm to f....... mm.

- 1/2 hp centrifugal pump to circulate the water through the piping.
- Multiple tapping differential manometers.
- Sump tank of suitable capacity. =
- Measuring tank -

OBSERVATIONS -

Sr. No.	Types of pipes	Manometer difference cm. of Hg	Volume In m^3	Time In Sec	Q_{act}= Vol/ t In m^3/s
1	Elbow = d =				
2	Bend = d =				
3	Sudden Expansion				
4	Sudden Contraction				

CALCULATIONS -

1) <u>ELBOW</u> -

In elbow, there is no change in the magnitude of velocity of water, but there is change in the direction of water, hence head loss exists.

Diameter of the elbow, d =

For elbow, mean area, A = (π / 4) d^2. = 2

Mean velocity of flow, V = Q/A m/s.

∴ Loss of head at elbow,

$$\textbf{Pressure head = h1 = x} \left[\frac{S_h}{S_l} - 1 \right]$$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

Actual head loss, h_1 =

h_1 = **K**(V^2 / 2.g) m of water.

K=

2) PIPE BEND -

Similar to elbow, loss of head at bend is due to change in the direction of water.

But unlike the elbow, change of direction is not abrupt,

Hence loss of head is less as compared to elbow.

Diameter of bend, d =

For bend, mean area, A = (π /4) d^2 =

Mean velocity of flow, V = Q / A (m /sec.)

$$\textbf{Pressure head =h=x} \left[\frac{S_h}{S_l} - 1 \right]$$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

Actual head loss, h_1 = Manometer diff. (m) x 12.6.

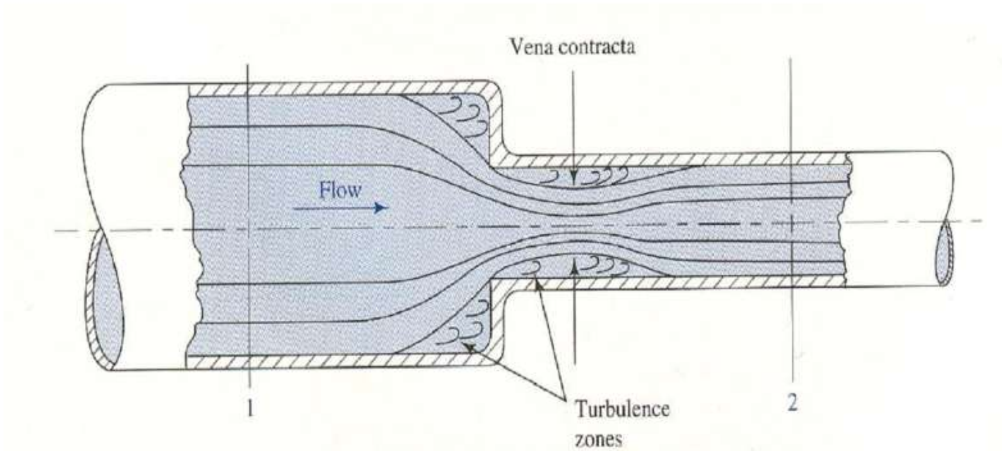
Loss of head at bend, h_1 = K (V^2 /2. g)

K=

Experimentally obtained value of K is greater than this as it includes the loss of head for the two collars also.

3) SUDDEN CONTRACTION-

The loss is associated with the contraction of flow and turbulence –



At sudden contraction, velocity of water increases which causes pressure head to drop (according to Bernoulli's theorem), in addition to this there is loss of head due to sudden contraction.

Manometer reading = (Head drop due to increment of velocity) + (head loss due to sudden contraction)

Assuming no loss to be there due to contraction and applying Bernoulli's theorem at inlet and outlet of the section,

$$\frac{P_i}{w} + \frac{V_i^2}{2.g} = \frac{P_o}{w} + \frac{V_o^2}{2.g}$$

A_i and A_o= Inlet and outlet area respectively, m^2.

Inlet size = $\therefore$ Ai =
Outlet size = $\therefore$ Ao =

$V_i = Q / A_i$ m/s.

$V_o = Q / A_o$ m/s.

Drop of head due to velocity increment,

$$h_v = \frac{V_o^2}{2.g} - \frac{V_i^2}{2.\ g}$$

$$\textbf{Pressure head} = h = x\left[\frac{S_h}{S_l} - 1\right]$$

S_h=Specific gravity of manometric fluid=13.6
S_l=Specific gravity of flowing fluid=1

Actual drop, h = (manometer reading x 12.6)
Loss of head due to sudden contraction

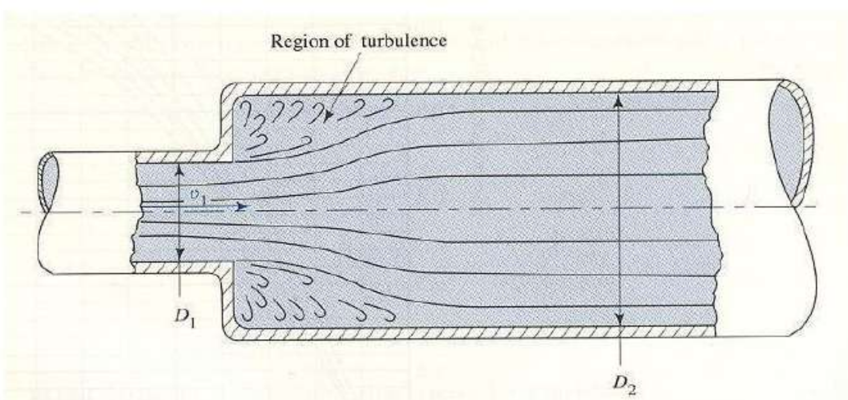
$h_c = h - h_v$.

