

**A Laboratory Manual for**

**Fluid Mechanics  
(BE04000161)**

**B.E. Semester 4 (Mechanical)**

**Institute logo**



**Directorate of Technical Education, Gandhinagar,  
Gujarat**

## **Institute Name**

### **Certificate**

This is to certify that Mr./Ms. \_\_\_\_\_  
\_\_\_\_\_ Enrollment No. \_\_\_\_\_ of B.E. Semester \_\_\_\_\_  
Mechanical Engineering of this Institute (GTU Code: \_\_\_\_\_ ) has  
satisfactorily completed the Practical / Tutorial work for the subject **Fluid  
Mechanics (BE04000161)** for the academic year \_\_\_\_\_.

Place: \_\_\_\_\_

Date: \_\_\_\_\_

**Name and Sign of Faculty member**

**Head of the Department**

## **Preface**

Main motto of any laboratory/practical/field work is for enhancing required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient weightage is given to practical work. It shows importance of enhancement of skills amongst the students and it pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Fluid Mechanics is the course which provides an understanding of Fluid Mechanics fundamentals. The course consists of different concept of Fluid Mechanics, Further, fundamentals of Fluid and their properties, Static force on surfaces and buoyancy, motion of fluid particles and streams, energy equation and its application, dimensional analysis and similarities, viscous and turbulent flow, flow through pipe also addressed in this course.

Utmost care has been taken while preparing this lab manual however always there is chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

**Practical – Course Outcome matrix**

<b>Course Outcomes (COs):</b>						
<b>CO-1:</b> Explain properties of fluids and principles of fluid statics						
<b>CO-2:</b> Apply continuity, momentum, and energy equations to solve engineering problems						
<b>CO-3:</b> Analyze laminar and turbulent flows in pipes and channels						
<b>CO-4:</b> Apply dimensional analysis and similitude to engineering and automotive model studies.						
<b>CO-5:</b> Demonstrate fundamentals of compressible flow and conduct fluid mechanics experiments relevant branch of engineering						
<b>Sr. No.</b>	<b>Objective(s) of Experiment</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>	<b>CO5</b>
1.	Verification of Pascal's law and hydrostatic pressure	√				
2.	To determine metacentric height of a floating body	√				
3.	Verification of Bernoulli's theorem		√			
4.	To measure the velocity of flow using venturimeter		√			
5.	To measure the velocity of flow using orificemeter		√			
6.	To determine the coefficient of discharge through open channel flow over a notch (V-notch/rectangular)		√			
7.	To determine coefficient of discharge of an orifice		√			
8.	To determine the different types of flow patterns by Reynolds' experiment			√		
9.	To determine the friction factor for the different pipes			√		
10.	To determine the loss coefficients for different pipe fittings			√		
11.	To measure the velocity of flow using Pitot tube		√			
12.	Demonstration of model studies (wind tunnel / CFD if available)					√

### **Industry Relevant Skills**

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.

1. Testing the performance of Fluid Machines, Pumps and Turbines.
2. Selecting the material for the required pumps, turbine and its layout.
3. Understanding the stability of ship by adjusting metacentric height.

### **Guidelines for Faculty members**

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

### **Instructions for Students**

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines.
7. Student should develop a habit of submitting the experimentation work as per the schedule and should be well prepared for the same.

### **Common Safety Instructions**

1. Students are expected to carefully wear shoes for safety.
2. Maintain laboratory clean and organized.
3. Switch off the main power supply to the experimental set up on completion of experiment.
4. Loose clothing and jewellery are prohibited.
5. Do not leave any running experimental set up unattended.

## Index (Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of performance	Date of submission	Assessment Marks	Sign. of Teacher with date	Remarks
1	Verification of Pascal's law and hydrostatic pressure						
2	To determine metacentric height of a floating body						
3	Verification of Bernoulli's theorem						
4	To measure the velocity of flow using venturimeter						
5	To measure the velocity of flow using orificemeter						
6	To determine the coefficient of discharge through open channel flow over a notch (V-notch/rectangular)						
7	To determine coefficient of discharge of an orifice						
8	To determine the different types of flow patterns by Reynolds' experiment						
9	To determine the friction factor for the different pipes						
10	To determine the loss coefficients for different pipe fittings						
11	To measure the velocity of flow using Pitot tube						
12	Demonstration of model studies (wind tunnel / CFD if available)						
Total							

## Experiment No: 1 Verification of Pascal's law and hydrostatic pressure

**Date:**

**Relevant CO: CO1**

**Objectives:** 1. To verify Pascal's Law  
2. To verify hydrostatic pressure

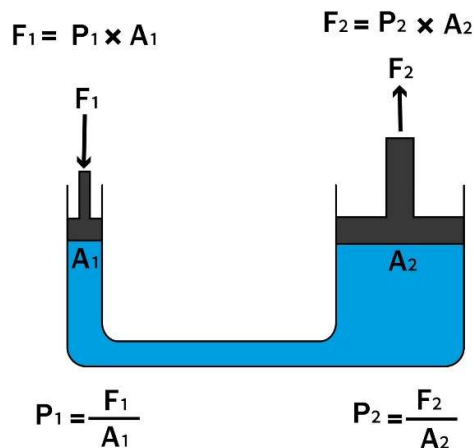
**Theory:**

Pascal's Law states that a change in pressure applied to an enclosed, incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

If a force  $F_1$  is applied to a small area  $A_1$  the pressure  $P = F_1/A_1$

According to Pascal's Law, this same pressure  $P$  is transmitted to a larger area  $A_2$ , resulting in a larger force  $F_2$

$$F_2 = P \times A_2 = (F_1/A_1) \times A_2$$



**Apparatus:**

1. Two syringes of different diameters (e.g., 10ml and 50ml)
2. flexible tube filled with water

**Procedure:**

1. Push the plunger of the smaller syringe (Input) with a known force.
2. Observe the movement of the larger syringe's plunger (Output).
3. Place a heavy weight on the larger plunger and try to lift it by pushing the smaller plunger.

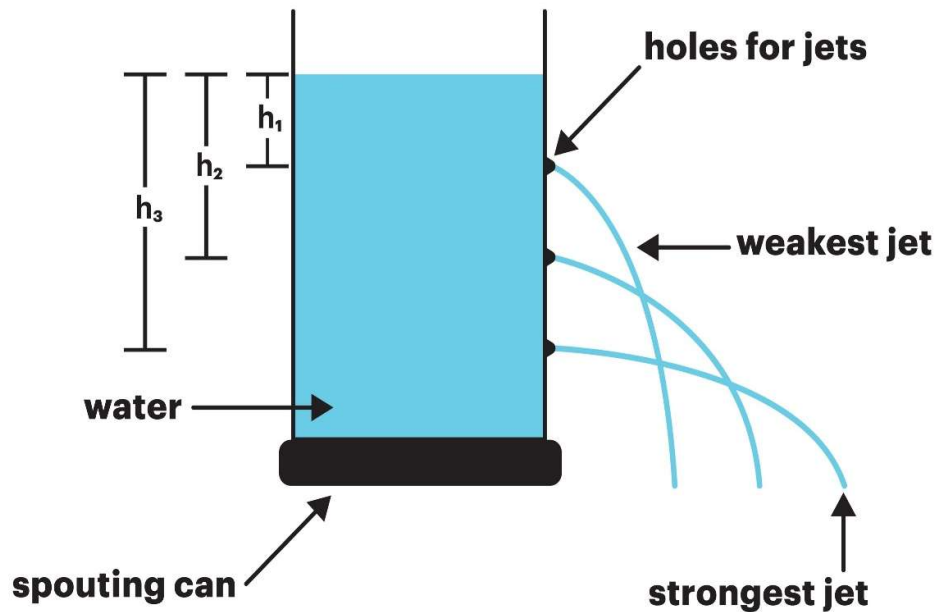
**Observation:** You will find that a light push (small force) on the small syringe can lift a heavy weight on the large syringe.

**Verification:** If the area of the second piston is 5 times larger, you will theoretically be able to lift 5 times the weight with the same input effort.

Hydrostatic Pressure refers to the pressure exerted by a fluid at equilibrium due to the force of gravity. It increases with depth.

The pressure  $P$  at a depth  $h$  is given by:

$$P = \rho gh$$



**Apparatus:**

A tall plastic bottle or tin can.

**Procedure:**

1. Punch three vertical holes on the side of the can at different heights: Top  $h_1$ , Middle  $h_2$  and Bottom  $h_3$
2. Fill the can with water while temporarily covering the holes with tape.
3. Remove the tape simultaneously.

**Observation:**

- The water stream from the **top hole** falls closest to the can (lowest pressure).
- The water stream from the **bottom hole** shoots the farthest (highest pressure).