Theoretically, $h_c = K\,(Vo2 / 2.g)$

K=

Actually, value of K depends upon inside diameter, curvature radius, turbulence surface roughness and many other factors. Hence, it is better to determine the -value of experimentally.

4) <u>SUDDEN EXPANSION</u>:-



Energy lost is because of turbulence. <u>Amount of turbulence depends on the differences in pipe diameters</u>

At sudden expansion of flow, pressure increases due to reduction in velocity, but there is pressure drop due to sudden expansion also. Hence, at sudden expansion one gets rise of pressure lesser than that predicted theoretically.

Assuming no loss of head and applying Bernoulli's equation at inlet and outlet, Similar to equation used for sudden contraction,

Rise of pressure,

$$h_v = \frac{V_i^2}{2.g} - \frac{V_o^2}{2.\,g}$$

Pressure head =h=x $\left[\frac{s_h}{s_l} - 1\right]$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

Loss of head due to sudden expansion,

Actual , he = h_v- (Manometer reading (m) x 12.6)

Theoretical, he = K (Vi -Vo) ^{2} /2g

K=

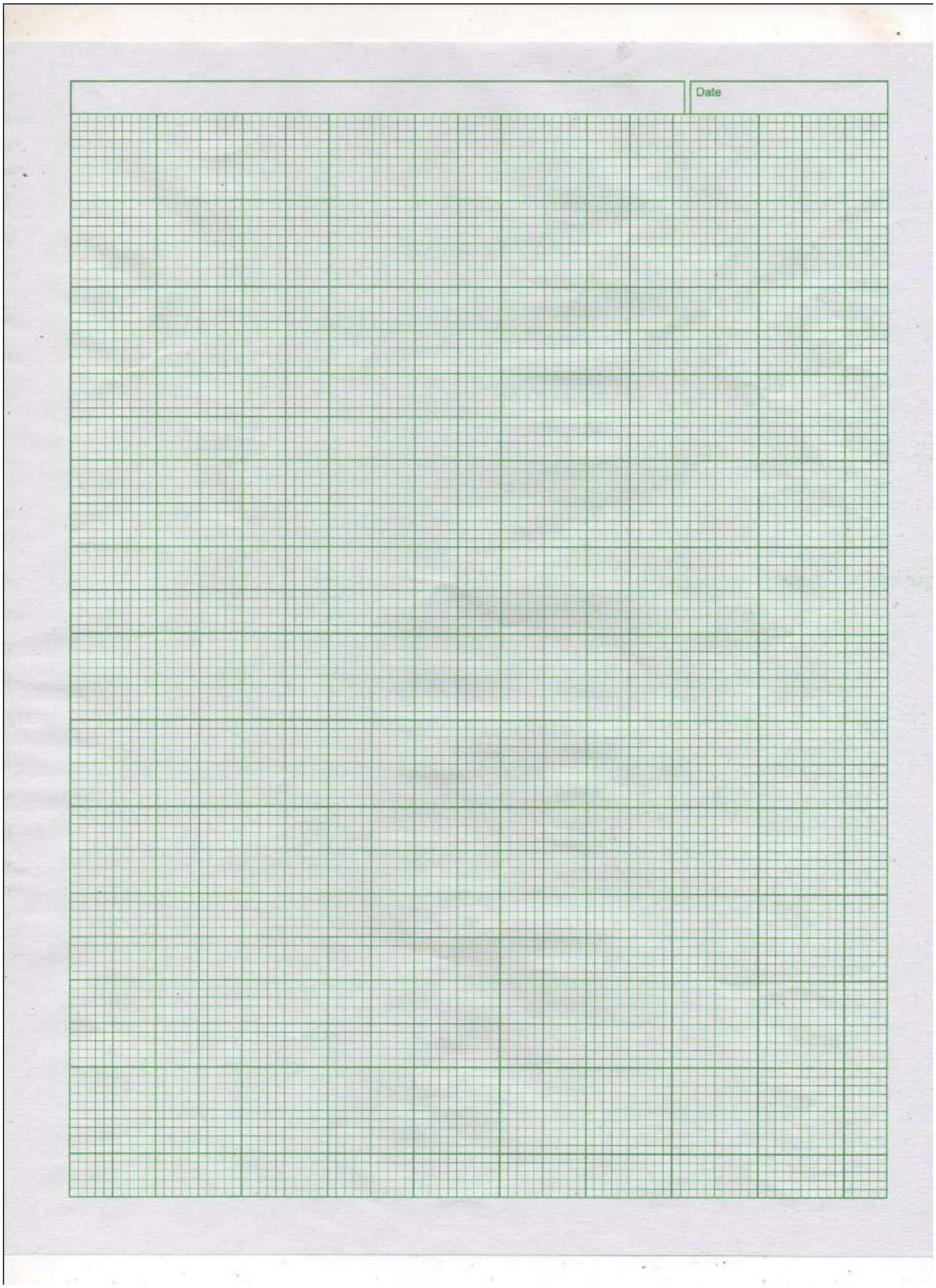
CONCLUSION -

1) For any type of fitting, there is a loss of head, but its magnitude depends upon the type of fitting.

2) Loss of head occurs due to change in magnitude or direction of the fluid velocity.

PRECAUTIONS –

- Open both the manometer cocks slowly and simultaneously, otherwise the mercury will run away from the manometer.
- Operate the valves gently. Do not forcely rotate them.
- Always use clean water for the experiment.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<tr><td colspan="2" rowspan="2">Title: Determination of Friction factor in pipe</td><td>Performed date:</td><td>Submitted Date:</td></tr>
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AIM: To determine the coefficient of friction factor in pipes of different materials

OBJECTIVES:

- To determine the coefficient of friction factor in pipes of different materials.

Apparatus: Pipes of different materials, measuring tank, stop watch, U-tube manometer, centrifugal pump.

THEORY:

The fluid flowing in a pipe is subjected to resistance due to,

1) Shear forces between fluid particles and the boundary wall of the pipes.
2) Shear forces among the fluid particles themselves resulting from the velocity of the fluid. This resistance to the flow of fluid is called frictional resistance. Frictional resistance causes the loss of head.

Darcy–Weisbach equation:

The Darcy–Weisbach equation contains a dimensionless friction factor, known as the Darcy friction factor. This is also called the Darcy–Weisbach friction factor, resistance coefficient or simply friction factor.

$$h_f = $$

EXPERIMENTAL PROCEDURE

1) Ensure that all the control valves are opened before starting the pump.
2) Switch on the supply to the system.
3) Start the pump and wait till the water flow rate gets steady.
4) Then close the bypass valve for water flow gets through the pipes.
5) Before these one out of three pipes is connect to the U tube manometer.
6) Now remove the air bobble from manometer.
7) Take reading from manometer.
8) Now stop the motor and connect the next pipes one by one and fellow same procedure.

OBSERVATIONS:

Following observation are made in pipe friction apparatus;

1) Material of pipe……

2) Measuring tank dimensions Breadth B= 260 mm Length L= 360 mm

3) Area of measuring tank A =L x B=

) Distance between taping L =1000 mm

5) Specific gravity of fluid in pipe S1=1 6) Specific gravity of fluid in manometer S2 =13.6

OBSERVATION TABLE –

Sr. No.	Dia. of pipe in mm	Material of pipe	Difference in mano-meter reading (X) mm	Hf = X [(S 2/S1)-1]	Rise in height of water in measuring tank	Time for collecting water in measuring tank	Q = (L*B*H) / T	Darcy's friction factor(f)
1								
2								
3								
4								
5								
6								

CALCULATIONS-

1) Actual discharge

$$Q_{act} =$$

2) Head loss due to friction h_f,

$$h_f = x\left[\frac{S_h}{S_l} - 1\right]$$

S_h=Specific gravity of manometric fluid=13.6

S_l=Specific gravity of flowing fluid=1

3) Friction Factor f,

$$F = \frac{2gd}{4LV^2}$$

RESULTS:

1) Darcy's friction factor for 1st pipe=
2) Darcy's friction factor for 2nd pipe=
3) Darcy's friction factor for 3rd pipe=