**Conclusion:** Since the bottom hole has the greatest depth of water above it, it experiences the highest pressure, verifying  $P = \rho gh$

**Quiz:**

**1. Explain Pascal's Law**

**2. Explain hydrostatic law.**

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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5. Som & Biswas – Introduction to Fluid Mechanics and Fluid Machines, McGraw-Hill

**References used by the students:**

**Rubric wise marks obtained:**

Criteria	%	10	9-8	7-6	5
Knowledge	30	Correct answers 90% or more by student.	Correct answers between 70-89%.	Correct answers between 50-69%.	Correct answers less than 50%.
Quality of report	20	Proper formatting and well attempted quiz and case study with excellent reported work	Only formatting is improper (Location of figures/tables, use of pencil and scale). Good	A few required elements (labeling/ notations) are missing. Average	Several elements are missing (content in paragraph, labels, figures, tables). Poor report
Participation type	30	Participation 25% Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Less Participation
Punctuality	20	Timely Submission	Submission late by one laboratory.	Submission late by two laboratories.	Submission late by more than two laboratories.
Criteria	%	Level of Marks	Multiplication	Total	Remarks
Knowledge	30		0.3 * _____		
Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 2 To determine metacentric height by metacentric height apparatus

**Date:**

**Relevant CO: CO1**

**Objectives:** To determine metacentric height of a floating body

**Theory:**

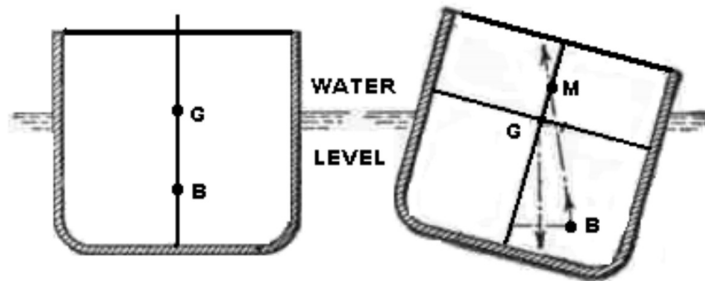
### **Buoyancy:**

When a body is completely submerged in a fluid, or it is floating or partially submerged, the resultant fluid force acting on the body is called the buoyant force. It is also known as the net upward vertical force acting on the body. A net upward vertical force results because pressure increases with depth and the pressure forces acting from below are larger than the pressure forces acting above.

The Centre of buoyancy is the centre of gravity of the displaced water. It lies at the geometric centre of volume of the displaced water.

### **Metacentre:**

For the investigation of stability of floating body, it is necessary to determine the position of its metacentre with respect to its centre of gravity. Consider a floating ship model, the weight of the ship acts through its centre of gravity and is balanced by an equal and opposite buoyant force acting upwards through the centre of buoyancy i.e. the centre of gravity of liquid displaced by the floating body.



A small angular displacement shifts the centre of buoyancy and the intersection of the line of action of the buoyant force passing through the new centre of buoyancy and the extended line would give the metacentre.

The distance between centre of gravity (G) and metacentre (M) is known as Metacentric height (GM).

There are three conditions of equilibrium of a floating body

Stable Equilibrium - Metacentre lies above the centre of gravity

- Unstable Equilibrium- Metacentre lies below the centre of gravity
- Neutral Equilibrium - Metacentre coincides with centre of gravity

The Metacentric height (GM) is given by

$$GM = (m * X) / (W * \tan\theta)$$

Where,

W = weight of the floating body

m = movable weight

X = distance through which the movable load is shifted

$\theta$  = Angle of Heel

### Apparatus Description

The apparatus consist of a SS tank and is provided with a drain cock. The floating body is made from Clear Transparent Acrylic. It is provided with movable weights, protractor to measure the angle of Heel and pointer. Weights are also provided to increase the weight of floating body by known amount.

### Experimental Procedure:

1. Fill the SS tank to about 2/3 levels
2. Place the floating body in the tank.
3. Apply momentum to the floating body by moving one of the adjustable weights (m) through a known distance.
4. Note down the angle of heel corresponding to this shifts of weight with the help of protractor and pointer.
5. Take about 4-5 such readings by changing the position of the adjustable weight and find out centre of gravity in each case

### Observation Table:

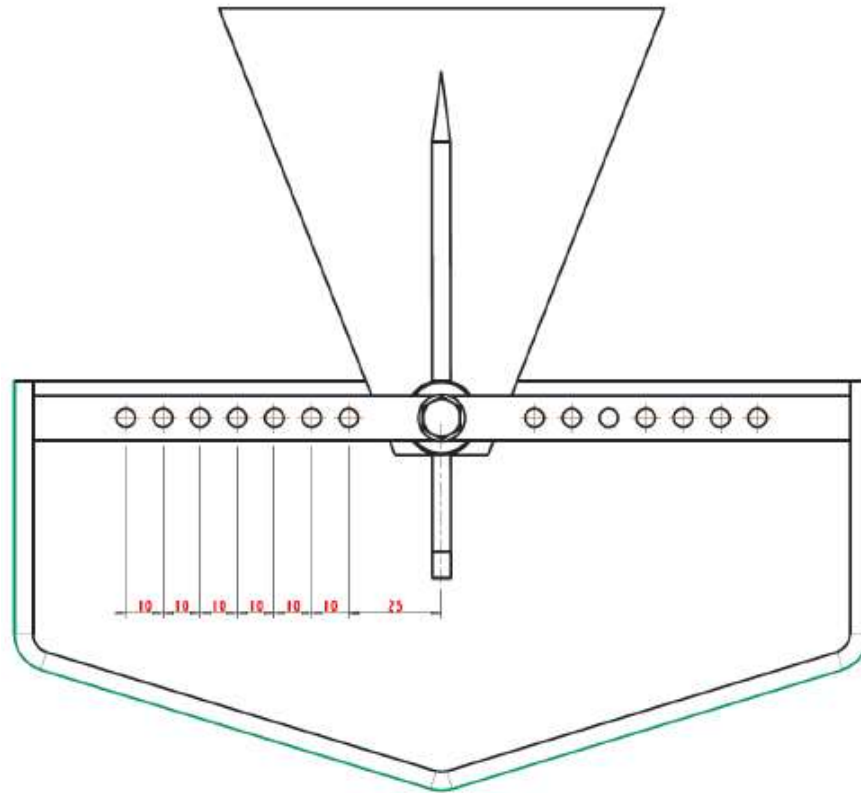
- Weight of the ship model =  $1.9 \times 9.81 = 18.64 \text{ N}$
- Given Movable Weights =  $100 \text{ gm} = 0.98 \text{ N}$

Sr. No.	Movable Weight (m) in N	Distance moved (X) in meter	Angle of Tilt $\theta$	Tan $\theta$	Metacentric Height GM in meter

**Conclusion:**

Thus Metacentre is the point about which a body starts oscillating when the body is tilted by a small angle.

- Metacentric Height of the given ship model is \_\_\_\_\_



**Quiz:**

1. Explain Archimedes principle

2. Enlist stability criteria of submerged and floating bodies.

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**3. Define the term: Buoyancy, Center of Buoyancy, Meta center and Metacentric height**

**4. Write the practical significance of Metacentric height.**

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
3. White, F.M. – Fluid Mechanics, McGraw-Hill.
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Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## **Experiment No: 3** **Verification of Bernoulli's theorem**

**Date:**

**Relevant CO: CO2**

**Objectives:** To verify Bernoulli's theorem

**Theory:**

Bernoulli's principle is named after the Dutch-Swiss mathematician Daniel Bernoulli who published his principle in his book Hydrodynamica in 1738.

Bernoulli's principle in its simplest form states that "the pressure of a fluid [liquid or gas] decreases as the speed of the fluid increases." The principle behind Bernoulli's theorem is the law of conservation of energy. It states that energy can be neither created nor destroyed, but merely changed from one form to another.

The energy, in general, may be defined as the capacity to do work. Though the energy exists in many forms, yet the following are important from the subject point of view:

- 1) Potential Energy
- 2) Kinetic Energy and
- 3) Pressure Energy

**Potential energy of a Liquid in Motion:**

It is the energy possessed by a liquid particle, by virtue of its position. If a liquid particle is  $Z$  meters above the horizontal datum (arbitrary chosen), the potential energy of the particle will be  $Z$  meter of liquid. Potential head of the liquid, at that point, will be  $Z$  meters of the liquid.

**Kinetic Energy of a liquid Particle in Motion**

It is the energy, possessed by a liquid particle, by virtue of its motion or velocity. If a liquid particle is flowing with a mean velocity of  $v$  meter per second, then the kinetic energy of the particle will be  $v^2/2g$  meter of the liquid. Velocity head of the liquid, at that velocity, will be  $v^2/2g$  meter of liquid.

**Pressure Energy of a liquid Particle in Motion:**

It is the energy, possessed by a liquid particle, by virtue of its existing pressure. If a liquid particle is under a pressure of  $p$   $\text{kg/m}^2$ , then the pressure energy of the particle will be  $p/w$  meter of liquid, where  $w$  is the specific weight of the liquid. Pressure head of the liquid under that pressure will be  $p/w$  meter of the liquid.