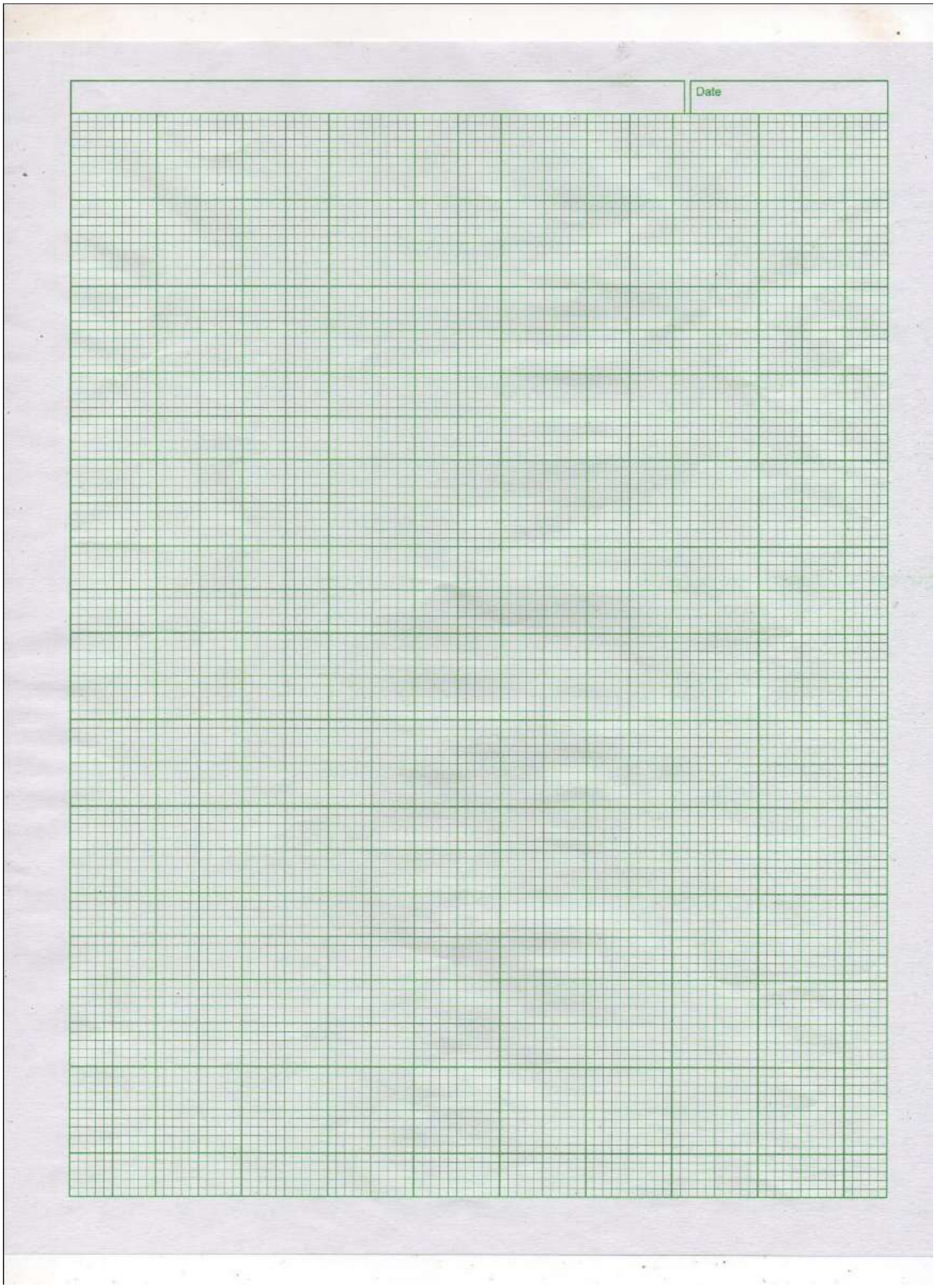
CONCLUSION: -

The friction factor f for different pipes is different because variation in material.

PRECAUTIONS: -

- Operate manometer valve gently while removal of air bubble so that mercury in manometer does not get lifted out from the manometer.
- Drain all the water from the sump tank after completion of the experiment.

Fig: Experimental Setup of Major Losses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AIM: Study of different types of flow by using the Reynolds experiment

OBJECTIVES: To determine the type of flow by using Reynold's Number

Apparatus: Reynold's experimental arrangement, Collecting tank, Stopwatch, Scale, color dye (Potassium Per magnet) etc.

THEORY:

Whenever a fluid is flowing through a pipe, the flow is either laminar or turbulent. When fluid is flowing in parallel layers or lamina, sliding past adjacent lamina, it is called laminar flow. When the fluid does not flow in parallel layers and there is intermingling of fluid particles then the flow is said to be turbulent. Existence of these two types was first demonstrated by ' Osborne Reynolds ' in 1883.

The apparatus consists of a constant head supply tank supplied with water. This tank is provided with a bell mouth outlet to which a transparent tube is fitted. At outlet of the tube a regulating valve is provided. A dye tank containing colored dye (potassium permanganate I.P) is fitted above the supply tank. The water flows through pipe and dye is injected at the center of the pipe. When the velocity of flow is low, (i.e. Flow is laminar) then dye remains in the form of straight filament. As the velocity of water (i.e. Flow of water) is increased, a state is reached when the dye filament becomes irregular and water. With further increase of velocity of water through the tube, dye filament becomes more and more irregular and ultimately the dye diffuses over the entire cross section of the tube.

The velocity at which the flow changes from laminar to turbulent for the case of a given fluid at given temperature and in a given pipe is known as critical velocity. The state of flow between these two types of flow is known as Transition state or flow in transition.

The occurrence of laminar and turbulent flow is governed by relative magnitudes of inertia and viscous forces. Reynolds related the inertia forces to viscous forces and arrived at a dimensionless parameter now called 'Reynolds number'.

DEFINITION:

In fluid mechanics, the Reynolds number (Re) is a dimensionless quantity that gives a measure of the ratio of inertial forces to viscous forces.

Re= Inertia Force / Viscous Force

Where,

Inertia Force = Mass × Acceleration

= (Density × Volume) × (Velocity/Time)

= (Density × (Volume/ Time) × Velocity)

= Density × Discharge × Velocity

$= \rho * (A \times V) \times V$

$= \rho \times A \times V^2$

Viscous Force = Shear Stress × Area in Contact with Fluid

$= \tau \times A$

$= \mu \times (du/dy) \times A$

$= \mu \times (V/D) \times A$

So,

$Re = (\rho \times A \times V2) / (\mu \times V \times A/D)$

$Re = (\rho VD/\mu)$

$Re = (VD/v)$

Where,

V = Velocity of flowing fluid

D = diameter of pipe flow
μ = Dynamic viscosity
v = Kinematic viscosity

Laminar Flow: A flow is said to be laminar when the various fluid particles move in layer with one layer of fluid living smoothly over on adjacent layer. A laminar flow is one in which the fluid particles move in layers or laminar with one layer sliding over the other. Therefore, there is no exchange of fluid particles from one layer to the other and hence no transfer of later of momentum to be adjacent layers. The particles, in the layer having lower velocity, obstruct the fluid particles in the layer with higher velocity. This obstruction force is called viscous resistance or viscosity. The laminar flow is one in which fluid layers glide over each other. It has low velocity and high viscous resistance.