**Total Energy of a liquid Particle in Motion:**

The total energy of a liquid particle, in motion, is the sum of its potential energy, kinetic energy and pressure energy. Mathematically,

$$\text{Total Energy, } E = z + \frac{v^2}{2g} + \frac{p}{w} \quad m \text{ of liquid}$$

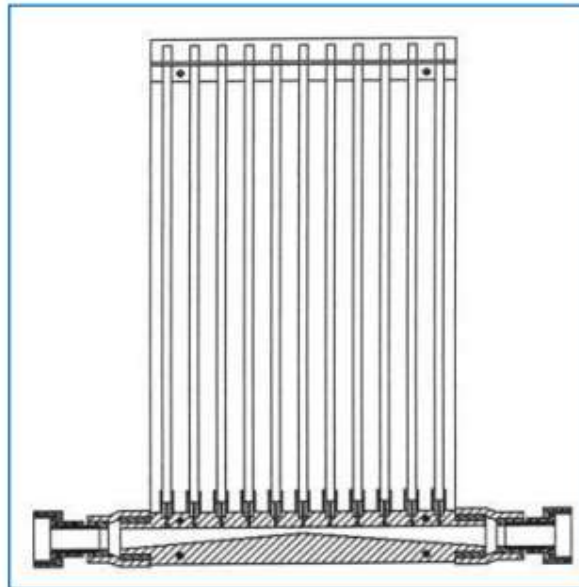
### Bernoulli's Equation

It states, "For a perfect incompressible liquid, flowing in a continuous stream, the total energy of a particle remains the same; while the particle moves from one point to another." This statement is based on the assumption that there are no losses due to friction in pipe. Mathematically,

$$E = z + \frac{v^2}{2g} + \frac{p}{w} = \text{constant}$$

### Apparatus Description:

The apparatus is made from transparent acrylic and has both the convergent and divergent sections. Water is supplied from the constant head tank attached to the test section. Constant level is maintained in the supply tank. Piezometric tubes are attached at different distance on the test section. Water discharges to the discharge tank attached at the far end of the test section and from there it goes to the measuring tank through valve. The entire setup is mounted on a stand.



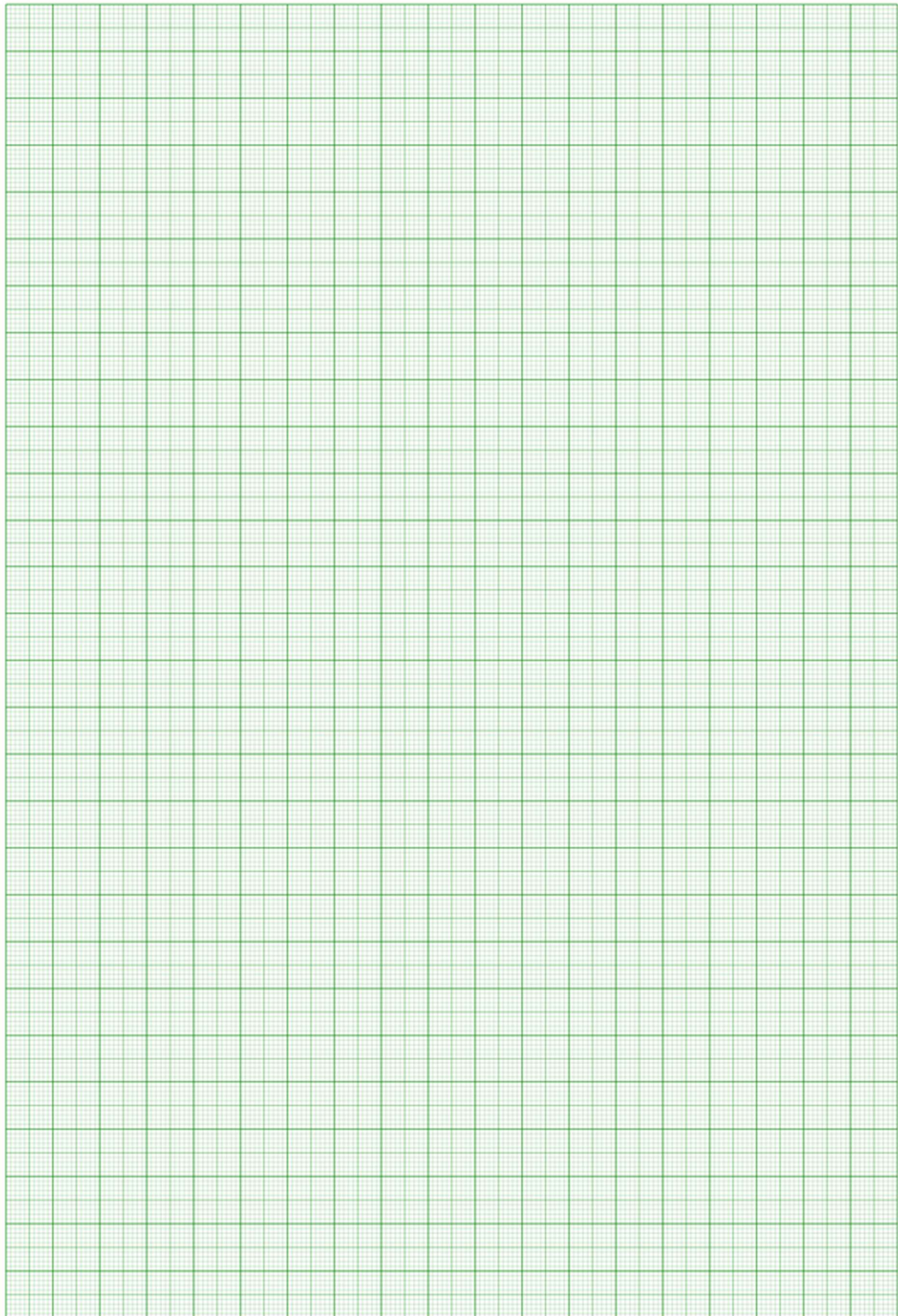
**Fig. 3.1 Test Section Bernoulli's setup**

### Experimental Procedure:

- 1) Note down the area of cross-section of the conduit at sections where piezometers have been fixed.
- 2) Open the supply valve and adjust the flow in the conduit so that the water level in the inlet tank remains at a constant level (i.e., the flow becomes steady).
- 3) Measure the height of water level (above an arbitrarily selected suitable horizontal plane) in different piezometer tubes.
- 4) Measure the discharge by calculating time taken for 10 liters flow.
- 5) Repeat steps (2) to (4) for other discharges.







**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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Knowledge	30		0.3 * _____		
Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 4 To measure the velocity of flow using Venturimeter

Date:

Relevant CO: CO2

Objectives:

- To measure the velocity of flow using Venturimeter.

Theory:

The most important class of flow meter is that in which the flow is either accelerated or retarded at the measuring sections by reducing the flow area, and the change in the kinetic energy is measured by recording the pressure difference produced.

This class includes

- The Pitot tube
- The Venturimeter
- The Nozzle
- The Notch or Weir
- The variable Areameter or Rotameter

However from apparatus point of view let us study a few in little detail.

### 1) Venturi Meter

Like orifice meter, a venturimeter is also used for the measurement of discharge in a pipeline. Since head loss caused due to installation of venturi meter in a pipeline is less than that caused due to installation of orificemeter, the former is usually preferred particularly for higher flow rates. A venturimeter consists of a converging tube which is followed by a diverging tube. The junction of the two is termed as 'throat' which is the section of minimum cross-section.

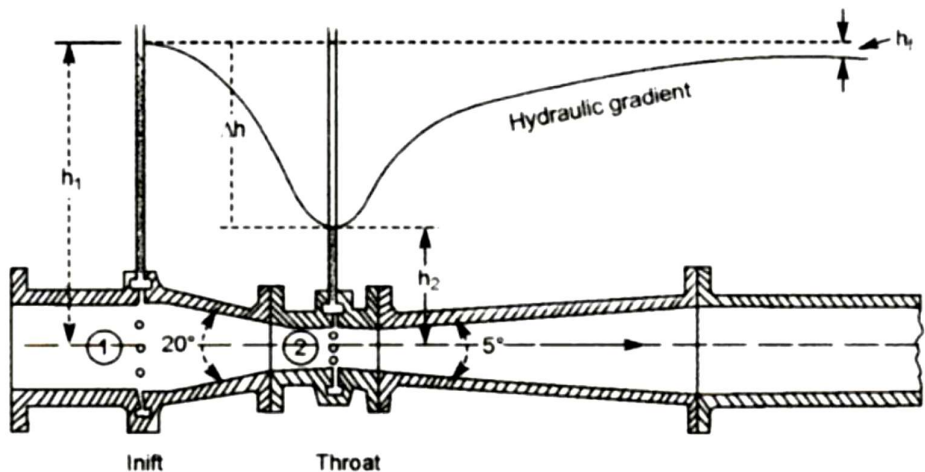


Fig: Venturi Meter

**Apparatus Description**

All flowmeters are mounted along a pipeline with sufficient distance to stabilize flow between two meters. The pressure taps are provided at sections as given in the fig. Pressure head difference between sections can be read on manometer having mercury as the manometer fluid. A valve, fitted at the end of the pipeline, is used for regulating the discharge in the pipeline.

Technical Specifications:-

Venturimeter:  
 Size = 26 mm  
 Throat Size = 16 mm  
 Dia Ratio = 0.615

**Experimental Procedure**

- Fill the storage tank/sump with the water.
- Switch on the pump and keep the control valve fully open and close the bypass valve to have maximum flow rate through the meter.
- To calibrate Venturimeter open control valve of the same.
- Open the vent cocks provided at the top of the manometer to drive out the air from the manometer limbs and close both of them as soon as water start coming out.
- Note down the difference of level of mercury in the manometer limbs.
- Keep the drain valve of the measuring tank closed till its time to start collecting the water.
- Close the drain valve of the measuring tank and note down the initial level of the water in the collection tank.
- Collect known quantity of water in the measuring tank and note down the time required for the same.
- Change the flow rate of water through the meter with the help of control valve and repeat the above procedure.
- Take about 2-3 readings for different flow rates.

**Observations & Result:**

**For Venturi meter**

Diameter at Inlet  $D_1 = \underline{\hspace{2cm}}$  mm  
 Diameter at throat  $D_2 = \underline{\hspace{2cm}}$  mm  
 Area at inlet  $A_1 = \underline{\hspace{2cm}}$  m<sup>2</sup>  
 Area at throat  $A_2 = \underline{\hspace{2cm}}$  m<sup>2</sup>  
 Delivery tank dimension: Length  $L = \underline{\hspace{2cm}}$  m width  $B = \underline{\hspace{2cm}}$  m  
 Delivery tank volume =  $L \times B \times H = \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$  m<sup>3</sup>

Sr. No.	Manometer Difference in mm of Hg	Time taken for filling 0.1 m height (H) of water in delivery tank t in Sec	Discharge Q (m <sup>3</sup> /s)	C <sub>d</sub>	Average C <sub>d</sub>
1.					
2.					
3.					

**Calculations**

- Discharge ,  $Q = \text{volume of water collected/time} = (L*B*H)/t$

Where,  $(l * b * h) = \text{Volume of collecting tank , m}^3/\text{s}$

- Let,  $(h_1-h_2)_{\text{Hg}} = \text{manometer difference in terms of mm of Hg}$

$(h_1-h_2)_w = \text{head difference in terms of m of water}$

$$(h_1-h_2)_w = (h_1-h_2)_{\text{Hg}} (13.6 - 1)$$

$$= 12.6 * (h_1-h_2)_{\text{Hg}}$$

- Coefficient of discharge  $C_d = \frac{Q}{A_2 \left[ \frac{2 g (h_1-h_2)_w}{1 - \left(\frac{A_2}{A_1}\right)^2} \right]^{1/2}}$

**Conclusion**

- Average values of the co-efficient of discharge for Orifice meter is = \_\_\_\_\_
- Average values of the co-efficient of discharge for Venturi meter is = \_\_\_\_\_

**Quiz**

- **Explain venturimeter.**

- **Derive an expression for the discharge through venturimeter.**

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 5 To measure the velocity of flow using Orifice meter

**Date:**

**Relevant CO: CO2**

**Objectives:**

- To measure the velocity of flow using Orifice meter.

**Theory:**

The most important class of flow meter is that in which the flow is either accelerated or retarded at the measuring sections by reducing the flow area, and the change in the kinetic energy is measured by recording the pressure difference produced.

This class includes

- The Pitot tube
- The Orifice meter
- The Nozzle
- The Notch or Weir
- The variable Areameter or Rotameter

However from apparatus point of view let us study a few in little detail.

Orifice Meter

A circular Opening in a plate which is fitted suitably in a pipeline is a simple device to measure the discharge flowing in the pipeline. Such a device is known as orifice meter and is as shown in the figure. The opening is normally at the centre of the plate as shown in figure. Applying Bernoulli's equation between section 1 and 2 and using continuity equation, it can be shown that,

$$Q = C_d \times A_2 \left[ \frac{2g(h_1 - h_2)_w}{1 - \left(\frac{A_2}{A_1}\right)^2} \right]^{1/2}$$

Where,

- $A_1$  is the area of cross section of the orifice inlet
- $A_2$  is the area of cross section of the orifice outlet,
- $(h_1 - h_2)_w$  is the difference in the heads at section 1 and 2 in m of water

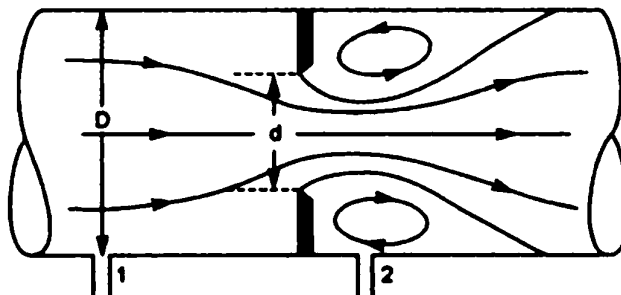


Fig: Simple Orifice Meter

**Apparatus Description**

All flowmeters are mounted along a pipeline with sufficient distance to stabilize flow between two meters. The pressure taps are provided at sections as given in the fig. Pressure head difference between sections can be read on manometer having mercury as the manometer fluid. A valve, fitted at the end of the pipeline, is used for regulating the discharge in the pipeline.

Technical Specifications:-

- Orificemeter:
  - Size = 26 mm
  - Orifice Size = 16 mm
  - Dia Ratio = 0.615

**Experimental Procedure**

- Fill the storage tank/sump with the water.
- Switch on the pump and keep the control valve fully open and close the bypass valve to have maximum flow rate through the meter.
- To calibrate Orificemeter open control valve of the same.
- Open the vent cocks provided at the top of the manometer to drive out the air from the manometer limbs and close both of them as soon as water start coming out.
- Note down the difference of level of mercury in the manometer limbs.
- Keep the drain valve of the measuring tank closed till its time to start collecting the water.
- Close the drain valve of the measuring tank and note down the initial level of the water in the collection tank.
- Collect known quantity of water in the measuring tank and note down the time required for the same.
- Change the flow rate of water through the meter with the help of control valve and repeat the above procedure.
- Take about 2-3 readings for different flow rates.

**Observations & Result:**

**For Orifice meter**

Diameter at Inlet = \_\_\_\_ mm  
 Diameter at orifice = \_\_\_\_ mm  
 Area at inlet  $A_1 =$  \_\_\_\_\_  $m^2$   
 Area at orifice  $A_2 =$  \_\_\_\_\_  $m^2$   
 Delivery tank dimension: Length  $L =$  \_\_\_\_ m width  $B =$  \_\_\_\_ m  
 Delivery tank volume =  $L \times B \times H =$  \_\_\_\_ x \_\_\_\_ x \_\_\_\_ = \_\_\_\_\_  $m^3$

Sr. No.	Manometer Difference in mm of Hg	Time taken for filling 0.1 m height (H) of water in delivery tank t in Sec	Discharge Q ( $m^3/s$ )	$C_d$	Average $C_d$
1.					
2.					
3.					

**Calculations**

- Discharge ,  $Q = \text{volume of water collected/time} = (L*B*H)/t$

Where,  $(l * b * h) = \text{Volume of collecting tank , } m^3/s$

- Let,  $(h_1-h_2)_{Hg} = \text{manometer difference in terms of mm of Hg}$

$(h_1-h_2)_w = \text{head difference in terms of m of water}$

$$(h_1-h_2)_w = (h_1-h_2)_{Hg} (13.6 - 1)$$

$$= 12.6 * (h_1-h_2)_{Hg}$$

- Coefficient of discharge  $C_d = \frac{Q}{A_2 \left[ \frac{2 g (h_1-h_2)_w}{1 - \left(\frac{A_2}{A_1}\right)^2} \right]^{1/2}}$

**Conclusion**

- Average values of the co-efficient of discharge for Orifice meter is = \_\_\_\_\_

**Quiz**

- **Explain orifice meter.**

- **Derive an expression for the discharge through orifice meter.**

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- **Compare venturimeter and orifice meter for measurement of flow through pipes.**

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
3. White, F.M. – Fluid Mechanics, McGraw-Hill.
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**References used by the students:**

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Criteria	%	Level of Marks	Multiplication	Total	Remarks
Knowledge	30		0.3 * _____		
Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

### Experiment No: 6

#### To determine the coefficient of discharge through open channel flow over a notch(V-notch/rectangular)

**Date:**

**Relevant CO: CO2**

**Objectives:** To determine the coefficient of discharge through open channel flow over a V-notch

#### Theory:

The notch is hydraulically defined as an opening provided in the side of the tank and liquid level in the tank is below the top edge of the opening. Notches are generally used for measuring the flow of liquid in channels. The bottom edge of the notch over which the liquid flows is known as sill or crest and its height above the bottom of tank is known as crest height. The height of free liquid surface above crest of notch is called head acting on the notch.

Different shapes of notch generally used are triangular, rectangular, trapezoidal etc.

The unit is provided with following notches:

1. Triangular notch ( Notch angle=  $45^\circ$  ,  $60^\circ$  )
2. Trapezoidal notch ( Crest length of notch = 0.03m and  $\Theta/2 = 30^\circ$  )



In the unit, centrifugal pump sucks water from the sump tank and discharges it to a small flow channel. The notch is fitted at the end of channel. All the notches are interchangeable by removing it by unscrewing. The water flowing over the notch falls in the collector. Water coming from the collector can be directed to the sump tank or to the measuring tank for the measurement of discharge

**Experimental Procedure**

1. Fit the required notch in the flow channel path.
2. Fill up the water in the sump tank.
3. Close the water supply gate valve to the channel and fill up the water in the channel upto sill level.
4. See that water does not leak from the notch fitting and hose pipes and keep the collector diverted in the sump tank.
5. Note down the initial reading of crest level by the sliding depth gauge provided on notch.
6. Now start the pump and open the gate valve slowly so that water starts flowing over the notch.
7. Let the water level become stable and note down the height of water surface at the upstream side by the sliding depth gauge.
8. Close the drain valve of the measuring tank, direct the collector into measuring tank and measure the discharge.
9. Take reading for different flow rates
10. Repeat the same procedure for other notch also

**Observation Table**

Sr. No.	Type of Notch	Sill Level reading "s" in meters	Water Height on upstream side "h" in meter	Time required to collect 10 litres of water 't' in second	Discharge Q in m <sup>3</sup> /s	Co-efficient of discharge
1.						
2.						
3.						
4.						