Turbulent Flow: There is a continuous transfer of momentum to adjacent layers. Fluid particles occupy different relative positions at different places. It is one in which the particles get thoroughly mixed on (called turbulence). The turbulent flow has higher velocity. The flow in canals, pipes and rivers is usually turbulent flow.

Transition Flow: The transition flow has intermediate properties between the laminar and turbulent flow. In laminar forces should be considered to calculate the friction loss and in the turbulent flow only the internal forces are considered because the effect of viscous force is negligible as compared to internal forces. Reynolds carried out experiments to decide limiting values of Reynolds number to quantifiably decide whether the flow is laminar, turbulent or transition.

Experimental procedure

1. Fill up sufficient water in dye tank and put a small amount of potassium permanganate into water.
2. Start water supply & adjust the water flow to about 2 lpm. Start the dye injection.
3. Wait for some time. A steady line of dye will be observed. Adjust dye flow, if required.

4. Slowly increases the water flow see that water level in supply tank remains constant. At particular flow rate, dye line will be disturbed note down this flow rate.
5. Further increase the flow. The disturbances of dye line will go on increasing and at certain flow; the dye line diffuses over the entire cross section. Note down this flow.
6. Slightly increase the flow and then slowly reduce the flow. Note the flow at which diffused dye tends to become steady, (beginning of transition zone while reducing velocity.)
7. Further reduce the flow and note the flow at which dye line becomes straight and steady.

Observations:

ρ = density of fluid = 1000 kg/ m^3

v = velocity, m / sec

D = diameter of the pipe =

Cross sectional area of pipe (A =)

μ = viscosity of fluid = 0.856×10^{-3} N.S/m^2

V= volume of 1 liter in measuring flask=0.001 m^3/s

Observation table -

Sr. No.	Volume (M^3)	Time (t)	Discharge Q = vol./time (m^3/s)	Velocity of water V = Q/A (m/s)	Reynolds No. Re = ($\rho VD/\mu$)	Types of flow observed
1						
2						
3						

Calculations-

While increasing the velocity, laminar flow is disturbed at slightly higher velocity. But at the time of reducing the velocity, the flow does not turn to laminar. At this velocity but becomes laminar at still lower velocity is called lower critical velocity.

Lower critical Reynolds number flow is always laminar and above upper critical Reynolds number flow is always turbulent. Practically, upper critical Reynolds number lies between 2700 to 4000 and lower critical Reynolds, number is approximately 2000. Between Reynolds number 2000 and 4000 the transition region exists.

Conclusion:

They are also used to characterize different flow regimes, such as laminar or turbulent flow: laminar flow occurs at low Reynolds numbers, where viscous forces are dominant, and is characterized by smooth, constant fluid motion; turbulent flow occurs at high Reynolds numbers and is dominated by inertial forces, which tend to produce eddies, vortices and other flow instabilities.