**Calculations:****FOR TRIANGULAR NOTCH**

1. Head over the notch,  $H = |h - s|$ ,  $m$
2. Actual discharge,  $Q_a = \frac{0.01}{t}$ ,  $m^3/s$
3. Theoretical discharge,  $Q_{th} = \frac{8}{15} (\sqrt{2g}) \left( H^{\frac{5}{2}} \right) \tan \left( \frac{\theta}{2} \right)$ ,  $m^3/s$  where  $\theta = 45^\circ$  or  $60^\circ$
4. Co-efficient of discharge,  $C_d = \frac{Q_a}{Q_{th}}$

**FOR TRAPEZOIDAL NOTCH**

1. Head over the notch,  $H = |h - s|$ ,  $m$
2. Actual discharge,  $Q_a = \frac{0.01}{t}$ ,  $m^3/s$
3. Crest length of notch  $L = 0.030 m$
4. Theoretical discharge,  $Q_{th} = \left( \sqrt{2g} H^{\frac{3}{2}} \right) \left[ \frac{2}{3} L + \frac{8}{15} H \tan \left( \frac{\theta}{2} \right) \right]$ ,  $m^3/s$ , where  $\frac{\theta}{2} = 30^\circ$
5. Co-efficient of discharge,  $C_d = \frac{Q_a}{Q_{th}}$



**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

**Experiment No: 7**  
**To determine coefficient of discharge of an orifice**

**Date:**

**Relevant CO: CO2**

**Objectives:**

1. To determine co-efficient of contraction ( $C_c$ )
2. To determine co-efficient of velocity ( $C_v$ ) and
3. To determine co-efficient of discharge ( $C_d$ ) for flow through a circular/round orifice.

**Theory:**

It has been observed that when a jet of water leaves an orifice it gets contracted, the maximum contraction takes place at a section slightly on the downstream side of the orifice, where the jet is more or less horizontal. Such a section is known as *vena-contracta*. The ratio of area of the jet at *vena-contracta* to the area of the orifice is known as co-efficient of contraction ( $C_c$ ).

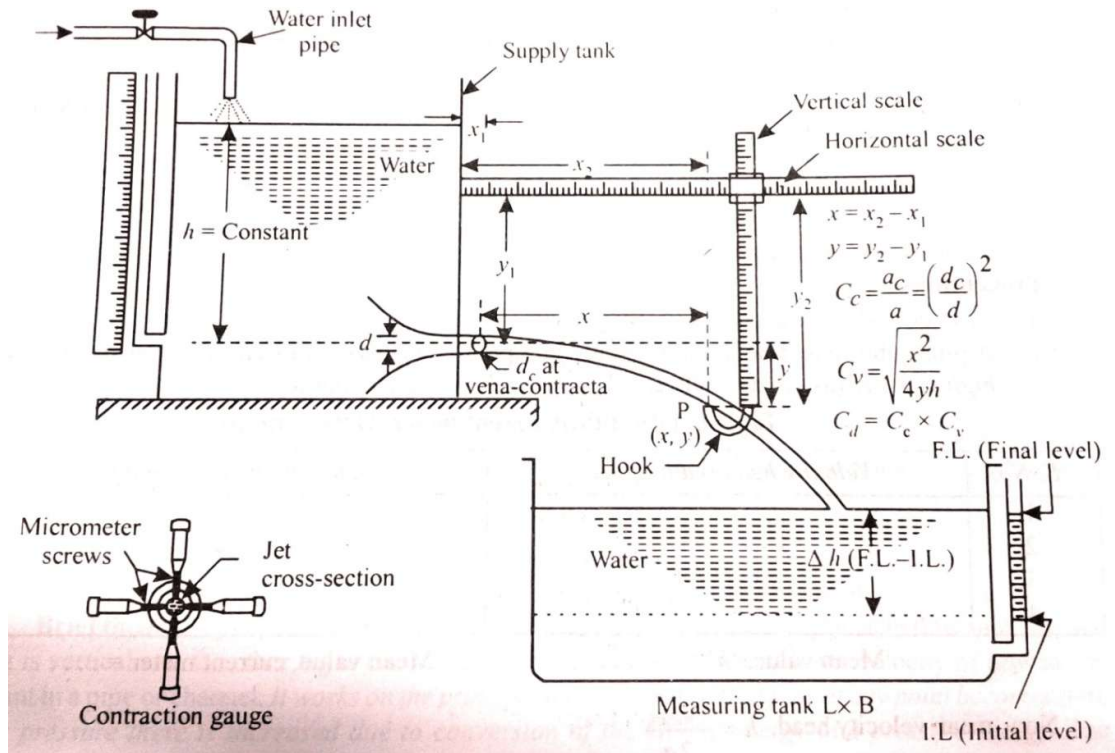
The ratio of actual velocity of the jet at *vena-contracta* to the theoretical velocity is known as co-efficient of velocity ( $C_v$ ).

For a vertical orifice  $C_v$  can be found out by measuring the horizontal and vertical co-ordinates of a point in the jet.

**Apparatus:**

Orifice apparatus comprises the following:

1. Supply tank provided with;
  - a. Circular orifice
  - b. Water inlet pipe
  - c. Scale and sliding apparatus
  - d. Meter rod
2. Measuring tank
3. Stop watch
4. Stand for mounting the supply tank



If,  $x$  = Horizontal ordinate of a point (say P) in the jet,  $m$

$y$  = Vertical ordinate of the same point,  $m$

$h$  = Head of liquid,  $m$

Then,  $C_v = \sqrt{\frac{x^2}{4yh}}$

The ratio of actual discharge to the theoretical discharge is known as **co-efficient of discharge ( $C_d$ )**.

The actual discharge may be determined by measuring the water in the measuring tank for a certain period of time ' $t$ '.

If,  $V$  = quantity (volume) of water collected in  $m^3$

$t$  = time in *second*

Then, actual discharge  $Q_{act} = \frac{V}{t}$   $m^3/s$

Again if,  $a$  = c/s area of the orifice

Then, Theoretical discharge  $Q_{th} = a \times \sqrt{2gh}$   $m^3/s$

Therefore, Co-efficient of discharge ( $C_d$ ) =  $\frac{Q_{act}}{Q_{th}}$

The value of  $C_d$  can also be found out by finding out  $C_c$  and  $C_v$ .  $C_d = C_c \times C_v$

**Procedure:**

1. Fill the supply tank with water and allow it flow through the orifice.
2. Maintain a constant head of water in the supply tank by adjusting the supply of water.
3. Measure the diameter of the jet at vena-contracta ( $d_c$ ) with the help of a micrometer contraction gauge.
4. Note down the initial readings of the scales (horizontal and vertical).
5. Slide the vertical scale on the horizontal scale through a reasonable distance and adjust its vertical scale so that point of the hook just touches the centre line of the jet of water.
6. Measure the co-ordinates of the point (say P) in the jet at this position.
7. Note down the time taken for rise of water through a certain height in the measuring tank.
8. Repeat the experiment for different constant heads and tabulate in observation table.

**Observation Table:**

Sr No	Head $h$ m	Jet dia. $d_c$ m	Jet area $a_c$ $m^2$	$C_c = a_c/a$	$X_2 - X_1 = x$ m	$y_2 - y_1 = y$ m	$C_v = \frac{x^2}{\sqrt{4yh}}$	Water level rise $\Delta h$ m in t sec	$V = LxBx\Delta h$ $m^3$	$Q_{act} = \frac{V}{t}$ $m^3/s$	$C_d = \frac{Q_{act}}{a\sqrt{2gh}}$	$C_c = C_d/C_v$
1												
2												
3												
4												
5												

**Calculations:**



**Suggested Reference:**

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Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 8

**To determine the different types of flow patterns by Reynolds' experiment**

**Date:**

**Relevant CO: CO3**

**Objectives:** To determine the different types of flow patterns

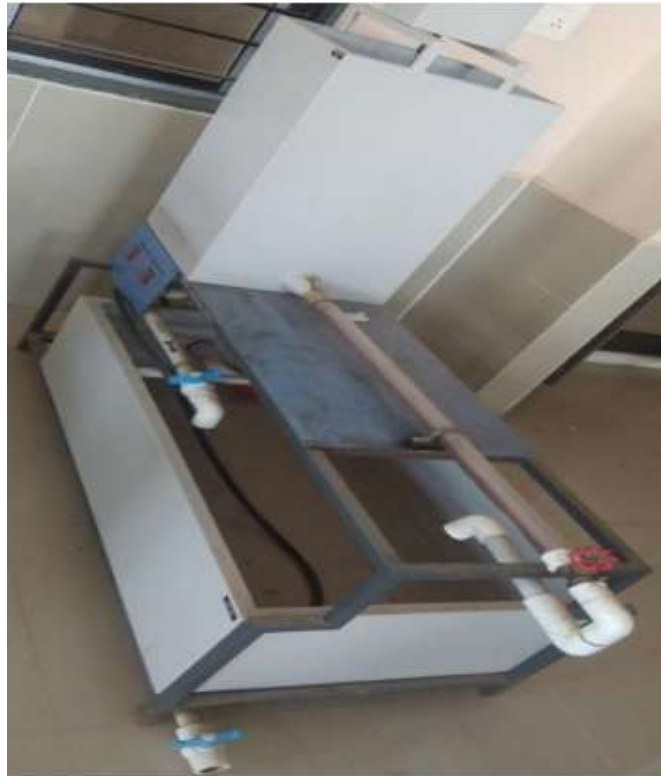
### **Theory:**

Osborne Reynolds in 1883, with the help of a simple experiment discussed and demonstrated the existence of the following two types of flow (for pipe flow):

1. Laminar flow ( Reynolds number,  $Re < 2000$ )
2. Turbulent flow ( Reynolds number,  $Re > 2000$ )
3.  $Re$  between 2000 and 4000 indicates transition from laminar to turbulent flow.

### **Apparatus**

1. A constant head tank filled with water
2. A small tank containing dye ( sp. weight of dye same as that of water)
3. A horizontal glass tube provided with a bell mouthed entrance
4. A regulating valve



Observations made by Reynolds The water was made to flow from the tank through the glass tube into the atmosphere. The velocity of flow was varied by adjusting valve. The liquid dye was introduced into the bell mouth through a small tube as shown in fig.

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1. When the velocity of flow was low, the dye remained in the form of a straight and stable filament passing through the glass tube so steadily that it seemed to be motionless. This was a case of laminar flow.
2. With the increase of velocity a critical state was reached at which the dye filament showed irregularities and began to wave. This was a transitional state.
3. With further increase in velocity of flow the fluctuations in the filament of dye become more intense and ultimately the dye diffused over the entire cross section of the tube, due to the intermingling of the particles of flowing fluid. This was the case of turbulent flow.

On the basis of his experiment Reynolds discovered that

- (i) In case of laminar flow : The loss of pressure head  $\propto$  velocity
- (ii) In case of turbulent flow : The loss of pressure head  $\propto V^2$

### Procedure

1. Fill the water tank with water and allow it to stand for some time so that the water comes to rest.
2. Partially open the outlet valve of the glass and allow the flow to take place at a very low rate.
3. Allow the flow to stabilize, then open the valve at the inlet of the dye injector and allow the dye to move through the tube. Observe the nature of filament.
4. Measure the discharge by collecting water in the graduated cylinder for a certain interval of time.
5. Repeat the steps 2 and 4 for different discharges.

### Observation Table

Sr. No.	Discharge measurement			Velocity of flow, V (m/s)	Reynolds number, Re	Flow regime
	Rise of water level in collecting tank, h (m)	Time of collection, t (sec.)	Discharge, Q (m <sup>3</sup> /s)			

### Calculations

1. Discharge,  $Q = \text{volume of water collected}/\text{time} = (l \cdot b \cdot h)/t$   
Where,  $(l \cdot b \cdot h) = \text{Volume of collecting tank, m}^3/\text{s}$
2. Velocity,  $= V = \frac{Q}{A}$ , Where A is area of pipe in m<sup>2</sup>
3. Reynolds number,  $Re = \frac{V D}{\vartheta}$   
Where  $\vartheta = \text{kinematic viscosity of fluid}$

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**Conclusion:**

**Quiz:**

1. Explain different types of flow

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 9 To determine the friction factor for the different pipes

**Date:**

**Relevant CO: CO3**

**Objectives:** To determine the friction factor for the different pipes

**Theory:**

The flow of liquid through a pipe is resisted by viscous shear stresses within the liquid and the turbulence that occurs along the internal walls of the pipe, created by the roughness of the pipe material. This resistance is usually known as pipe friction and is measured in meters head of the fluid, thus the term head loss is also used to express the resistance to flow.

Many factors affect the head loss in pipes, the viscosity of the fluid being handled, the size of the pipes, the roughness of the internal surface of the pipes, the changes in elevations within the system and the length of travel of the fluid.

The resistance through various valves and fittings will also contribute to the overall head loss. In a well-designed system the resistance through valves and fittings will be of minor significance to the overall head loss and thus are called Major losses in fluid flow.

The Darcy-Weisbach equation

Weisbach first proposed the equation we now know as the Darcy-Weisbach formula or Darcy-Weisbach equation:

$$h_f = \left[ C_f \left( \frac{L}{D} \right) \left( \frac{V^2}{2g} \right) \right]$$

Where:

$h_f$  = head loss (m)

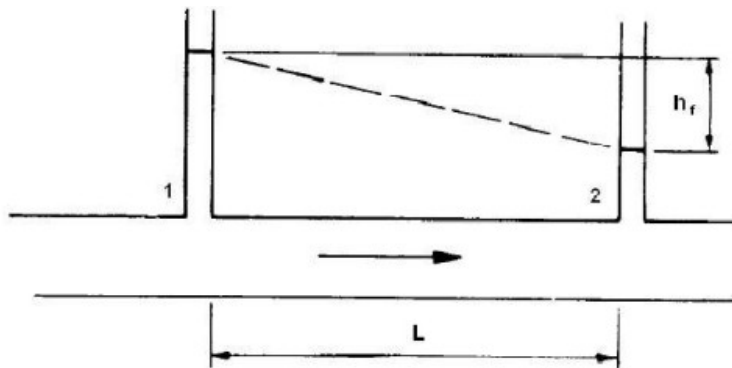
$C_f$  = Darcy friction factor

$L$  = length of pipe work (m)  $D$

$D$  = inner diameter of pipe (m)

$V$  = velocity of fluid (m/s)

$g$  = acceleration due to gravity ( $m/s^2$ )



The Darcy Friction factor used with Weisbach equation has now become the standard head loss equation for calculating head loss in pipes where the flow is turbulent.

**Apparatus Description:**

The experimental set up consists of a large number of pipes of different diameters. The pipes have tapping at certain distance so that a head loss can be measure with the help of a U – Tube manometer. The flow of water through a pipeline is regulated by operating a control valve which is provided in main supply line. Actual discharge through pipeline is calculated by collecting the water in measuring tank and by noting the time for collection.

**Technical Specification:**

- Test length = 1000 mm
- Pipe Diameter:
- Pipe 1(G.I. Pipe): Inner Diameter: 27 mm
- Pipe 2(Copper Pipe): Inner Diameter: 22 mm
- Pipe 3(Stainless steel pipe): Inner Diameter: 17 mm

**Experimental Procedure**

1. Fill up clean water in the sump tank.
2. Open all the outlet valves and start the pump.
3. Check for leakage in each pipe and stop leakages if any
4. Open the outlet valve of the pipe to be tested.
5. Remove all air bubbles from manometer and connecting transparent pipes.
6. Adjust valve opening so that water heads in manometer are at readable heights.
7. Note down the heads in the limbs of manometers and flow rate.
8. Now, change opening of bypass valve and note down heads and flow rate again.
9. Repeat the procedure for other diameter pipes.

**Observation Table**

Sr. No.	Types of Pipe	Manometer difference, H (mm o Hg)	Time taken to fill 10 litres of water in delivery tank t (sec)
1.	G.I.pipe (Ø = 27mm)		
2.	G.I.pipe (Ø = 27mm)		
3.	Copper pipe (Ø = 22mm)		
4.	Copper pipe (Ø = 22mm)		
5.	SS pipe (Ø = 17 mm)		
6.	SS pipe (Ø = 17 mm)		

**Calculations:**

1. For G.I. pipe (D = 27mm)  
 C.S. area of the pipe  $A = (\pi/4) D^2 = (\pi/4) (0.027)^2 = \text{_____ m}^2$   
 Test section Length L = 1 m
2. Discharge,  $Q = (0.01 / t) \text{ m}^3/\text{s}$   
 Velocity of flow,  $V = (Q/A) = \text{m/s}$

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3. Let, H = manometer difference in terms of mm of H<sub>g</sub>

$$\begin{aligned} h_f &= \text{frictional head loss in terms of m of water} \\ &= H (13.6 - 1) \\ &= 12.6 * H \end{aligned}$$

4. According to Darcy-Weishback equation , frictional head loss is given by

$$h_f = \left[ C_f \left( \frac{L}{D} \right) \left( \frac{V^3}{2g} \right) \right]$$

From above equation calculate C<sub>f</sub>

**Conclusions:**

(1) The head loss due to friction is dependent upon \_\_\_\_\_

(2) Average value of 'f' for G.I pipe = \_\_\_\_\_

Copper pipe = \_\_\_\_\_

SS pipe = \_\_\_\_\_

**Quiz:**

1. State the various losses of energy when fluid flows through pipe

2. Derive Darcy- weisbach formula for head loss due to friction in pipe flow

3. Derive chezy' s formula for velocity of flow through pipe

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
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Punctuality	20	Timely Submission	Submission late by one laboratory.	Submission late by two laboratories.	Submission late by more than two laboratories.
Criteria	%	Level of Marks	Multiplication	Total	Remarks
Knowledge	30		0.3 * _____		
Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## **Experiment No: 10**

### **To determine the loss coefficients for different pipe fittings**

**Date:**

**Relevant CO: CO3**

**Objectives:** To determine the loss coefficients for different pipe fittings

**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, topography, losses, availability of size and length 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 head. The apparatus is designed to demonstrate the loss of head due to following pipe fittings-

- (1) Pipe bend (Large bend)
- (2) Pipe elbow (small bend)
- (3) Sudden expansion of the flow
- (4) Sudden contraction of the flow

Losses due to change in cross-section, bends, elbows, valves and fittings of all types fall into the category of minor losses in pipelines. In long pipeline, the friction losses are much larger than these minor losses and hence, the latter are often neglected. But, in shorter pipelines, their consideration is necessary for the correct estimate of losses. The minor losses are, generally expressed as

$$h_L = k_L (V^2/2g)$$

**Experimental Set-up**

The setup consists of 15 mm 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.