1. If Reynolds No. < 2000 Laminar flow
2. If Reynolds No. >2000 Transition flow
3. If Reynolds No. >4000 Turbulent Flow

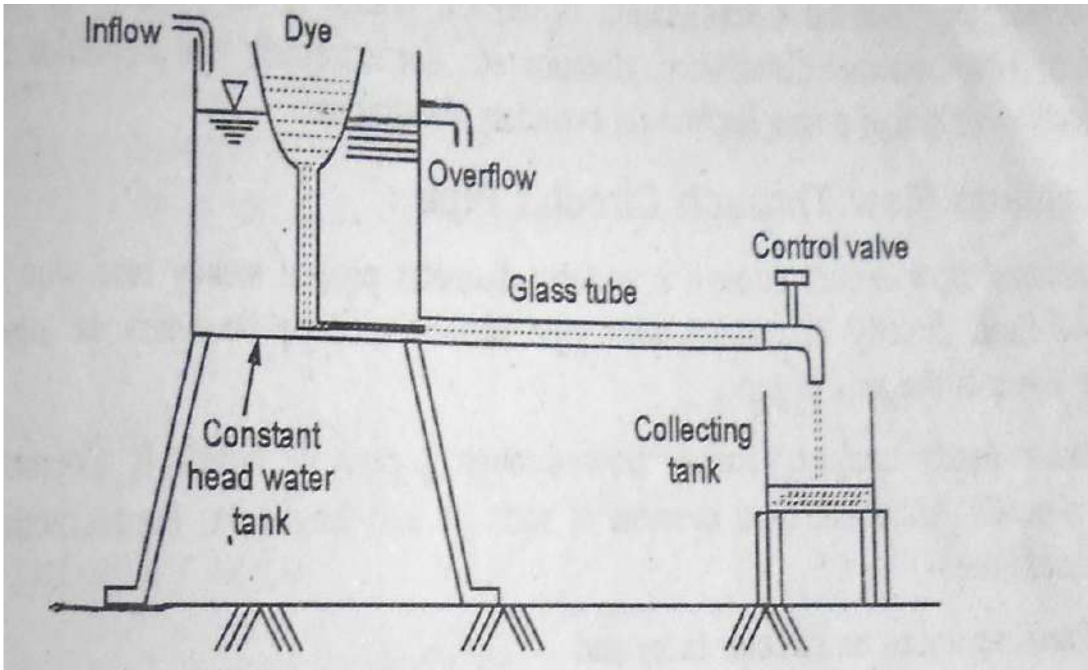


Fig. 6.1 Reynold s Experiment

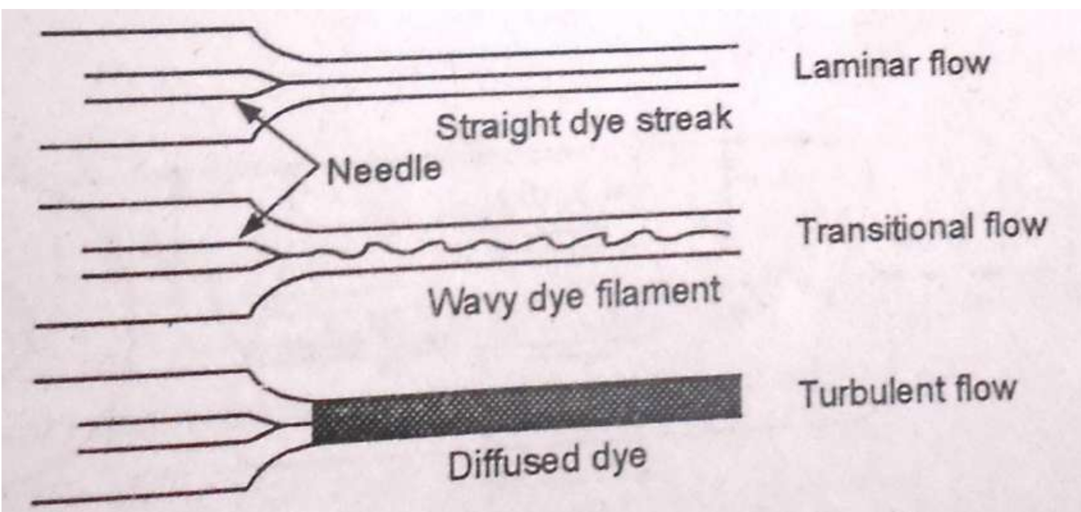
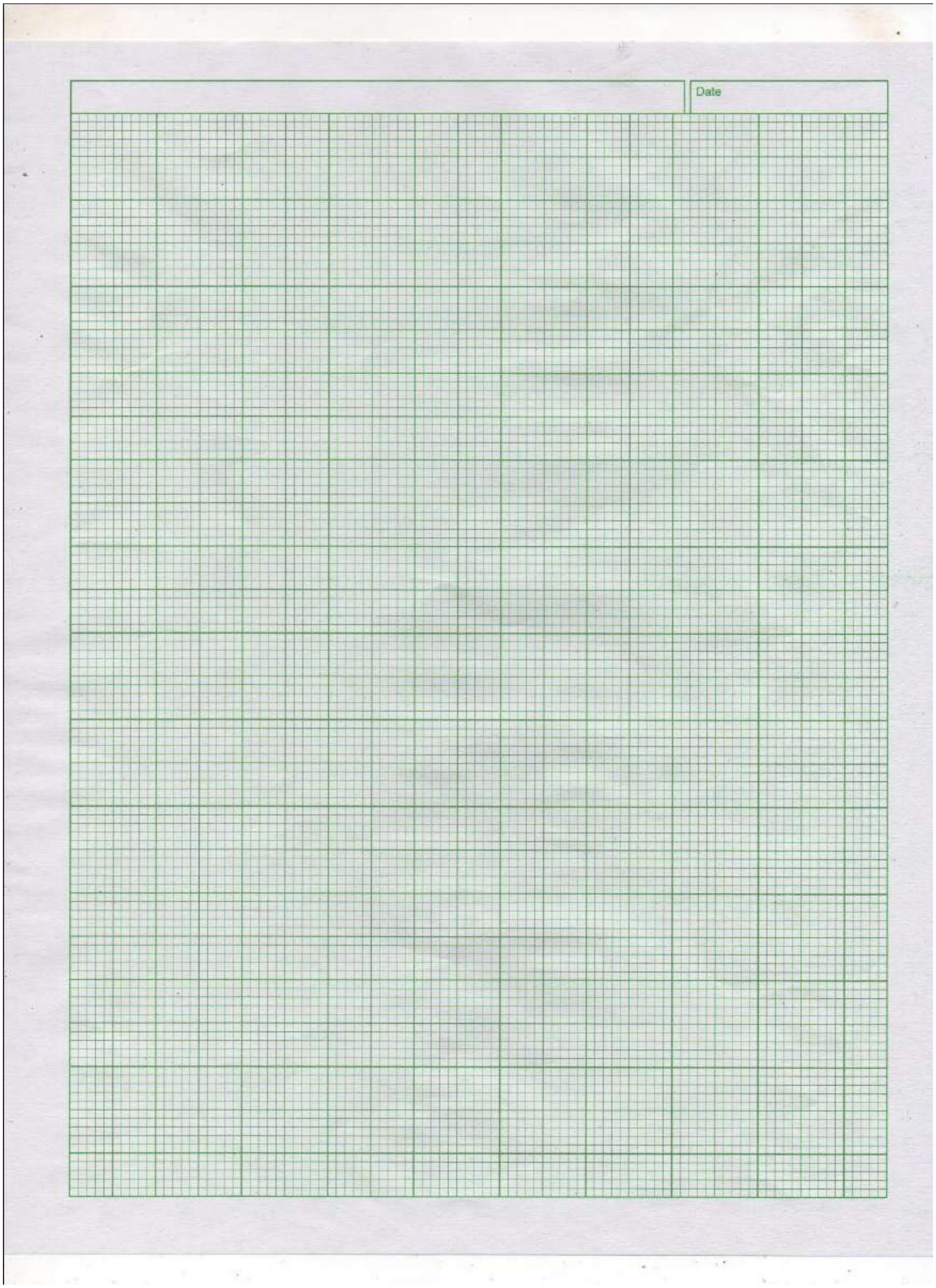