**Specifications**

- (1) Basic piping of 15mm size
- (2) 15mm small bend – 1 No
- (3) 15mm large bend – 1 No
- (4) Sudden expansion from  $\text{Ø}=15\text{mm}$  to  $\text{Ø}=26\text{mm}$
- (5) Sudden contraction from  $\text{Ø}=26\text{mm}$  to  $\text{Ø}=15\text{mm}$
- (6)  $\frac{1}{2}$  hp centrifugal pump
- (7) Multiple tapping differential manometer
- (8) Sump tank

**Experimental Procedure:**

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

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- (2) Connect the electric supply and see that the flow control valve and bypass valve are fully open and all manometer cocks are closed. Keep the water collecting funnel in the sump tank side.
- (3) Start the pump and adjust the flow rate. Now slowly open the manometer tapping connection of small bend. Open both the cocks simultaneously.
- (4) Open air vent cocks and remove air bubbles and slowly & simultaneously close the cocks.
- (5) Note down the manometer reading and flow rate.
- (6) Repeat the procedure for other pipe fittings

### Observation Table

Sr. No.	Type of fitting	Manometer difference in meter of Hg (H)	Time required to collect 10 litres of water 't' in second	Discharge Q in m <sup>3</sup> /s	Velocity in m/s	Head Loss Co-efficient K <sub>L</sub>
1.	15mm small bend (Elbow)					
2.	15mm large bend					
3.	Sudden expansion from Ø=15mm to Ø=26mm					
4.	Sudden contraction from Ø=26mm to Ø=15mm					

### Calculations

For Elbow (Small Bend)

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.

1. Mean cross sectional area  $A = (\pi/4) D^2 = (\pi/4) (0.015 \text{ m})^2 = \underline{\hspace{2cm}} \text{ m}^2$

Where D= mean diameter = 0.015 m

2. Discharge,  $Q = (0.01 / t) \text{ m}^3/\text{s}$

Velocity of flow,  $V = (Q/A) = \text{m/s}$

3.  $h_L = (13.6-1) H = 12.6 H$  in meters

4. Theoretical head loss  $h_L = k_L (V^2/2g)$

5. From above equation find loss coefficient  $k_L$

For Large Bend

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.

1. Mean cross sectional area  $A = (\pi/4) D^2 = (\pi/4) (0.015 \text{ m})^2 = \underline{\hspace{2cm}} \text{ m}^2$

Where D= mean diameter = 0.015 m

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2. Discharge,  $Q = (0.01 / t) \text{ m}^3/\text{s}$   
Velocity of flow,  $V = (Q/A) = \text{m/s}$
3.  $h_L = (13.6-1) H = 12.6 H$  in meters
4. Theoretical head loss  $h_L = k_L (V^2/2g)$
5. From above equation find loss coefficient  $k_L$

For Sudden Enlargement

1. Mean cross sectional area  $A = (\pi/4) D^2 = (\pi/4) (0.015 \text{ m})^2 = \underline{\hspace{2cm}} \text{ m}^2$   
Where  $D =$  mean diameter  $= 0.015 \text{ m}$
2. Discharge,  $Q = (0.01 / t) \text{ m}^3/\text{s}$   
Velocity of flow,  $V = (Q/A) = \text{m/s}$
3.  $h_L = (13.6-1) H = 12.6 H$  in meters
4. Theoretical head loss  $h_L = k_L (V^2/2g)$
5. From above equation find loss coefficient  $k_L$

For Sudden Contraction

1. Mean cross sectional area  $A = (\pi/4) D^2 = (\pi/4) (0.015 \text{ m})^2 = \underline{\hspace{2cm}} \text{ m}^2$   
Where  $D =$  mean diameter  $= 0.015 \text{ m}$
2. Discharge,  $Q = (0.01 / t) \text{ m}^3/\text{s}$   
Velocity of flow,  $V = (Q/A) = \text{m/s}$
3.  $h_L = (13.6-1) H = 12.6 H$  in meters
4. Theoretical head loss  $h_L = k_L (V^2/2g)$
5. From above equation find loss coefficient  $k_L$

**Conclusion:**

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**Quiz:**

- 1. Derive equation of Co efficient of discharge for different pipe fittings.**

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
3. White, F.M. – Fluid Mechanics, McGraw-Hill.
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5. Som & Biswas – Introduction to Fluid Mechanics and Fluid Machines, McGraw-Hill

**References used by the students:**

**Rubric wise marks obtained:**

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Knowledge	30		0.3 * _____		
Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## Experiment No: 11

### To measure the velocity of flow using Pitot tube

**Date:**

**Relevant CO: CO2**

**Objectives:** To measure the velocity of flow using Pitot tube

**Theory:**

It is a device used for measuring the velocity of flow at any point in a pipe. It is based on the principle that if the velocity of flow at a point becomes zero, there is an increase in pressure due to the conversion of the kinetic energy into pressure energy. The Pitot tube consists of a capillary tube, bent at right angle. The lower end, which is bent through 90° is directed in the upstream direction. The liquid rises up in the tube due to conversion of kinetic energy into pressure energy. The velocity is determined by measuring the rise of liquid in the tube.

When a Pitot tube is used for measuring the velocity of flow in a pipe or other closed conduit the Pitot tube may be inserted in the pipe as shown in figure. Since a Pitot tube measures the stagnation pressure head (or total head) at its dipped end. The pressure head may be determined directly by connecting a suitable differential manometer between the Pitot tube and pressure tapping at the pipe surface. Consider two points (1) and (2) at the same level in such a way that point (2) is just at the inlet of the Pitot tube and point (1) is far away from the tube. At point (1) the pressure is  $P_1$  and velocity of stream is  $V_1$ . However, at point (2), is called stagnation point, the fluid is brought to rest and the energy has been converted to pressure energy. Therefore the pressure at (2) is  $P_2$ , the velocity  $V_2$  is zero and since (1) and (2) are in the same horizontal plane, so  $Z_1 = Z_2$ .

Applying Bernoulli's equation at points (1) and (2)

$$\frac{P_1}{\rho} + \frac{v_1^2}{2g} = \frac{P_2}{\rho} + \frac{v_2^2}{2g}$$

$$v_2 = 0$$

$$\frac{v_1^2}{2g} = \frac{P_2}{\rho} - \frac{P_1}{\rho}$$

$$v_1 = \sqrt{2g \left( \frac{P_2}{\rho} - \frac{P_1}{\rho} \right)}$$

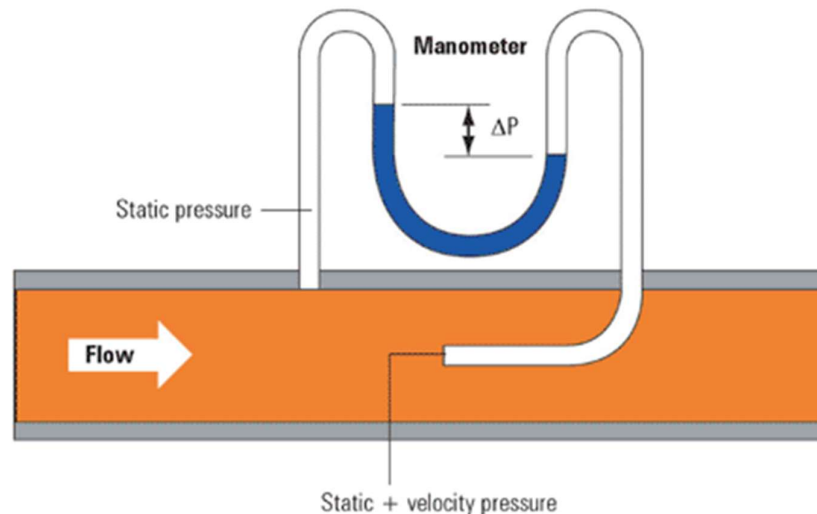
$$v_1 = \sqrt{2gH}$$

This is theoretical velocity.

$$\text{Actual Velocity } (v_1)_{\text{act}} = C_v \sqrt{2gH}$$

**Description:**

The apparatus consists of a Pitot tube made of copper and fixed below a pointer gauge. The pointer gauge is capable to measure the position of Pitot tube in transparent test section. The pipe has a flow control valve to regulate the flow. A U-tube manometer is provided to determine the velocity head. A pump is provided to circulate the water. Discharge is measured with the help of measuring tank and stop watch.