Fig. 6.2 Visualization (Types of flows)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<tr><td colspan="2" rowspan="2">Title: Determination of Hydraulic Coefficients of Orifice</td><td>Performed date:</td><td>Submitted Date:</td></tr>
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AIM: To determine the hydraulic coefficient for a sharp edge circular orifice under steady flow condition.

OBJECTIVE:

To determine hydraulic coefficients:

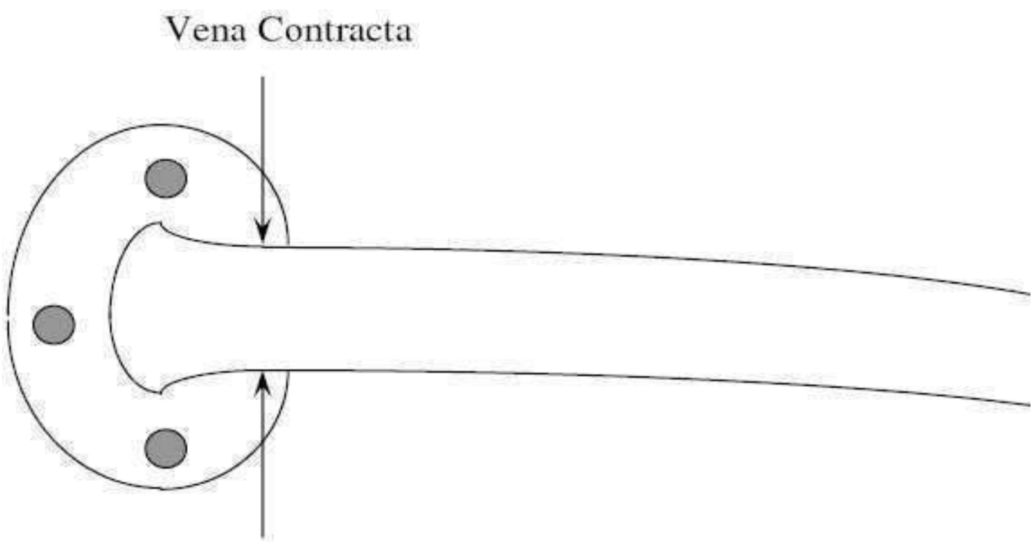
1. **Coefficient of contraction C_C**
2. **Coefficient of contraction C_v**
3. **Coefficient of contraction C_d**

THEORY:

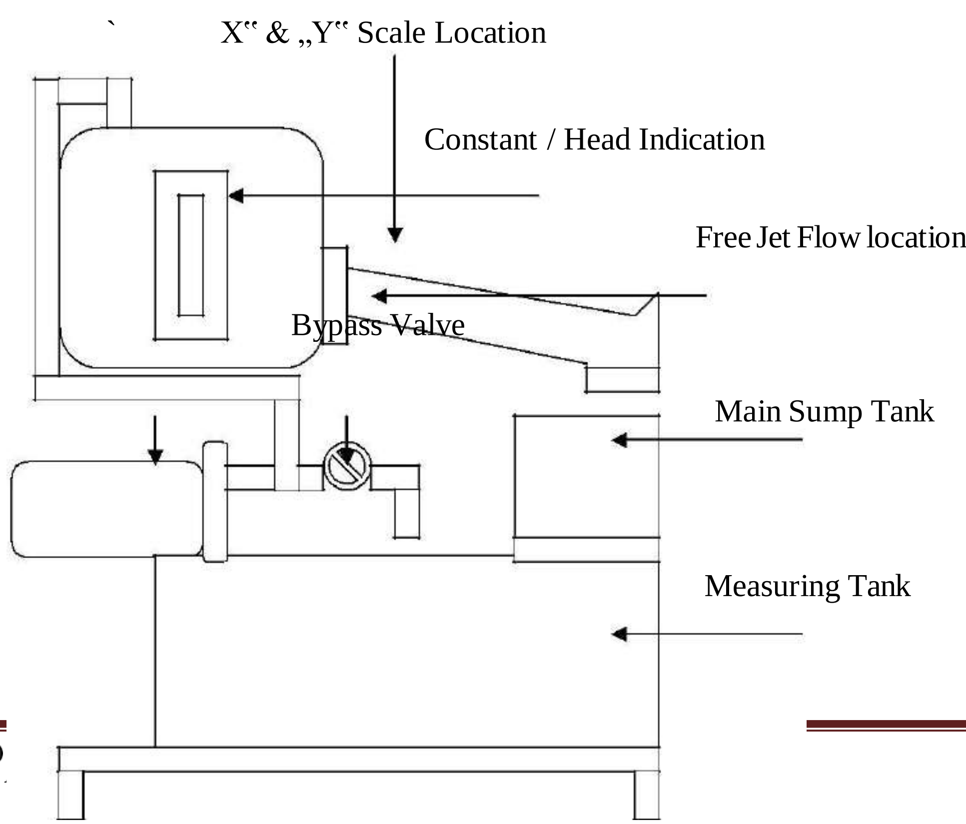
Evangelista Torricelli discovered a relationship between the nozzle discharge velocity and the free-surface height in a tank by using Bernoulli analysis together with conservation of mass principle. However, this analysis needs to be corrected in order to take into account the frictional effects (boundary layer formation) at the walls of the outlet section.

This correction is made by the correction factor known as the discharge coefficient or coefficient of discharge denoted by *cd*. Keeping this fundamental aspect in view, we developed this „orifice & mouthpiece set up". Using our set up, students can not only understand fundamentals of jet flow through orifice & mouthpiece but carry out actual experimentation / calculations & observe their working relation. Here a typical set up is formed with a single-phase centrifugal pump as a fluid circulating device. This centrifugal pump is mounted on a main sump tank from which it lifts the fluid to circulate (water as a fluid). With a bypass valve after pump outlet, which returns excess fluid to main sump tank, outlet is connected to a constant head tank with suitable piping. This head tank has a specific provision of adjustable overflow pipe, which helps to maintain constant head during actual experimentation. Baffles or flow smoothening arrangement is made at the entry point of this constant head tank.

Here this constant head tank is having a provision to fit either orifice or mouthpiece to get a free jet flow. This out coming free jet flow will be passed over a x – y type scale pointer. And then this out coming free jet flow is collected in a measuring tank. Measuring tank is provided with volumetric scale. So, with provided stop stock, one can easily measure the actual flow through free jet flow. And outlet of this measuring tank could be returned to main sump tank, so as to make it a re-circulating system. Drain valve is provided for main sump tank.



Experimental Setup:



PROCEDURE:

1. First set the head pipe in maximum position
2. Start the motor
3. Allow same time to flow through orifice.
4. Note x and y coordinate
5. Take the time required for 100mm rise in tank
6. Take at least 3-4 reading for different head level

OBSERVATIONS TABLE:

Sr. No.	X co-ordinate	Y co-ordinate	Head (mm)	Head (m)	Diameter	Time For 100mm Rise in Second
1.						
2.						
3.						

CALCULATION:

1. For actual Output Flow, note time as well as measuring Tank reading. And then calculate actual flow as below.

$$\text{Output Flow} = \frac{\text{Measuring Tank content in Liters}}{\text{Time in Minutes}} \; 60$$

For e.g. if Measuring Tank content is 5 ltrs & Stop Clock shows 1 min then output flow is calculated as below –

$$\text{Output Flow} = \frac{5\ \text{Ltrs}}{1\ \text{Minutes}} \times 60 = 300\ \text{LPH.}$$

2. For Orifice or Mouthpiece i.e. 8.5 mm diameter - use following Formula to get Cd, Cv & Cc in respective manner.

$$Cd = \frac{(0.0349577 * \text{Flow (LPH)})}{(h)^{0.5}}$$ (h in mm)

&

$$Cv = \frac{0.5 * X}{(h * Y)^{0.5}}$$ (X, Y & h in mm)

Cc = ---- (Cc is Unit less)

RESULT TABLE:

Sr. No.	H	Cv	Mean Cv	Qact	Qth	Cd	Mean Cd

CONCLUSION:

1. The mean coefficient of velocity for the orifice is ……..

2. The mean coefficient of discharge for the orifice is ……

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Aim: Study of Moody’s chart.

Introduction:

The Moody’s chart is a graphical representation used in fluid mechanics to determine the friction factor (f) for flow through pipes. It relates the Reynolds number (Re), relative roughness (ε/D), and friction factor, and is widely used in hydraulic and environmental engineering design.

Basis of Moody’s Chart:

The chart is based on the **Darcy–Weisbach equation**, which is used to calculate head loss due to friction in pipes:

$$hf=f * L/D * V^2/2g$$

Reynolds Number:

- Indicates type of flow
- Depends on velocity, diameter, and viscosity
- $Re=VD / \nu$

Relative Roughness (ε/D):

- Ratio of pipe surface roughness (ε) to diameter (D)
- Determines nature of turbulent flow
- Higher roughness → higher friction losses

Features of Moody's Chart:

- Combines experimental results (Nikuradse data)
- Covers both smooth and rough pipes
- Provides quick estimation of friction factor
- Avoids solving complex equations like Colebrook equation

Importance:

- Design of water supply pipelines
- Sewer and drainage systems
- Irrigation pipelines
- Hydraulic calculations in civil engineering

Conclusion:

- Moody's chart is an essential tool for determining friction losses in pipe flow and plays a crucial role in the design and analysis of fluid flow systems.