**Experimental procedure:**

**Starting Procedure:**

3. Clean the apparatus and make tank free from dust.
4. Close the drain valves provided.
5. Fill sump tank  $\frac{3}{4}$  with clean water and ensure that no foreign particles are there.
6. Close all flow control valves given on the water line and open By-pass valve.
7. Check the level of Hg in manometer tube. It should be up to half. If it is less, then fill it.
8. Close all pressure taps of manometer connected to different pipe-fittings.
9. Ensure that On/Off switch given on the panel is at OFF position.
10. Now switch on the main power supply (220 Volts AC, 50 Hz).
11. Switch on the pump.
12. Operator the flow control valve to regulate the flow of water through orifice.
13. Open the pressure tapes of manometer of related test section, very slowly to avoid the blow of water on manometer fluid.
14. Now open the Air release valve provided on the manometer, slowly to release the air in manometer.
15. When there is no air in the manometer, close the air release valve.
16. Adjust water flow rate in desired section with the help of control valve.
17. Set the Pitot tube at the center of test section.

18. Record the manometer readings and measure the discharge with the help of measuring tank and stop watch.
19. Now move the Pitot tube up and down at the same flow rate and note the manometer readings to find out the velocity at different points in pipe.
20. Calculate the co-efficient of the Pitot tube from actual and theoretical velocities and plot the velocities at different points inside the pipe.
21. Repeat the same procedure for different flow rates of water, operating control valve and By-pass valve.

**Closing Procedure:**

1. When experiment is over, close all manometers pressure taps first, switch off pump.
2. Switch off power supply to panel.
3. Drain water from all tanks with the help of given drain valves.

**Specification:**

Pitot Tube : Material Copper of compatible size fitted with scale.

Test Section : Material Clear Acrylic, compatible to 1" dia Pipe.

Water Circulation : FHP Pump.

Flow Measurement : Using Measuring Tank with Piezometer.

: Capacity 40 Liters

Sump Tank : Capacity 70 Liters.

Stop Watch : Electronic.

Control Panel Comprise of: Standard make ON/Off Switch, Mains Indicator, etc.

The whole set-up is well designed and arranged in a good quality painted structure.

**Formulae:**

Discharge, 
$$Q = \frac{A * R}{t} \text{ m}^3/\text{s}$$

Velocity, 
$$v_a = \frac{Q}{a} \text{ m/s}$$

Actual Velocity, 
$$v_a = C_v \sqrt{2gH} \text{ m/s}$$

$$H = h \left( \frac{\rho_m}{\rho_w} - 1 \right) \text{ (m of water)}$$

Co- efficient of Pitot tube,

$$C_v = \frac{v_a}{\sqrt{2gH}}$$

**Observation & calculation:**

**Data:**

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$$A = 0.1 \text{ m}^2$$

$$a = 0.0006157 \text{ m}^2$$

$$\rho_m = 1590 \text{ kg/m}^3$$

$$\rho_w = 1000 \text{ kg/m}^3$$

$$g = 9.81 \text{ m/s}^2$$

**Observation Table:**

Sr. No	Pressure head at different points on up side			Pressure head at centre 0	Pressure head at different points on down side			R (cm)	t (sec)
	8 mm	6 mm	4 mm		8 mm	6 mm	4 mm		
1									
2									
3									

**Calculation Table:**

Sr. No	$C_v$	$V_8$	$V_6$	$V_4$	$V_0$	$V_4$	$V_6$	$V_8$
1								
2								
3								

**Conclusion:**

**Quiz:**

1. Derive equation for the velocity of flow

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
3. White, F.M. – Fluid Mechanics, McGraw-Hill.
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**References used by the students:**

**Rubric wise marks obtained:**

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Quality of report	20		0.2* _____		
Participation	30		0.3* _____		
Punctuality	20		0.2* _____		
<b>Total Marks</b>					

## **Experiment No: 12**

### **Demonstration of model studies (wind tunnel / CFD)**

**Date:**

**Relevant CO: CO5**

**Objectives:**

1. To understand the concept of model studies and similitude
2. To observe flow patterns, pressure distribution, and aerodynamic forces
3. To introduce experimental and numerical approaches in research
4. To understand the importance of model studies in engineering design

**Theory:**

**Model Studies**

Model studies involve testing a **scaled-down version (model)** of a real system (**prototype**) to predict actual behavior. They help reduce **cost, time, and risk** in engineering research.

**Similitude**

For accurate results, the model and prototype must satisfy:

- **Geometric similarity**
- **Kinematic similarity**
- **Dynamic similarity**

Important dimensionless numbers:

- Reynolds number
- Mach number
- Froude number

**Wind Tunnel Testing**

Wind tunnels are used to study:

- Lift and drag forces
- Pressure distribution
- Flow separation and wake formation

**Computational Fluid Dynamics (CFD)**

CFD uses numerical methods to solve **Navier–Stokes equations** and predicts:

- Velocity and pressure fields
- Turbulence characteristics
- Aerodynamic forces

**Apparatus:**

**Wind Tunnel Setup**

- Subsonic wind tunnel
- Test model (airfoil / building / vehicle model)
- Pitot tube / pressure taps

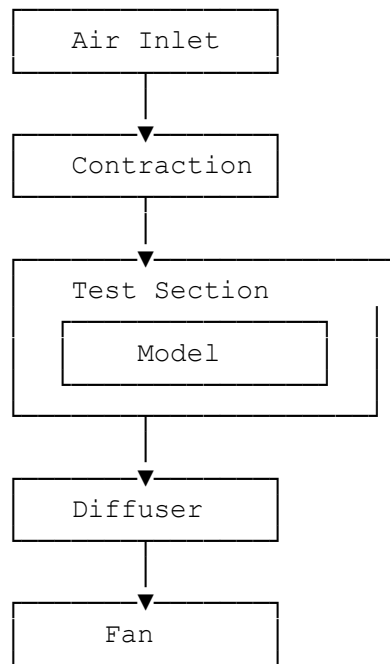
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- Manometer / pressure sensors
- Smoke generator or flow visualization system
- Force balance (lift and drag measurement)

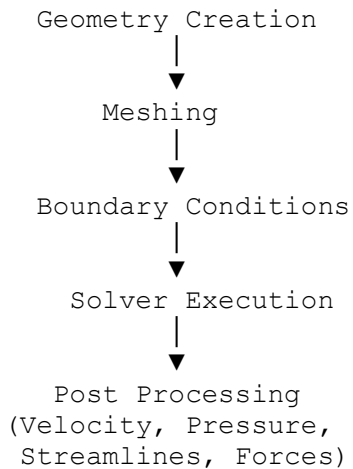
**B) CFD Setup**

- Computer system
- CFD software (ANSYS Fluent / OpenFOAM / COMSOL)
- Geometry and meshing tools

**Wind Tunnel Experimental Setup**



**CFD Analysis Flow Diagram**



## **PROCEDURE**

### **A) Wind Tunnel Demonstration**

1. Place the model inside the test section of the wind tunnel.
2. Set the required airflow velocity.
3. Visualize the flow using smoke or tufts.
4. Measure pressure distribution and aerodynamic forces.
5. Note flow separation and wake formation.

### **B) CFD Demonstration**

1. Create/import the model geometry.
2. Generate mesh for the computational domain.
3. Define fluid properties and boundary conditions.
4. Run the CFD solver.
5. Analyze velocity contours, pressure plots, and streamlines.

## **OBSERVATIONS**

<b>Parameter</b>	<b>Observed</b>	<b>Wind Tunnel</b>	<b>CFD</b>
Flow pattern	Observed		Simulated
Pressure variation	Measured		Computed
Lift & Drag	Experimental		Numerical

## **APPLICATIONS**

- Aircraft and automobile aerodynamic design
- Wind load analysis on buildings
- Turbomachinery and duct flow studies
- Wind energy systems

## **ADVANTAGES**

- Reduced experimental cost
- Improved design accuracy
- Visualization of complex flow behavior
- Safe and controlled testing environment

## **LIMITATIONS**

- Scaling errors in physical models
- Approximation errors in CFD
- High cost of advanced experimental facilities

## **PRECAUTIONS**

- Ensure proper calibration of instruments
- Avoid excessive air velocity beyond limits
- Use appropriate turbulence models in CFD

## **CONCLUSION**

Model studies using wind tunnel experiments and CFD simulations play a vital role in engineering research by enabling accurate prediction of real-world fluid flow behavior before full-scale implementation.

**QUIZ:**

1. What is meant by model studies?
2. Explain similitude and its types.
3. Why is Reynolds number important in wind tunnel testing?
4. Compare wind tunnel testing and CFD analysis
5. List applications of CFD in engineering.

**Suggested Reference:**

1. R.K. Bansal – A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
2. P.N. Modi & S.M. Seth – Hydraulics and Fluid Mechanics, Standard Book House.
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Punctuality	20		0.2* _____		
<b>Total Marks</b>					

**Fluid Mechanics  
(BE04000161)**

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